FACING COMPETITION: THE HISTORY OF INDIGO EXPERIMENTS IN COLONIAL INDIA, 1897-1920

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FACING COMPETITION: THE HISTORY OF INDIGO EXPERIMENTS IN COLONIAL INDIA, 1897-1920

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This dissertation is dedicated to my parents.

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LIST OF ABBREVIATIONS

Agr.: Agriculture

BSA: Bihar State Archives, Patna (India)

GOB: Government of Bengal

GOI: Government of India

IOR: India Office Records (Located at the British Library, London)

IPG: Indian Planters’ Gazette and Sporting News

NAL: National Agricultural Library, Beltsville, USA.

PRO: Public Records Office, Kew

Rs.: Indian Rupees (1 rupee=100 paisas)

MEASUREMENTS AND GLOSSARY OF TERMS

1 *bigha*=0.87 *acre*; 1 *acre*=0.4 *hectare*

1 *maund* = 80 lbs. Approximately

Abwab: exaction taken from the peasants by the landlords

Asamiwar: system of indigo cultivation in which the planter employed labor on the plantation
owned by him

Indican: the glucoside present in the indigo leaves that was transformed into color

Indoxyl: an intermediate compound formed in the process of conversion into color

Indigotin/Indigo: the blue color

Khuski: the system under which the natives grew indigo independently and sold it to the planter
at the prevailing market prices

Raiyat: tenant

Raiyati: system of indigo cultivation by the tenants under contract with the planters

Satta: written contract

Sith: the refuse and wastewater from indigo manufacturing

Thika: lease of land for a definite period

Zamindar: lanlord

Zirat: proprietor's private land

SUMMARY

This historical study focuses on scientific research conducted across laboratories and farm stations in colonial India and England to improve the yield of indigo – the blue dyestuff extracted from the leaves of *Indigofera tinctoria.* The launch of cheaper and purer synthetic substitute by two German companies in 1897 provided the primary impetus for these endeavors. The commercial attack by synthetic indigo was predictably resisted by those who were willing and ready to fight on behalf of natural indigo for a slice of the Western markets. The solid resistance of the native indigo growers drove the planters to use science rather than wage cut as a tool for reducing the cost of production of the natural dye. These efforts of chemists, bacteriologists, botanists, and agricultural experts continued till 1920. By studying the efforts of scientists called upon by the European planers living in India and the colonial government this dissertation analyzes the nature of science in a colonial context. At the same time it also reveals the dilemmas faced by the producers of the natural dye as they tried to fight the competition of the synthetic product in the market. The doctoral dissertation explains: when and how were the laboratories and farm stations organized? Who were the experts and what type of expertise was brought to bear on the problem at hand? What results were obtained? To what extent did the efforts of the experts meet the goal of improving yield and consistency? And finally, under what circumstances were those efforts abandoned at the end of the period in question? Moving beyond the experts and outside the laboratories and farm stations, the dissertation also elucidates the nature of the support for these experiments by the planters and the colonial government.

CHAPTER 1

INTRODUCTION

The Historiography

The purpose of this dissertation is to describe in detail the efforts made to protect natural indigo – the blue dyestuff extracted from the leaves of the indigo plant (*Indigofera tinctoria*) - against the market competition of cheaper and purer synthetic indigo - which was derived from coal-tar hydrocarbons. Throughout the nineteenth century British India was the pre-eminent producer and supplier to the West of indigo for its thriving textile industry. The introduction of synthetic indigo on the market in 1897 by two German companies threatened to end India's dominant role in the indigo trade. To counteract competition from the synthetic substitute the European planters living in India, supported by the colonial and the national governments, conducted scientific research in the laboratories and farm stations. This dissertation fundamentally focuses on these scientific efforts made in India and England, and contributes to the scientific and technological history of Modern South Asia.

Indigo, derived from plant sources in the nineteenth century, was an extremely important dye (colorant) for the textile industries in the West. The main nineteenth-century colorants were red, black, and blue. For dyeing cloth blue the primary colorant the world over was indigo. This was mostly supplied from British India, Dutch Java, and Spanish Central America, in that order of importance. It would no exaggeration to state that indigo produced in the colonies was critical to the principal industry of Europe and North America – the textile industry.

The world of colonial, plant-derived blue entered a turbulent phase as the hydrocarbon-derived synthetic blues began to enter the international market. In the 1860s the aniline blues made their appearance. [1] These blues were cheaper than natural indigo and were adopted to some extent for use by the dyers and printers. But the anilines never really threatened natural indigo's core market. Some later blues, particularly alizarin blue, turned out to be more serious competitors by partly winning over some of the natural dye's previous consumers.

But, importantly for the future of natural indigo, efforts were underway in Germany to discover a synthetic substitute for indigo itself. The tremendous demand for natural indigo, particularly for the dyeing and printing industries of Lancashire, stimulated research in Germany into a synthetic product. This became one of the main scientific and technological endeavors of the 19th century, following the success of synthetic alizarin (1869-1870), the red colorant that displaced the "natural red" earlier extracted from the root of the madder plant. The German dye-making firms knew that smashing the British monopoly would bring tremendous profits. During the 1870s and '80s, Adolf Baeyer, at Munich, and other academic chemists derived considerable scientific benefits from collaborations with Heinrich Caro, at BASF, and other leading industrial chemists. Caro provided Baeyer with information about potentially interesting reactions and novel products that became topics for academic research. The technical problems, particularly a synthetic route based on a low cost starting material, eluded both Baeyer and Caro. Nevertheless, the eventual success of artificial indigo was based on researches that Baeyer had commenced at the Gewerbeinstitut in Berlin in 1865, with the

[1] Anthony Travis, *The Rainbow Makers: The Origins of the Synthetic Dyestuffs Industry in Western Europe.* (Bethlehem: Lehigh University Press, 1993): 72-73, 131-135

encouragement and collaboration of Caro in the mid-1870s, and on Baeyer's contractual agreements with both BASF and Hoechst at the beginning of the 1880s.

Until the early 1880s, Caro was the principal industrial participant, even though the process he scaled up on the basis of Baeyer's research was a commercial failure. Baeyer, following his understanding of the reaction, was able to establish in 1883 that the intermediate product of the indigo degradation was pseudo-indoxyl, not indoxyl. This enabled him to draw the modern chemical structure for indigo. This was announced in a letter to Caro, dated 3 August 1883. The industrial manufacture of indigo is based on two processes developed by Carl Heumann in 1890 at Zurich Polytechnic. The starting points were the abundant coal-tar hydrocarbons benzene and naphthalene. In 1897, following extensive research and development, BASF and Hoechst in Germany were the first firms to manufacture synthetic indigo. [2]

The "transition" from *natural* to *synthetic* – which itself was a belabored one and occurred over a period of decades, implied a shift in focus from the colonies as the primary producers of indigo to Germany as the main supplier of synthetic indigo. Throughout, the centrality of indigo to the textile industries, however, remained. In the first decade of the 20th century the newly industrializing East Asian countries turned out to be the main consumers. The import of synthetic indigo into China alone went up from 10,000,000 lbs. to 38,000,000 lbs between 1908 and 1913. The outbreak of the First World War disrupted the role of Germany as the supplier of indigo worldwide. The

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[2] Relevant secondary literature delineating the invention and commercialization of synthetic indigo would include: Anthony Travis, *The Rainbow Makers: The Origins of the Synthetic Dyestuffs Industry in Western Europe.* (Bethlehem: Lehigh University Press, 1993); Carsten Reinhardt and Anthony Travis, *Heinrich Caro and the Creation of Modern Chemical Industry.* (Dordrecht: Kluwer, 2000); Johann Peter Murmann, *Knoweldge and Competitive Avantage: The Co-evolution of Firms, Technology, and National Institutions.* (New York, Cambridge University Press, 2003).

English and American entrepreneurs responded to the shortage in the supply of the synthetic indigo dye and other coal-tar products from Germany through indigenous production.[3]

Scholars have rightfully acknowledged the critical importance of indigo as a dye of international standing by studying its history, including the history of the "transition" in great detail. But much of the literature on the subject has generally considered the technological victory of *synthetic* indigo over *natural* indigo as an unproblematic given. Based on sources within the synthetic dye industry in Germany and Britain, these works essentially try to explain the process through which the dominance of the synthetic dyes, including indigo, was established. They attempt no serious analysis of the efforts to protect the blue natural dye against the synthetic alternative. [4]

At a theoretical level, it would be fair to say that the current studies of the transition from natural to synthetic indigo assume the death of the natural dye to be inevitable. The onset of synthetic indigo appears in these writings as "progress" towards a superior technique. It would seem, then, that the technology of production of the agricultural product was "backward," that the indigo planters were "conservative" -

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[3] The disruption in the supplies of indigo and synthetic dyes from Germany during the First World War led to their first large-scale production in the USA as covered in the relevant sections of: David Hounshell and John K Smith, *Science and Corporate Strategy: Du Pont R&D, 1902-1980.* (New York: Cambridge University Press, 1988); Anthony Travis, *Dyes Made in America, 1915-1980: The Calco Chemical Company, American Cyanamid, and the Raritan River.* (Jerusalem: Edelstein Center/Hexagon Press, 2004); for an account of the production of synthetic indigo in England beginning 1917, see M R Fox, *Dye-Makers of Great Britain, 1856-1976: A History of Chemists, Companies, Products, and Changes*. (Manchester: ICI, 1987)

[4] Augusti Nieto-Galan's recent monograph on natural dyes largely focuses on the application end of the industry in Europe as against the production end in the colonies: Augusti Nieto-Galan, *Colouring Textiles: A History of Natural Dyestuffs in Industrial Europe* (Dordrecht: Kluwer Academic Publishers, 2001)

standing in the way of the forward march of scientific advance and technological progress.

Such an assumption is not tenable if one looks carefully at colonial records and at the efforts made to protect the natural dye against the competition from the synthetics. This dissertation shows clearly that neither the indigo planters nor the colonial government in India were "conservative." The planters and the government initiated a robust program of scientific experiments and continued it for a long time. The final defeat of natural indigo in the market place does not imply that the indigo planters and the colonial and imperial bureaucrats were innately "against science." Rather, the problem of improving the yield and consistency of natural indigo was difficult: key scientific knowledge was lacking, profits were falling for the benefactors of science, and time was short in which the experts were expected to deliver results. If anything, those that stood to protect the natural dye failed in solving the problem *even after they utilized science*. In highlighting the efforts made by those that fought on behalf of natural indigo for a slice of the market this research modifies the earlier perception that the technological transition from natural to synthetic indigo was painless and automatic.

Other than modifying the technological history of transition this research also provides a fresh perspective on the scientific and technological history of Modern South Asia. In the Indian context, a number of STS scholars have criticized colonial rulers for their feeble attempts at developing indigenous scientific and technical institutions. [5] What little progress was made in the introduction of technological projects – for instance in the introduction of the railways, building of irrigation canals, and provision of public health –

[5] For a representative argument of this sort, see Deepak Kumar, *Science and the Raj, 1857-1905* (Delhi: Oxford University Press, 1995)

it is argued, was a byproduct of the basic desire to secure economic advantages for the metropolis and consolidate the authority of the foreigners. [6] Ironically - even if understandably - the positive efforts of the state towards sponsorship of indigo experiments in India, the subject of this study, have been the target of attack within the anti-colonial discourse that dominates the history of science for the colonial period. These scholars have criticized the colonial state for putting its meager resources earmarked for promotion of science into commodities like indigo. They criticize these efforts as being inspired by the motive of supporting European investments, not securing welfare of the teeming millions. [7] So the argument runs that first of all only limited science was introduced into the colony. And whatever science was introduced was destined to benefit the foreigners.

The economic historians of colonialism have added further weight to these arguments. They contend that agricultural plantations, even if they created jobs for the natives, on balance harmed Indian cultivators, agriculture, and the economy. In pursuing that line of argument they have illustrated how the "commercialization" of agriculture resulted in food scarcity and ultimately to famine because of the diversion of land from food-crops to cash crops. [8]

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[6] For glimpses of such arguments on railways, see Ian J Kerr, "Colonialism and Technological Choice: The Case of the Railways in India," *Itinerario* (1995): 91-111; on canal irrigation projects, see Ian Stone, *Canal Irrigation in British India: Perspectives on Technological Change in a Peasant Economy.* (Cambridge: Cambridge University Press, 1984, 2002); in the field of medicine, see David J Arnold, *Colonizing the Body: State Medicine and Epidemic Disease in Nineteenth-Century India* (Berkeley: University of California Press, 1993)

[7] Deepak Kumar, *Science and the Raj, 1857-1905*, see especially the section on plantation research: 152-158

[8] Binay Bhushan Chaudhuri, "Growth of Commercial Agriculture in Bengal, 1859-1885," *Indian Economic and Social History Review* (1970) 7: 25-60

These critiques are certainly valid. But, insofar as they relate to the historiography of science and technology in India, they have barely dealt with plantation research and development (R&D) - perhaps one of the most vibrant areas of scientific research and technological innovation in colonial India. European planters invited some of the most accomplished chemists and agronomists to carry out indigo experiments and assigned resources for the conduct of goal-oriented research. What is more, they even persuaded the colonial state to provide funds for these experiments. As such these laboratories may well have been enclaves supporting the "best" science practiced in the colonies, and therefore deserve to be studied in more detail.

In that context, the present study advances Science and Technology Studies in India in two ways: firstly, it focuses on science on its own terms to analyze a significant aspect of the history of science in India. The plantation laboratories deserve more attention from historians because they represent one of the earliest efforts to create a modern scientific infrastructure in India. While they were set up to benefit a class of foreign capitalists based in India, these early scientific endeavors *also* opened the way for cultivating science indigenously. The tradition of inviting scientists from the West and experiences gained with indigo experiments by the entrepreneurs and government officials had consequences elsewhere. The case of indigo is very informative in this regard. Records relating to indigo laboratories indeed indicate that planters' laboratories may well have inspired the government to employ experts for the benefit of other sectors of agriculture. A direct link exists between the indigo laboratories and the first centralized agricultural station of India that was set up in 1905 at Pusa to serve as a resource center for agricultural crops in colonial India. Two agricultural experts from one of the indigo laboratories at Dalsingserai, Bernard Coventry and H M Leake, were re-employed to lead the operations at Pusa. Bacteriologist Cyril Bergtheil, also working on indigo experiments, was appointed as the first Imperial Bacteriologist of British India.

Secondly, this study borrows tools from Laboratory Studies within the STS literature [9] to consider efforts to improve natural indigo in India. Since the mid-1970s, a considerable literature has emerged in the history and sociology of science that has demonstrated the extent to which scientific facts are socially constructed – that is, they are products of social practices and processes and not "pure" reflections of nature. These theorists have proposed links between the nature of scientific knowledge produced on the one hand and the structure of scientific community (David Bloor, 1976), "negotiations" indulged in by groups of scientific experts (Harry Collins, 1985), and events in specific laboratories, on the other. [10] The application of these new perspectives has generally been inadequate for the study of science in the nonwestern context, and nonexistent in the Indian context. Utilization of these newer methods of analysis will enable an understanding of the very difficult process of knowledge formation, and undermine a historically inaccurate understanding that the planters were "conservative."

Lastly, this research brings the history of British Raj closer to the scientific and technological history of Modern South Asia. A rich body of literature exists on the

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[9] Bruno Latour, "Give me a Laboratory and I will Raise the World," in Karin Knorr-Cetina and Michael Mulkay (eds), *Science Observed: Perspectives on the Social Study of Science* (Thousand Oaks: Sage, 1983); Bruno Latour and Steve Woolgar, *Laboratory Life. The Construction of Scientific Facts* (Princeton: Princeton University Press, 1986); Steven Shapin and Simon Schaffer, *Leviathan and the Air-Pump: Hobbes, Boyle and the Experimental Life* (Princeton: Princeton University Press, 1989); Steven Shapin, *A Social History of Truth: Civility and Science in Seventeenth Century England* (Chicago: University of Chicago Press, 1994)

[10] David Bloor, *Knowledge and Social Imagery* (Chicago: University of Chicago Press, 1976, 1991); Harry Collins, Changing Order: Replication and Induction in Scientific Practice (Sage: Beverly Hills, 1991)

several dimensions of the indigo industry in colonial India. Much of the existing literature examines the cultivation and manufacturing of indigo as they bear on the rising tide of the national movement in India. Within that larger interpretive framework economic historians have examined the agriculture and commerce of indigo, [11] and prevailing labor relations on the plantations. [12] Political historians have focused on the revolts on the indigo tracts to make important arguments about the nature of peasant movements during the British Raj. [13] Still others have studied the participation of natives on the indigo plantations in the growing national movement in India culminating in the Gandhian *styagraha* of 1917. [14] Indeed it is in calling every foreign actor simply a "colonialist" that the current anti-colonial discourse fails to consider the factors that complicated the synergies between the process of governmental decision-making and the requirements of indigo business. This dissertation specially focuses on the sponsorship of indigo laboratories by the government at different levels and at different periods of time - what facilitated and what impeded these efforts - in order to explain the nature of the colonial state in a new light.

By focusing on the scientific and technological dimensions of indigo cultivation and manufacturing this research fills what is certainly a glaring gap in the current

[11] Benoy Chowdhury, *Growth of Commercial Agriculture in Bengal, 1757-1900*. (Calcutta: R K Mitra, 1964)

[12] Prabhat Kumar Shukla, *Indigo and the Raj: Peasant Protests in Bihar, 1780-1917*. (Delhi: Pragati Publication, 1993)

[13] Blair B Kling, *The Blue Mutiny: The Indigo Disturbances in Bengal, 1859-1862.* (Philadelphia: University of Pennsylvania Press, 1966)

[14] Jacques Pouchepadass, *Champaran and Gandhi: Planters, Peasants and Gandhian Politics.* (Delhi: Oxford University Press, 1999)

literature while *also* connecting with central themes of interest in the historiography of Modern South Asia. First and foremost the dissertation considers the agrarian structure of colonial India to situate the scientific and technological alternatives available for indigo improvement. Secondly, through many of the chapters the narrative in the dissertation examines the political context across colonial India and imperial Britain to explain the patronage of laboratory experiments on natural indigo. In so doing it contributes to the existing literature on the nature of the political relationship between the metropolis and the colony. And, by focusing on the laboratories, farm stations, and on experts and their work, this research addresses the nature of knowledge formation in colonial conditions, another significant area of emphasis in the South Asian historiography.

The Focus And Outline Of The Dissertation

The commercial attack by synthetic indigo, as this dissertation will illustrate, was predictably resisted by those who were willing and ready to fight on behalf of natural indigo for a slice of the Western markets. Huge stakes were involved in the displacement of the natural product. The plantation industry was a capitalist investment of Europeans in colonial India. For hundreds of planters of European origin saving natural indigo was important for protecting their livelihood and their way of life.

The national government in Britain and the colonial state in India had their own reasons for trying to preserve the indigo industry of colonial India. The imperial framework had throughout the nineteenth century facilitated the passage of the blue dye from India to the dyers and printers in the home country. Their perspective on what they considered worth saving in the metropolis vis-à-vis what they thought worth saving in the colony guided their response to the claims of the Indian indigo industry for support. Metropolitan assistance in 1897 came through the sponsorship of some scientific investigations in England, but largely though the encouragement of the colonial administrators in India to support scientific research. Later, with the outbreak of the War in 1914, the metropolitan interests in natural indigo were revived again in the context of a disruption of supplies of synthetic indigo to England from the German sources.

In India the colonial administrators at the center and in the province had their own motivations for backing the efforts to protect the natural indigo industry. The blue dye was the primary article of export from colonial India and its key industry. The colonial bureaucrats were wary of letting it wither away. In the early 20^{th} century the central government in India also supported indigo experiments as part of its overall goal of encouraging scientific research and development in the colony.

From the perspective of the administrators, the decline of the industry would also entail the loss of thousands of jobs for the natives who worked on the plantations and in the factories where the actual production of the dye took place. The provincial bureaucrats worried even more about the joblessness that would result from the destruction of the regional industry. They had additional reasons to be helpful to the planters with whom they had established intimate political and social linkages. The planting community was a valuable ally in times of political disturbances. Planters also helped authorities in carrying out sundry administrative tasks such as disaster management or the disbursement of humanitarian aid when national calamities like flood and drought struck the region.

Is the story of the efforts made to protect natural indigo, then, merely the story of imperialists and colonialists, and their endeavors in India? Not quite. This dissertation will show that the natives – the indigo growers and the workers/*coolies* at the indigo factories were *not irrelevant* in determining the nature of efforts to save the natural indigo industry. It is true that the natives were politically dis-empowered on account of having been excluded from self-representation and membership in the governing elite. But that does not mean that they were completely powerless politically in the colonial context. In fact, it was fundamentally the solid peasant resistance that drove the planters to use science rather than wage cuts as a tool for improving yield and for reducing the cost of production of the natural dye. The fear of discontent among the natives haunted the administrators, who were not willing to risk an outbreak of political agitation. They in turn made it clear to the planters that they would not permit any reduction of wages on the plantations. Thus it may be said that peasant power, mediated through the colonial administrators, was responsible for the onset *and persistence* of scientific investigations to improve natural indigo in colonial India.

It is those scientific pursuits that are analyzed at the core of this dissertation. When and how were the laboratories and farm stations organized? Who were the experts and what type of expertise was brought to bear on the problem at hand? What results were obtained? To what extent did the efforts of the experts meet the goal of improving yield and consistency? And finally, under what circumstances were those efforts abandoned at the end of the period in question?

Moving beyond the experts and outside the laboratories and farm stations, the dissertation also analyzes the nature of the support for these experiments by the planters and the colonial government. The planters promptly initiated scientific research in India in response to the introduction of synthetic indigo. Subsequently they sought and received the colonial government's subsidy for their experiments.

This dissertation overwhelmingly focuses on the three levels of administration - India House and the Secretary of State in England, the central government in Simla/Calcutta, and the provincial government of Bengal in Calcutta. It is their enduring support for the indigo experiments that concerns us here. The government soon became the primary vehicle of scientific experiments in colonial India. Its resources turned out to be the lifeblood of natural's fight against the German synthetic dye. An examination of the administrative records of colonial officials in British India reveals a fascinating story of how political economy determined the support provided to indigo experiments by the government at different levels and at different periods of time.

The dissertation is divided into nine chapters including the Introduction and the Conclusion. Chapter 2 addresses the main argument by showing the options that were available to the planters in 1897 on cost cutting. It considers the cultivation and manufacturing imperatives to evaluate where the planters thought they could intervene to reduce production costs. The historical evolution of the relationship between the colonial state, the European planters, and the native indigo growers also determined the space that was available to the planters for manipulating the cost of inputs like land, raw materials, and wages. Chapter 3 documents the move towards the option of conducting scientific experiments. The planters knew the realm of agriculture best. It is in this field that they sought their first solutions. They first considered switching from indigo to sugarcane, which had attractive commercial possibilities. The metropolitan government offered the services of experts within its institutions to explore the relative merits of the two products. While a few planters began sugarcane production on a small scale, the majority of them decided to stay with indigo manufacturing.

The next two chapters describe the initiation and conduct of scientific experiments by scientists called upon by the planters. The colonial government was willing to finance these experiments. An organized attack was launched to “improve” natural indigo through the efforts of chemists, bacteriologists, botanists, and agricultural experts. Chapter 6, for its part, describes the events between 1905 and 1908, especially the new situation which arose when one of the chemists working on indigo was shifted to a laboratory at the University of Leeds at the initiative of India House in London. The period was marked by the polarization of views among experts who were broadly divided into two camps – one vouching for the chemical approach and the other for the agricultural route to improve yield.

Chapter 7 focuses on the efforts of the provincial government of Bengal and its sponsorship of basically agricultural experiments in India to the exclusion of chemical experiments. The last chapter documents the conduct of indigo experiments during the War when the chemical approach was popular once again. It was basically the unavailability of synthetic indigo from German sources at this time that stimulated the interest of the imperial government in Indian indigo. That interest waned as British manufacturers successfully produced synthetic indigo using German techniques. All laboratory and farm-based experiments on natural indigo ended soon after the end of the War.

The Land Where Indigo Was Produced - Bihar

In the last quarter of the nineteenth century Bihar, the northernmost division within the larger province of Bengal, was the most significant supplier of finest quality indigo from British India. More precisely, north Bihar or Tirhut, comprising the four districts of Muzaffarpur, Darbhanga, Champaran, and Saran, were the most prominent areas for the cultivation and manufacture of indigo. [15] These four districts showed an increase in indigo acreage by 286 percent between 1830 and 1875, and by more than 69 percent between 1875 and 1894-95. [16]

Parallel production of indigo also took place in other parts of British India besides Bihar. Yet north Bihar or Tirhut remained the center of gravity for the export-based natural dye industry. Since the early 19th century the natives in the territories to the north and west of Bihar had been engaged in indigo manufacturing. These regions came to comprise the North West Provinces when that new administrative division was formed out of the newly conquered territories in 1835. In the second half of the 19th century indigo production also spread to the Madras and Punjab provinces. But the indigo from the rest of India was of an inferior quality, and was manufactured using inferior techniques. It fetched a low price and catered to the lower end of the market. In contrast the indigo from Bihar was of a high quality and was sold at the highest price. The proprietors based in England, the agency houses of Calcutta, and the large retinue of managers and assistants – all Westerners – controlled the production and shipment of

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[15] The province of Bengal under the East India Company comprised of three distinct regions, namely Bengal proper (modern Bangladesh), Orissa, and Bihar. An Act of 1912 separated "Bihar and Orissa" from Bengal, and later another act of 1937 separated Bihar from Orissa.

[16] Jacques Pouchepadass, *Champaran and Gandhi: Planters, Peasants and Gandhian Politics* (New Delhi: Oxford University Press,1999) : 20-22

indigo from Bihar. Indigo was produced in Bihar under their closet supervision using the best available techniques. [17]

North Bihar/Tirhut was part of the Indo-Gangetic alluvial plains. The Himalayas to the north and the Ganges to the south bordered these fertile plains. The fertility of the soil varied to an extent across Bihar. But the overall richness of the soil was an advantageous factor for the indigo plantations. The dense population of the area also provided relatively cheap labor for the planters.

These agricultural tracts also had an organic relationship with the city of Calcutta - a port city and the commercial capital of India. Much of indigo plantations in Bihar were controlled either directly by agency houses based in Calcutta or by proprietors in the home country that operated through the agency houses. All the indigo from Bihar was ferried down the rivers Ganges and Hughly to Calcutta for export.

The Actors – Planters And Natives

The Planters As Indigo Manufacturers

Almost all planters in Bihar were British. In the early 19th century the East India Company had turned a blind eye to the entry of some French, Italian, and Portuguese immigrants at a time when the demand for the blue dye surpassed production. But subsequently their entry was clearly discouraged.

The plantation industry in colonial India provided career avenues to the young British aspirants. The recruits came from the middle and upper middle classes in British

[17] Jacques Pouchepadass, *Champaran and Gandhi: Planters, Peasants and Gandhian Politics* (New Delhi: Oxford University Press,1999): 3n.

society. W. M. Reid, a planter himself, has vividly described the arrival of a young planter at Calcutta looking ahead to a career in indigo planting. The agents based in the port city generally received the newcomer. The latter would soon be given instructions to proceed to an indigo concern somewhere in Tirhut. A couple of days after his arrival in Calcutta the would-be planter would proceed to Muzaffarpur by train. After de-boarding at Muzaffarpur he would be ferried to the lead factory to meet with the manager. He would then be assigned a particular task. Over the next 5-15 years, according to Reid, the ambition of the young man would be to prove himself in the "field." He would aspire to become a manager. At the same time he would also use his credibility with the financiers in Calcutta to buy up factories. In the end, of course, he dreamed of one day selling his factory, returning to his home country, and using the wealth acquired abroad to rise in the social hierarchy. [17]

Reid's judgment on the quality of life for the British planters is a divided one. The lifestyle for the British planter improved as he graduated from the position of an assistant to the grade of a manager. The managers of bigger and better concerns led a more comfortable life. The solitude of being away from home and living in the extremely hot climate was compensated to some extent by the paraphernalia of an elitist and privileged lifestyle. [18]

The verdict of Jacques Pouchepadass on indigo planting as a career for the Englishman is definitive. He says, "Whatever the occupational inconvenience and hazards the planters had to face, the stakes were worth the gamble." The stress of the

[17] W M Reid, *The Culture and Manufacture of Indigo with Description of a Planter's Life and Resources.* (Calcutta: Thacker, Spink and Co., 1887): 3-11, 21-33

[18] W M Reid, *The Culture and Manufacture of Indigo with Description of a Planter's Life and Resources.* (Calcutta: Thacker, Spink and Co., 1887): 12-20

work itself was no doubt considerable. The business was risky too. But on balance many men made their fortune in the industry. The profit margins were enormous before the synthetic product was produced and marketed, and more than made up for the years in which the crop failed. Stories of success kept bringing new aspirants into the field. [19]

The Natives As Indigo Growers And Workers

The indigo tracts encompassed different forms of land tenure. The native *thikedars* and *zamindars,* mostly belonging to the upper castes, had a special relationship with the British planters. The *thikedars* or owners of very large holdings sold the *thika* (lease) of their land to the planters for a fixed term of several years. Even in other areas where individual growers cultivated indigo, the *zamindars* (proprietors) of the village extracted the rent that they were conventionally entitled to from the planters.

The majority of native landed classes worked as contract farmers for the planters or as wageworkers. Those who grew indigo on contract complained about the low prices for indigo. Besides they always found themselves in a confrontational situation with the planters because the latter wanted them to put their best and most fertile land under indigo. The farmers wanted to use this land for growing subsistence crops or crops that would fetch them a better price in the market than indigo.

The natives were also employed in the factories in other capacities. Jacques Pouchepadass has pointed to the existence of two separate hierarchies of indigenous staff. One looked after the management of the factory. The other supervised the agricultural and manufacturing operations.

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[19] Jacques Pouchepadass, *Champaran and Gandhi: Planters, Peasants and Gandhian Politics* (New Delhi: Oxford University Press,1999): 13

A factory could have one or several *munshi.* A *munshi* was the head of the administrative staff and placed just below the manager. He was adept at handling administrative and judicial responsibilities. Educated natives that could speak English were hired to do this job. Most of them belonged to the higher caste of *kayasthas.* Two or more *musharrirs* or clerks assisted each *munshi*.

The head of the supervisory staff was called the *jamadar.* He supervised the manufacturing and cultivation on the plantations. He was most helpful in dealing with the native contract growers. Every year the most contentious issue on the plantations was deciding which plot should be put under indigo. The *jamadar* with his knowledge of local agricultural conditions proved especially helpful in settling such issues. [20]

[20] Jacques Pouchepadass, *Champaran and Gandhi: Planters, Peasants and Gandhian Politics* (New Delhi: Oxford University Press,1999): 49-52

CHAPTER 2

INDIGO REIN AND THE HISTORY OF PLANTER-PEASANT RELATIONS

The arrival of BASF produced synthetic indigo, "Indigo Rein" on the market in 1897 brought new challenges beckoning a response from the producers of natural indigo, "Bengal indigo." The planters in colonial India were now required to undertake new measures. Could they consolidate their holdings? Could they reduce wages and procurement prices for raw material? What scientific and technological avenues were practically available? The answer to these questions lay in the rural, colonial context of late nineteenth century India. Only a consideration of developments leading up to 1897, especially those bearing on the relations between the planters, peasants, and the state can provide a window to the options that were available with the planters at this time.

Before the launch of synthetic indigo on the market at the end of the nineteenth century indigo planters were never called upon to regulate the price of the natural dye. In the decade before 1897, in fact, the price of one pound of the "good consuming" Bengal variety natural indigo (60-65% concentration by weight) had varied between a maximum of 5s. 11d. and 4s. 2 d. per lb. at auctions held in London. [1] Prices fluctuated in line with cost of production in India, which varied from year to year. Bad weather, pests, and labor disturbances on plantations could potentially harm the crop and reduce total output. Whenever that happened the planters tried to recover their fixed costs by selling at a higher price. Also, the demand for indigo within the British textile industries was inelastic. Therefore any shortfall in the production of natural indigo automatically led to an increase in its prices. On the other hand, good weather in certain years led to overproduction and a slump in prices.

[1] *The Journal of the Society of Dyers and Colourists* (1896)

Never before had the indigo planters faced the type of competitive threat that they did now. Aniline blue, first patented by French inventors in July 1860, gradually became available to the British dyers and printers over the course of the decade. [2] These coal tar based dyes were relatively cheaper. But they did not give the level of fastness that was provided by natural indigo. Alizarin blue later did win over some of the customer base from the plant-derived indigo. But the challenge posed by the introduction of synthetic indigo in 1897 was the most serious one ever. Initially the price of synthetic was up to 15 -25% higher than natural's. But even at a higher price Indigo Rein altered the basic demand and supply equation by making a larger quantity of indigo available in the market. [3] Also, the consumers now had a choice. What was acceptable to them in term of quality before 1897 was no longer acceptable now. Thus natural indigo producers began to experience new types of pressure from the market to be both price and quality competitive.

With the passage of time the threat from synthetic indigo became even more serious. The German manufacturers of synthetic indigo showed an ability to drive prices down continuously. By 1901synthetic began to set the bottom line in the price of indigo. BASF's production records affirm a continuous decline in the price of synthetic indigo between 1897 and 1914. The most drastic reduction in prices in fact occurred within the first seven years. (See Table 2.1 below)

[2] Anthony Travis, *The Rainbow Makers: The Origins of the Synthetic Dyestuffs Industry in Western Europe.* (Bethlehem: Lehigh University Press, 1993): 72-73, 131-135

[3] For the history of alizarins, including alizarin blue see Anthony Travis, *The Rainbow Makers*: 163-203; for the reference to the comparative prices of natural and synthetic indigo, again see, Anthony Travis, *The Rainbow Makers*: 223. The initial hesitation of consumers against using the new product soon wore thin. German manufacturers effectively persuaded the consumers into believing that the new product was chemically the same – only purer.

Table 2.1
Decline in synthetic indigo's price

Year	Price / kg in German marks
1897	3.40
1899	3.00
1901	2.40
1903	2.10
1904	1.80
1914	1.55

Source: BASF Corporate Archives [4]

The planters were forced to respond. Indigo Rein soon began to take away consumers that had earlier used natural indigo. Continental buyers as well as those buying for the home trade in Britain showed an increasing interest in the synthetic product. The lower price of synthetic indigo was an important aspect that made it attractive to the consumers. Therefore, reducing the price of natural indigo appeared to the planters to be a likely tool to beat the competition of synthetic.

The story in this chapter begins in 1897 with a consideration of the planter's options with regard to reducing the cost of production of natural indigo. The realm of cultivation and manufacturing was the one that the planters knew best. And it is here that they made their first intervention. The most critical questions in this regard were: Where could the savings be made? How large or small were the margins for reducing cost in the

[4] BASF Corporate Archives, J11/20: 3-4

long chain of production from the seed in the field to the indigo cake in the factory? Which costs could be reduced and which ones were less amenable to change? Several factors determined answers to these questions. The nature of the agricultural production system, planter-peasant relationships, and government's policy towards the indigo industry on the one hand and labor on the other hand were the key determinants. A consideration of all of those will form the subject matter of this chapter.

The chapter is divided into two broad sections. The first describes the basic system of cultivation and manufacturing of natural indigo in order to illustrate the different factors of production. It also borrows from the existing literature to break down the costs involved in producing the indigo dye in colonial India. The historiography of production of natural indigo is a relatively rich one. Benoy Chowdhury's research on the history of indigo plantations in Bengal and Bihar is a classic on the subject. [5] Chowdhury's emphasis is on showing an extremely important characteristic of colonial agriculture – its "commercialization." There exists another more recent and equally comprehensive account of indigo manufacturing in Bihar by Jacques Pouchepadass. [6] Production records of the indigo establishments in Bihar have not survived. Under the circumstances Pouchepadass has effectively used administrative papers left by the colonial bureaucrats to give an account of the life on plantations. In the first part of the book Pouchepadass utilizes econometric tools to work out the cost of production and the overall working of the plantation economy. In the second part he traces the lineage of peasant and worker's opposition to the indigo system, and clarifies the growing

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[5] Benoy Chowdhury, *Growth of Commercial Agriculture in Bengal, 1757-1900*. (Calcutta: R K Mitra, 1964)

[6] Jacques Pouchepadass, *Champaran and Gandhi: Planters, Peasants and Gandhian Politics*. (Delhi: Oxford University Press, 1999)

connection of those movements with the rise of the Gandhian national movement in colonial India.

The first section of the chapter will also provide the planter's account as a manufacturer of the blue dye. It will use very similar material to that used by the above-named scholars, but to engage in a different kind of analysis. The basic issue forcing the planters was that cheaper synthetic indigo had become a threat, and they had to formulate a strategy to protect their product. The indigo enterprise may have been "exploitative" of the peasants and workers. It may also have been unbeneficial to the natives. Those are not the central questions examined here, which have been addressed by Chowdhury and Pouchepadass before. Instead, the first section of the chapter considers the different factors of production to calculate the different costs involved and analyze where the savings could have been made.

The second section turns to examine historical reasons that constrained planters as they strove to devise a strategy of land and labor management in order to protect their business against the competition from the synthetics. Certain actions were possible and others impossible in the colonial and rural context of North Bihar at the turn of the 20th century. Only a consideration of the evolution of planter-peasant relations and the government's efforts to regulate them through the 1800s provides clues to the alternatives the planters had in 1897.

Planting indigo required land, and as foreigners in a new country the European planters had to acquire land. That did not prove to be an easy task despite the colonial government being on their side. Slowly the planters negotiated ownership and cultivating rights with the holders of superior land rights – called *zamindars* (*thikedars* in Bihar) –

and ordinary peasants. A certain stage had been reached by the end of the 19th century that left only specific possibilities and precluded others as far as supplemental efforts toward land management were concerned.

The options on wages and remunerations to workers and cultivators were also limited. Throughout the 1800s the indigo tracts had witnessed riots related to demands for better remuneration.[7] Towards the close of the 19th century the government was particularly wary of permitting any adventurism on the issue of payments to the cultivators and workers. Had the wages historically kept up to subsistence levels? Could the planters consider wage reduction in 1897? Would the peasants tolerate lower wages without revolting? And, would the colonial state risk restless natives in order to protect the natural indigo industry? These questions can be best answered by considering long-term trends through the course of the nineteenth century showing how the government had slowly but surely started responding to planters' handling of wages.

The Cultivation Of Indigo And Agricultural Costs

Low technical and capital input was a notable feature of indigo cultivation in late nineteenth century Bihar. [8] The fertile and traditionally densely populated flood plains of Bihar provided a huge cache of cheap labor. In such a situation the indigo planters found no incentive to raising labor productivity through the improvement of farming techniques. Also, it was a norm for the European planters to aim for making quick and short-term profits. They tried to recover their initial investment as soon as possible. A

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[7] Blair B Kling, *The Blue Mutiny: The Indigo Disturbances in Bengal, 1859-1862*. (Philadelphia: University of Pennsylvania Press, 1966); P K Shukla, *Indigo and the Raj: Peasant Protests in Bihar, 1780-1917.* (Delhi: Anamika Publication, 1993)

[8] Jacques Pouchepadass, *Champaran and Gandhi*: 4-47, 62-67

few good seasons returned huge profits after which they routinely sold their factory including the land, land rights, and the building and equipment at the manufacturing unit to later batches of immigrating businessmen from Britain. They retired to England with their profits. Thus in the normal run of things the planters had no real interest in making long-term investments to improve the technical standards on the plantations. [9]

Land and cultivation rights were an elementary factor in the production of the blue dye. Planters chartered land from proprietors on different terms for which they had to pay a rent. They preferred to take lease (*thika*) of land from the local landlord (*zamindar*) who was the proprietor of the entire village. The *thika* provided to the planter not just land but also the traditional coercion rights that the landlord as the superior landed class had traditionally employed to collect rent from peasants. Planters used those rights to persuade peasants in Bihar to grow indigo. The average annual rate of payment for the *thika* lease in north Bihar amounted to 5 rupees per *bigha*.[10]

The planters also had indigo cultivated on contract. The most prevalent system of contract was that of *tinkathiya* wherein the peasant cultivator was obliged to grow indigo on three-fifths of his land. The planter gave an advance to the peasant for the current year of operations on low terms of interest or even without interest. He also provided other inputs for cultivation like seed and implements and took the responsibility to cart away the produce. The peasant's responsibility was then limited to sowing, weeding, and harvesting. The planter purchased the produce at a pre-agreed price. The planter's

[9] Benoy Chowdhury argues that a perennial problem of the indigo industry lay in the fact that the profits from the industry were never ploughed back into the plantations, but rather repatriated to the mother country.

[10] *Final Report on the Survey and Settlement Operations in the District of Muzaffarpur, 1892-1899.* (Calcutta: Bengal Secretariat Press, 1901): 886; 1 bigha=0.87 acre; 1 acre=0.4 hectare.

association in Bihar had fixed a minimum procurement rate for this *raiyati* indigo (cultivated by the *raiyat* or peasant) at 12 rupees per acre or 10 rupees 7 *annas* per *bigha*.[11]

Another part of the cost incurred in cultivation was on fertilizers and seed. Bihar's loamy flood plains were a mixed blessing. They offered the advantage of loose soil that was easier to dig and sow with indigo. But such lands would be typically deficient in nutrients like phosphoric acid and nitrogen. To overcome this deficit the indigo cultivators and planters added farm manures, chemical manures like saltpeter and lime, bone dust, and oil cakes to farmlands. But adding fertilizers purchased from the market was rare. Growers quite often utilized the refuse from the manufacturing process called *sith* as manure. John Augustus Voelcker, an agricultural chemist invited to India in 1892-93, has reported wide use of *sith* on indigo tracts. [12]

Indigo seeds in Bihar came from the United Provinces, a region about five hundred miles to the northwest of Bihar. The seeds produced locally in Bihar were known to germinate poorly and deteriorate in storage. Thus the planters depended on an external source of supply. Thousands of small, independent peasants in the United Provinces engaged in production of seed to be sold to the planters in Bihar. Varying output from year to year in the northwest and the extent of middlemen's profit determined the price of indigo seed. But the cost per *bigha* to the planter came to a minimum of 3 rupees 8 *annas*. [13]

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[11] Jacques Pouchepadass, *Champaran and Gandhi*: 63

[12] John Augustus Voelcker, *Report on the Improvement of Indian Agriculture*. (Delhi: Agricole Publishers, 1986, first published 1893): 259

[13] Jacques Pouchepadass, *Champaran and Gandhi*: 63

The last component of agricultural cost was labor. It was also the largest component among the agricultural costs. There are two ways in which this expense can be considered. For the *raiyati* indigo, the price paid to cultivators was primarily for their labor since the planter provided all other inputs. Therefore, in cases when *raiyati* indigo was acquired from culivators, the price for the raw produce was in effect the labor cost. For calculating labor costs for the land held by the planters in lease, one must take into account the fact that the wage rates differed for different kinds of agricultural operations. Also, wage rates varied across seasons according to the extent of demand.

Indigo planting was a labor-intensive operation at every stage. The cultivation pattern for indigo in Bihar generally followed the cycle of season. Cultivators began preparing land as early as the beginning of December in an effort to retain moisture received from the rains in October-November. In the first round of preparation the ground was dug (*tamni*) with a hoe having blades as long as possible. The stubble from the previous crop was uprooted and removed. The land was then dressed to break clods and compact the soil below to minimize loss of moisture from below. After that the land was ploughed. The extremely laborious process of *ustanni* followed ploughing – when natives crouched on their knees to break all clods. The entire cycle from dressing to *ustanni* was then repeated. Usually work on the plantations came to a halt in the month of January unless an unexpected bout of rains hardened the top of the soil, requiring a repetition yet another time of the three operations described above.

In February, when the nights became milder, sowing took place. Planters waited for the winter rains. All the planting had to be competed within 3-4 days until after the rain. The roller followed immediately after the sowing and covered the sown furrows.

Young shoots appeared a few days later. The period of early growth of seedlings required very close monitoring because the seedlings were prone to attack by blights and hot winds. Moist Easterly winds (*poorvaiya*) and spring rains benefited early growth. Then it was time for first weeding, which was performed by laborers provided with grubbing hoes to uproot the weeds. A second weeding took place when the plant reached a height of about 30 to 40 centimeters. When the plant was about two feet high the soil was lightly ploughed to loosen and aerate the roots and to clear the weeds again.

At the beginning of June, when the small red indigo flowers blossomed and the lower leaves turned yellow, it was time to harvest the crop. Sometimes harvesting could be delayed until July or even August. The cutting was done before daybreak to keep the harvest from the scorching sun. Laborers cut the branches with sickles and gathered them in heaps on the field. Entire branches with leaves were cut and carted to the manufacturing centers although only leaves contained color. This was simply a measure towards saving labor and time. The branches were loaded on the carts and rushed to the factories by early morning. Indigo had a self-extinguishing trait to it; soon after being cut the leaves began losing their color, and therefore every effort was made to minimize the time lag between harvest and the beginning of the manufacturing cycle.

On average the annual course of indigo cultivation thus demanded labor for 1 round of *tamni*, 3 ploughings, 2 *ustanni*, 2 weedings, 1 sowing, 1 cutting, cartage, and 1 round of manuring. The rates for *tamni*, ploughing, sowing, and cutting were 2 *annas* a day, while *ustanni*, weeding, and sprinkling of manure were less expensive at 1 *anna* a day. Based on those rates the total expense toward payment of wages per *bigha* may be worked out. Pouchepadass has computed different costs to claim that agricultural expenditure, as against manufacturing and other expenditures comprised on an average 40-45% of the total cost on the indigo plantations.[14]

As we shall see below, the percentage of wage costs in the total cost of production – including those for cultivation and manufacturing – was even higher.

The Production Of The Blue Dye And Manufacturing Costs

The actual production of the blue dye from the plant took place at “factories” - the manufacturing unit located throughout the plantation lands. [15] Raw indigo was carried to these outworks from the adjoining plantations and peasant lands.

The manufacturing process too was labor intensive. As the indigo consignment reached the factories, workers - called *bojhaniya* - loaded them into vats. Water from a tank (*khajana*) was poured into the vats either with pumps or with water wheels that were worked by cattle. Meticulous attention was paid to have indigo vertically placed in tightly bound sheaves that were kept submerged by beams secured on projections on the vats' sides called *majusi, tan, sirpaha, ballal,* or *kainch*. Managers, usually Westerners, but sometimes also trained natives, closely supervised the loading operation.

This was the first stage in indigo manufacturing when the indigo leaves were made to undergo fermentation. Some planters had the leaves plucked from the branches to be submerged in water in the fermentation vat while others put the leaves into vats along with the branches. The plant was steeped in water for a duration varying between

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[14] Jacques Pouchepadass, *Champaran and Gandhi*: 54, 63

[15] Details of the manufacturing process have been taken from a pamphlet on indigo manufacturing privately published by a planter in 1892. J Bridges Lee, *Indigo Manufacture.* (Lahore: January 1892)

10-14 hours depending on air and water temperature. Steam boilers were used to warm water in larger factories. At those factories s*ith* or indigo refuge was used as a fuel.

The next stage in the manufacturing process involved the process of oxidation of liquor obtained from the previous stage. The greenish-yellow solution was drained off to the beating vat. Here another set of workers – called coolies in local dialect– vigorously "beat" the extract for about three to four hours to facilitate its exposure to air. The coolies used their feet to kick, shake, and stir the liquid. Many factories also used a beating wheel operated by steam. The beating rake was variously called *phahuri, pharuha*, or *pharma*.

After oxidation a pulpy indigo precipitate settled down. The extra water from the top was drained off, and the indigo pumped out or manually shifted to the boilers. The boilers were made of copper, or iron; they were embedded in a brick structure provided with a chimney. The boiling of liquor lasted for about two hours and a third set of coolies continuously stirred the slush during the process of boiling. In the end indigo became insoluble and separated from whatever water was still left.

The boiling indigo was poured onto a straining vat called a *mej*. This was a brickwork basin with a roughcast coating. It could also be constructed of massive wood. It was usually 10-12 meters long, 3-4 meters wide, and about 50 centimeters deep. A coarse canvas cloth supported by a bamboo grid, called *channa* and *chaddar*, spanned it at the top. The liquid that dripped from indigo through the cloth was repeatedly recycled to extract the last bit of indigo from the liquid. The cloth was then folded over the indigo, which had become pulpy by now. Indigo was left to drain for the night with a weight put on top of it.

The following day the blue pulpy mass was brought to the press. It was first poured into wooden boxes lined with cloth and perforated with holes. The press, *piris* or *pirich* in common language, a powerful apparatus with an iron screw, compressed the lids of the box. The remaining water from the indigo was thus squeezed out. Pressing was a delicate and time consuming process. It proceeded gradually so as not to damage the blocks of indigo. The pressed indigo was then cut with a wire into bars and then into "cakes" by a specialized cutter. Each cake was stamped with the plantation's brand mark. Filterers, pressers, and finally cutters carried out these operations in turn.

Once the cakes had been stamped they were transported to the drying house - a brick building about 200 square meters or more. The walls of this building were pierced with numerous openings to permit air circulation, but were provided with curtains to keep out draught and direct sunlight. The interior of the drying house was furnished to the ceiling with rows of deep bamboo shelves. Each day's production was carefully labeled on the shelves to avoid mixing cakes. In November or December, during the dry season, the thoroughly dehydrated cakes were carefully cleaned to remove the thick layer of mould that would have appeared on them. The cakes sometimes went to a sweating room, a small airtight building in which desiccation was completed. The product was then ready for packing.

There were fixed costs that were incurred in setting up the factories. The central part of the factory was a fairly large building that accommodated several vats. Its size varied according to the number of vats. A separate drying house was also an essential part of the built structure. All of these required an initial investment but a meager maintenance cost. Among the regular equipments in use at the factories were water pumps, vats, beating wheels, steam engines, boilers, and presses. These also required a one-time investment. But the vats could require replacing after they wore out. Boilers and steam engines could give mechanical problems during operation. Sometimes they could be fixed and at other times they required replacing.

But the largest component of manufacturing cost was comprised of wages paid to the laborers. A large number of names were in common use to describe workers handling different operations – coolies for loading the fermentation vats, those at beating vats, boilers, steam engines, and fitters and pressers, cake cutters etc. According to Pouchepadass's calculations the manufacturing costs comprised 20 % of the total cost of production, of which the major component was comprised of wages paid to the coolies.

The Indigo Enterprise And Financial Costs

The indigo operations in Bihar were carried out with funds made available by the commercial houses based in Calcutta. The principal banks advancing loans to the indigo planters were the Agra and Masterman's Bank and the Agra Bank. [16] They provided both fixed capital for buying or renting land, buildings, and machinery, and short-term loans for the purchase of seeds and fertilizers, advance to peasants, wages to laborers etc. Initially the planters took loans to buy land and cultivating rights. These were paid back over a period of ten to fifteen years. In addition the planters borrowed capital for their annual operations. Short-term loans were raised at the beginning of the cultivating and manufacturing cycle as an advance, and paid back after the product was ready for sale at

[16] India Office Records, Report of the Magistrate of Muzaffarpur, June 1877, included in the Annual Report of the Commissioner of Patna Division, 1876-77, cited in Benoy Chowdhury, *Growth of Commercial Agriculture*: 121 and fn., 171

the end of the season. Usually planters paid an interest of 10-12 per cent per annum on the loans.

The sale of indigo transpired through brokers. The planters brought their produce to the marts in Calcutta to brokers' premises. J Thomas and Company and W. Moran and Company were the principal brokers of indigo. They charged between 2 and 2.5 per cent brokerage fee.

Some indigo was sold to buyers locally. The rest of it had to be forwarded to other markets. It was usually the managing agents in Calcutta that took charge of the shipment and final distribution of the produce in the overseas markets. From Calcutta indigo still had to travel a long distance to the markets in the West and elsewhere. For the indigo headed for Britain, the produce had to be safely shipped, enter English ports, reach another set of brokers, and finally the retailers. Among the managing agents the prominent ones were Begg Dunlop and Company, Schoene, Kilburn and Company, Gisbourne and Company, Moran and Company, and Gillanders Arbuthnot and Company.[17]

All the financial charges including interests, brokerage, and handling charges together came to about 30% of the total cost of natural dye. [18] Planters paid interest on both annual advances as well as the initial capital borrowed at the time of setting up of the plantations. They also incurred miscellaneous charges such as those for accounting. They paid commissions of numerous kinds too.

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[17] Magistrate's report, cited in Benoy Chowdhury, *Growth of Commercial Agriculture in Bengal*: 121 and fn., 171

[18] Jacques Pouchepadass, *Champaran*: 32-33, 64

Pouchepadass's calculations are vital for understanding the alternatives that the indigo planters had as far as reducing the price of their product was concerned. The planters' costs were distributed over agricultural, manufacturing, and financial operations. The relative share of those costs was 50% agricultural, 20% manufacturing, and 30% financial (including distribution costs). Also, wages to cultivators and laborers formed between 50 and 75 % of the total cost of the dye. These economic data are pertinent to make sense of the steps undertaken by the planters.

From a purely economic point of view the reduction of agricultural costs and wage costs appeared as the likely direction for the planters to move. As the single largest part of the total expense they offered the most obvious choice for implementing savings. The value of land (and therefore land rents) had been buoyant over the second half of the nineteenth century. But planters did not have any control over the forces that led to a rise in land prices. Could the planters reduce wages? The rest of this chapter will present a historical study of the evolution of planter-government relations as well as planter-peasant relations to illustrate why the wages could not be reduced, and therefore, why the planters did not consider that option.

Indigo Manufacturing And The Early Colonial Conditions

Bengal became the epicenter of indigo manufacturing in the third quarter of the eighteenth century concurrent with the consolidation of the East India Company's (EIC) rule in that province. At this time the heart of indigo industry was Lower Bengal, one of the four administrative divisions of Bengal. Most plantations were concentrated in the three districts of Nadia, Jessore, and Barasat. Around the same time indigo manufacturing also began in the four districts of Bihar, another administrative division within Bengal. The most prominent districts in Bihar were Muzaffarpur, Darbhanga, Saran, and Champaran.[19] Acreage and output in Lower Bengal far outweighed those in Bihar at this time.

The colonial administration actively encouraged entrepreneurs from home to set up indigo plantations in Bengal. The company almost exclusively provided capital for starting the operations of European planters. Immigrating planters did not come to India with their own capital. Most of them were fortune-seekers from the British Isles, generally young, and hoping to become rich in the fastest manner possible on the indigo plantations. They had come on being invited by their relatives who were either company officials or private traders based in the nearby port-city of Calcutta.

Support for indigo by the EIC partly emerged from the established policy that called for commercial exploitation of agricultural products in the colony. Similar efforts were made to introduce the long-stapled cotton and tea in India. But the exceptional interest in indigo was for good reason. The export of indigo from India provided the company and those company officials trading in a private capacity a convenient way to remit their profit and salary to England. Promoted by them, indigo soon rose to prominence as the major article of export as well as the primary medium of remittance trade.

The EIC continued to protect the indigo industry – indirectly when not directly. As of 1802 the company decided to curtail its scale of financing of the indigo industry as

[19] For an account of planters' early efforts to start plantations in Bihar see Minden Wilson, *History of the Behar Indigo Factories*. (Calcutta: Bengal Secretariat Press, 1908): passim; Prabhat Kumar Shukla, *Indigo and the Raj: Peasant Protests in Bihar, 1780-1917.* (Delhi: Pragati Publication, 1993): 42-65

the business had struck its own roots. Its role in the financing of indigo plantations was taken over by a new type of mercantile institution that had arisen in Calcutta, called the Agency Houses. Agency houses were engaged in a variety of activities that included banking, manufacturing, and shipping of agricultural and bulk-handled products. They also engaged in trade among the Asian countries. In addition they handled trusts, wills, estates of their clients, and in several ways facilitated the transfer of wealth to Britain. [20] As the century wore on, and as indigo exports from India kept rising, the agency houses retained their dominant role in the organization of indigo production. Because the destiny of the indigo industry was so closely tied up with the agency houses, the EIC on numerous occasions went out of its way to advance loans to these mercantile houses in their times of financial trouble.

However, the EIC moved cautiously as far as regulating planters' relationship with native peasants was concerned. In the earlier period legal restrictions forbade land ownership by the planters. The company government was extremely nervous that large scale buying up of native lands by planters might result in clash with the established proprietors, and thus had imposed restrictions through Regulation 38 of 1793 and the Charter Act of 1813.

Planters obtained almost all of their indigo from native cultivators. They entered into contract with individual peasants for cultivation of indigo under the "*raiyati*" system. Cultivators were provided with a yearly advance to grow indigo on part of their plots –

[20] A number of accounts exist that describe the functioning of Calcutta's agency houses: S B Singh, *European Agency Houses in Bengal, 1783-1833*. (Calcutta: Firma K L Mukhopadhyay, 1966); Amales Tripathi, *Trade and Finance in the Bengal Presidency, 1793-1833.* (Calcutta: Oxford University Press, 2nd edition, 1976); Stanley D Chapman, "The agency houses: British mercantile enterprise in the far east, c. 1780-1920," *Textile History* 19: 2 (1988): 239-254; Stephanie Jones, *Merchants of the Raj. British Managing Agency Houses in Calcutta: Yesterday and Today.* (Basingstoke: Macmillan, 1992)

usually one-fourth of the total land. Once the crop was ready the entire produce was carted away to factories by the farmer or by the planter depending on the specific terms of the contract. The planters paid farmers for their produce at a rate fixed beforehand.

The seemingly innocuous *ryoti* system of indigo cultivation was built around several forms of compulsion. Hard economic data is difficult to obtain for the earliest period regarding net profit or loss to the farmers on indigo. A few surviving accounts addressing that question do suggest that cultivation of indigo often brought a “dead loss” to cultivators. For the poor peasants of Bengal, who were perpetually short of liquid cash, the monetary advance offered by the planters was often an inducement to get into indigo cultivation. The advance was not adequate to meet the entire cost of cultivation and harvesting, and would usually be exhausted by the time the planting of indigo was completed. Thereafter, the peasants supplied all other means of cultivation on their own and bore the risks of cultivation. The price paid by the planters in the end never sufficed so that the indigo growers could pay off the principal. Also, indigo was an extremely precarious crop and when it failed, as it often did, peasants were indebted to the planters. After that it was extremely difficult for the peasants to get out of their contractual obligation to cultivate indigo. Even when a cultivator failed to return the advance at the end of the cultivating season, the planter gave him more money for fresh planting in the next season. Most commonly the debts on peasants kept accumulating until in the end they had to be written off as bad debts. The planter did not begrudge this. Over the years he obtained indigo worth several times the value of the monetary advance. Rather the indebtedness of the peasants was an appropriate tool through which planters forced the peasants to sow indigo in their fields. The contract to grow indigo passed down the generation keeping peasant families obligated to grow indigo.

For the planters *raiyati* remained the preferred system for organizing the cultivation of indigo. There was a huge unpaid labor component to this type of cultivation that the planters found advantageous. Low prices paid for indigo did not cover all labor costs incurred by the peasants in planting, cultivating, and carting. The peasants were able to bear this burden only because they utilized the repertoire of "free" family labor for indigo. The cultivation of food crops on three-quarters of their land enabled them to feed their families. [21] Planters also employed a variety of unlawful means to maintain their dominance in the *raiyati* system vis-à-vis the peasantry. And, colonial administrators lacked the political will and power to intervene at the local level to mitigate those ills.

Planters' larger concern was to protect the sanctity of contracts that they signed with peasants for cultivating indigo. They argued vehemently for the enactment of more comprehensive laws arguing that peasants often refused to respect all the terms of their contract. Official responses to such requests fluctuated over time. In the first half of the nineteenth century sometimes the government allied with the capitalists and at other times with the peasants.

In 1811 a case was made for legislating in this regard. Due to prodding by the planters the Magistrate of Jessore argued to his superiors that the peasants often accepted advances from more than one planter. Lack of honesty among lower classes and the boldness of peasants due to the weaker legal status of the planters in the Indian

[21] Benoy Chowdhury, *Growth of Commercial Agriculture in Bengal*: 129-130

countryside were cited to be at the root of such acts of misdemeanor. [22] The government headed by Lord Mayo at that time, however, was reticent. It refused to accept the argument that the peasants, who appeared to be quintessentially weak, often broke their contract with the planters. The extreme case of indebtedness of some of them might have pushed them into a situation where they found it impossible to cultivate indigo. Therefore Mayo's government ruled that acts of breaking the indigo contract could be adequately monitored under the existing laws dealing with the non-payment of ordinary debts. The cases of highhandedness by the planters in dealing with peasants on the indigo tracts were well known and any additional powers would only make matters worse, the government argued.

The contest over contract laws, their interpretation in courts, and their implementation continued. The colonial government became more sympathetic to the planters' perspective subsequently. Regulation 6 of 1823 cleared the way for bringing suits against the peasants and their "instigators" for hindering the fulfillment of contracts. In 1830 an even stronger regulation was passed, which was paramount to being a summary law for the enforcement of indigo contracts. The government of the day argued that the boom of 1823 had started a spate of reckless speculation in the industry often causing competing interest groups to indulge in unfair practices. Benoy Chowdhury has rightly pointed out that statutes introduced by the government were partial. While they aimed to stop "faithlessness" of the peasants, they did not address the unfair and often illegal ways through which many of the indigo contracts were signed between the

[22] India Office Records, Government of Bengal, Judicial Criminal Proceedings, (Criminal), Nos. 9-10, May 18, 1811, cited in Benoy Chowdhury, *Growth of Commercial Agriculture in Bengal*: 148 and fn., 259

planters and the peasants in the first place. Even the Court of Directors in London denounced the act as "class legislation." The directors argued that the peasants were not "free agents" when they entered into contracts, constrained as they were due to "poverty, abjectness of spirit, intimidation, or bribery." They also criticized the Regulation because in their opinion it singled out only the peasants as offenders; it left out the planters from scrutiny that were widely known to use unfair means to sign contracts. The Regulation was repealed in 1835. [23]

The court of judicial magistrates across various districts was another stage where the actual import of the regulations and best ways of implementing them was debated. The outcome of specific litigations on indigo contracts brought to courts by the planters and peasants depended on the outlook of the particular presiding officer. Planters *en bloc* resented and petitioned against any verdict that seemed to them to be going against their interpretation of the contract laws. Overall, Chowdhury argues, planters achieved "significant triumphs" in their attempt to secure the interests of indigo plantation, often at the expense of peasants' interests. The Charter Act of 1833 also gave planters the right to purchase lands, which proved to be a key legislation as far as the future of indigo plantations in Bengal was concerned.

"Indigo Riots" In Lower Bengal

The indigo industry underwent major transitions at mid century, and a number of economic, administrative, and political developments at the time were at the root of those

[23] India Office Records, Letter from Court (Judicial), April 10, 1832, cited in Benoy Chowdhury, *Growth of Commercial Agriculture in Bengal*: 149-162 and fn., 278

changes. Indigo lost its primary importance as a remittance commodity to the colonial administrators. From 1826-1856, indigo was only surpassed by opium as an item of export from India. But recently, yet another item of export had surged ahead of indigo – food grains, and Bengal supplied half of the total export of food grains from India. In the decade prior to 1859, indigo formed only ten per cent of the export from Bengal. The relative decline of indigo as an export item, argues Blair B Kling, a historian of indigo revolts in Bengal, somewhat curtailed the bargaining position of the industry overall. [24]

At mid nineteenth century the indigo-growing districts of Lower Bengal witnessed increasing agitation by the peasants. John Peter Grant, (1854-61) Bengal's second Lieutenant Governor, took concrete measures to address peasants' grievances most of which were related to the alleged excesses of the planters. The Secretary of State for India, Sir Charles Wood, supported Grant in his efforts. These officials clearly articulated the target of their attack – the illegitimate use of coercion by the planters in making natives grow indigo and the payment of non-remunerative prices to them.

It is not difficult to see why the planters had to use various forms of compulsion. J Cockburn, the Deputy Magistrate of Jessore, discussed the issue of net profit or loss to the peasants accruing from indigo. Under most favorable conditions, when the peasant received the advance in full and the weather was benign, a peasant could grow 20 bundles of indigo on one *bigha* of land. At the price of 5 bundles for a rupee his 20 bundles would sell for Rs. 4. The cost of cultivation for the same, according to Cockburn, came to rupees

[24] Blair B Kling, *The Blue Mutiny: The Indigo Disturbances in Bengal, 1859-62.* (Philadelphia: University of Pennsylvania Press, 1966): 25, 219

3 and 3 *annas* that gave a meager profit of 13 *annas* to the peasant. [25] Besides, indigo cultivation was disadvantageous for the peasants because the cultivating cycle for indigo interfered with that of an important staple - rice. While calculating the stakes for peasants one must also take into account the profit that the peasant would have made if he grew some other more remunerative crop in place of indigo. Factoring in this aspect Lieutenant Governor Grant calculated that on average a peasant lost rupees 7 for every *bigha* of indigo that he cultivated. [26] Basing his criticism on these facts, John Grant galvanized the judicial and police administration in Bengal towards dispensing justice.

Kling has argued that the attack on the indigo system by Grant and Wood was inspired by "the tenets of mid-Victorian Liberalism, as upheld by John Peter Grant in Bengal and Charles Wood in London." [27] The recent administrative reorganization of Bengal under the "Lieutenant-Governor system" had certainly brought planter-peasant relationships under closer scrutiny of the administrators. Many Christian missionaries based in Calcutta had also voiced their concern over the treatment meted out to peasants. But the steps of Grant and Wood were also ideologically inspired. Grant believed that the indigo system inhibited free enterprise because it did not allow the peasant to sell his produce in an unregimented market. Grant said that he would not let Indian peasants be treated like "Carolina slaves." He also upheld another principle of liberalism – that of judicial supremacy, and thus directed his officials to take a neutral position in dealing

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[25] India Office Records, Papers Relating to Indigo Cultivation in Bengal, Vol. 1, Section 10; India Office Records are available at the British Library, London (henceforth, "IOR").

[26] C E Buckland, *Bengal Under the Lieutenant-Governors*.(Calcutta, 2nd edition, 1902): 249

[27] Blair B Kling, *The Blue Mutiny: The Indigo Disturbances in Bengal*: 220

with instances of disagreements between the planters on the one hand and peasants on the other hand. All along in the past the planters had utilized their closeness with colonial administrators to have executive fiats issued, which in effect forced peasants to cultivate indigo. With Grant at the helm of affairs now, the peasants noticed a change of heart within the government. A groundswell of opposition followed on the indigo tracts. Not only did peasants turn to courts seeking justice, but they also took the extreme step of refusing to take advances for the next cropping season. All this happened in the autumn of 1859.

Describing the politics in Calcutta in 1860 Kling noted that, "the exploitation of the indigo cultivators had already become the central political issue in the capital of India." Indigo interests comprising of brokers, managing agents, and merchants in Calcutta, in addition to the planters, demanded a special law to enforce indigo contracts. They received the support of the larger mercantile community in Calcutta that had been growing in respectability and influence as the vanguard of private enterprise in India. Provincial administrators headed by John Peter Grant stood their ground. Two additional nodes exerting influence on this highly partisan politics were the offices of the Governor-General, Lord Canning, who sympathized with the planters, and Secretary of State Charles Wood, who was overall sympathetic to the cause of peasants.

Act XI was passed in the legislature in1860 to deal with the situation. To the planters it provided a summary law for the enforcement of contracts and planting of the crop for the current season. But, at the same time, John Grant went out of his way to make peasants comprehend that they were free not to sign fresh contracts for planting indigo. More importantly, the act provided for the appointment of a Commission of

Inquiry (the Indigo Commission) that would look into all aspects of the working of the indigo system and suggest measures to mitigate its ills.

Despite the success obtained in cropping during that season planters lost ground in the long run. The large-scale conviction of peasants under the 1860 act reduced hopes of reconciling the peasants to indigo. If anything, it incited further violence. An unfavorable report of the Indigo Commission, reaching London in November 1860, minimized any chance of political support from the metropolis. The commission was fairly balanced in its composition. It comprised two officials, a representative of the planters, another of the class of Indian *zamindars* (landlords), and a Calcutta missionary, who was considered sympathetic to the interests of peasants. Although considered to be mild in its tone by its critiques, the report still identified the paying of low wages to the peasants by planters as the key anomaly of the indigo industry. Although skirting the issue of forced contracts it nonetheless pointed out that the peasants had little chance of getting out of an indigo contract once they had signed it. It also asked for the discontinuation of the summary law for enforcing the contracts. [28]

Although peace returned to Lower Bengal in 1863, a lack of trust between the planters and the peasants continued. James Hills of Nadia district represented an ever-decreasing minority in being able to continue. He succeeded in persuading the peasants to re-grow indigo by raising the remuneration two-fold. Most planters, however, folded up their business.

From the planters' side there was a lack of willingness to offer a better price for indigo. Most planters found offering higher prices for indigo an unattractive proposition. A higher procurement price for indigo was in effect a higher wage for the peasants for the

[28] Blair B Kling, *The Blue Mutiny: The Indigo Disturbances in Bengal*, chapters 6 & 7, passim

labor expended on growing indigo. The only way to recover the extra wage would have been to improve yield and productivity from cultivation and manufacturing. But it was not possible for the planters to take initiatives in this regard largely because under *ryoti* indigo was grown privately on peasants' plots. And any major changes in the pattern of land management also did not seem possible in the volatile political situation. From the peasants' side, on the other hand, there was a deep-rooted ill will against the indigo system. Such was their antagonism for indigo by now that many of them refused to grow indigo whatever the terms offered to them.

Planters squarely blamed the government for the demise of the indigo industry in Lower Bengal. James Tissendie, a manager with an indigo company was so disillusioned with government's attitude on matters related to indigo that he wanted to resign his job. Tissendie said, "I very much regret that I accepted the management of this concern. When I accepted it, I was under the impression that Government would have supported us in all that is lawful, but it is now quite evident that they have no such intentions." [29] Robert T Larmour, the manager of Bengal Indigo Company, the largest indigo concern of that time, also blamed the government. "Whatever estrangement has taken place between the people and myself has been the act of Government alone, generated and fostered by Government with the premeditated intention of driving me out of the District." [30]

It is not difficult to see the reasons behind the disenchantment of Tissendie and Larmour. There had been a significant turnaround in the attitude of the political establishment recently that had destabilized the world of indigo planters. So far the government had followed a policy – by design or by default – of non-interference on

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[29] IOR, Government of Bengal, Judicial Proceedings, April 1861: 296-300

[30] IOR, Government of Bengal, Judicial Proceedings, February 1862: 364-65

matters of labor relations on the indigo plantations. But now, by insisting that the procurement prices for indigo be fair and that the peasants be recompensed for their labor in cultivating indigo, the government had initiated a new policy of social control of labor market. The government's posture on the question of peasants' remunerations also revealed a new political program wherein the state took it up to itself to guarantee the basic rights of the rural classes.

The impetus for this change in policy could have come from several sources. Some historians have argued that the government's program of rural welfare was inspired by the ideology of broader responsibility towards natives. [31] Other historians have analyzed these measures as acts of political astuteness on the part of the government. After the 1857 Mutiny the government had become more sensitive to the plight of the teeming peasantry. Fearful that the peasants could be mobilized for future acts of treason the government began looking into their grievances. Indeed it has been argued by historians that in the second half of the nineteenth century the colonial government and the Indian urban intelligentsia competed for the leadership of rural masses. [32]

Indigo Plantations In Bihar At Transition

Although Bihar remained unscathed by the disturbances of 1860-63, the turn of events in Lower Bengal significantly changed the nature and organization of indigo cultivation and manufacturing in that division. Very soon Bihar became the primary exporter of indigo to the West. The major increase of indigo acreage in Bihar took place

[31] For a synthesis of recent arguments in this regard see, Thomas R Metcalf, *Ideologies of the Raj, New Cambridge History of India, Part 3, Vol. 4.* (Cambridge: Cambridge University Press, 1994)

[32] Blair B Kling, *The Blue Mutiny: The Indigo Disturbances in Bengal*, chapters 6 & 7, passim

in the four northern districts. As a matter of fact, the districts of Muzaffarpur, Darbhanga, Champaran, and Saran showed an increase in acreage by 286 percent between 1830 and 1875. The most drastic increase took place after 1860. [33]

Since the same managing agents based in Calcutta funded and sponsored the indigo plantations of both regions, the experience gained in Lower Bengal was utilized to make amends in Bihar. The first major impact came in an increase in the level of wages for the plantation workers (coolies) and procurement prices for indigo. A second important change came in the field of land management.

The planters in Bihar and the business houses in Calcutta had come to accept the

Table 2.2
Index number for coolie wages

Year	Index number
1855	52
1860	78
1875-85	100
1893	117
1900	117
1911	117

Source: Jacques Pouchepadass, *Planter, Peasants, and Gandhian Politics*

[33] Jacques Pouchepadass, *Champaran and Gandhi: Planters, Peasants, and Gandhian Politics*. Delhi: Oxford University Press, 1999, pp., 20-23

position that indigo manufacturing could only be continued through payment of more reasonable wages and remunerations to workers and peasants. A very prominent managing agency of Calcutta, Gisbourne and Company, wrote to their managers in Bihar

Table 2.3
Index number for procurement prices

Year	Index number
1850	48
1868	87
1877	100
1897	116
1910	130

Source: Jacques Pouchepadass, *Planter, Peasants, and Gandhian Politics*

that: “A fair day’s wage for a fair day’s labor is the only way of establishing satisfactory relations between employers and employed, and we wish you to act on this principle.” [34] So believing the planters generally raised the wages for the peasants. The wage and price

[34] Letter from Gisbourne and Company, dated July 12, 1861, enclosed in Governor General, Lord Canning’s letter to Secretary of State Charles Wood, dated July 22, 1861, cited in Blair B Kling, *The Blue Mutiny: The Indigo Disturbances in Bengal*: 193, fn., 56

increases across plantations has been documented by Jacques Pouchepadass (See Tables 1 and 2 above). [35]

But wage increases were not brought about in isolation. The planters adopted measures to make savings elsewhere in order to make up for the increased cost expended on labor. These additional measures ensured that the final price for indigo before and after the wage increase remained the same. [36] Planters took initiatives to increase their control over land. A common refrain among many planters in the past had been that the peasants were lackadaisical, and that they did not put their best lands and best efforts to obtain higher and better yield. The planters were confident that an improved supervision of the tillage, cultivation, and harvesting of indigo would bring better results.

Planters' initiatives with regard to land and labor management in Bihar were nonetheless of a "negotiated" nature. As before, the last thing the administrators wanted was a restless native; they remained watchful of the steps taken on the plantations. But a new element of the planter-peasant relationship in the third quarter of the 19th century was also the stronger position of the colonial administrators to monitor them. In that sense peasant power – even if it was of a mediated nature – had become a more crucial determinant of developments on the plantations.

Much of the indigo in Bihar was grown under the *asamiwar* system of contract. Under this system the peasants were obliged to grow indigo on six *katthas* out of every

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[35] It is interesting to note that the rate of increase was more favorable with regard to procurement price of which the primary beneficiaries were the land-owning cultivators/peasants. The coolies or landless workers, relatively powerless, had to remain contented with a less drastic increase in remunerations.

[36] Jacques Pouchepadass, *Champaran and Gandhi: Planters, Peasants, and Gandhian Politics*: Table E, unpaginated

bigha of land that they cultivated. Following peasant agitations in Bihar in 1867-68, the government intervened to reduce peasants' obligation for cultivation of indigo to three *katthas* of land. The new system so inaugurated was called the Tinkathiya (three-*katthas*) system. At the same time, however, the government also mandated that the peasants practice crop rotation. Peasants always preferred to give their best lands to food crop production year after year, while the planters tried to persuade them to rotate the land on which indigo was grown. The government was clearly trying to be even-handed. They intervened on behalf of the peasants in reducing their tillage obligation and in favor of planters by making peasants adopt crop rotation.

The most significant initiative by the planters beginning 1860s came in starting the *neez* system of indigo cultivation on privately owned lands. The planters followed an aggressive policy of buying up personal lands of smaller peasants and landlords, variously called *khas, nij, sir,* and *khas khamar* lands. These were the lands that the proprietors had reserved for their subsistence and that of their family. The ownership rights to these personal lands were authenticated not by any written documents, but by the custom of the village. [37] Often the means employed by the planters to acquire peasants' land violated local customs and conventions. They invited criticism from the government in 1876-77 in this regard. But the process of transfer of land ownership continued. Planters used loopholes in the existing system and also took advantage of the poverty of the farmers to buy up land.

Planters had clear motives behind starting *neez* cultivation. Clear titles in land helped in the task of closer supervision of indigo production. But, more importantly,

[37] For a description of the nature of land rights in mid-nineteenth century Bengal, see Dharma Kumar, *The Cambridge Economic History of India, Vol. 2*. (Cambridge: Cambridge University Press, 1989)

buying up of lands also enabled the planters to assume stronger legal rights vis-à-vis the laboring classes. Landless laborers and tenants-at-will (those tenants that could be evicted at discretion) did not quite possess as much protection under the law as landed proprietors. Benoy Chowdhury has argued that, " If the planter could oust the peasants from land, and the peasants, as a consequence, sank into a position of landless labourers, a class unprotected by the existing regulations, the situation would be ideal for the planters." [38]

The government for its part took steps in an effort to regulate the working of the indigo plantations. After the disturbances of 1868 it made a sincere effort to promote the *khuski* system of contract cultivation under which the terms were relatively favorable for peasants. In this system peasants grew indigo on their own lands without planters' supervision and sold it to them at market rate. Jacques Pouchepadass has called *khuski* a "free contract system" to draw a contrast with the other prevailing contract system, *asamiwar/tinkathiya*. The colonial government looked at this contract system with favor and thought that its popularization would reduce the conflict-ridden relationship between the planters and the peasants. In 1871 the officials introduced *khuski* in the Saran district on a large scale. Hathwa estate, which was under the control of Court of Wards, became the site for this trial.[39] However, despite the government's active promotion *khuski* did not become prevalent in Bihar.

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[38] Benoy Chowdhury, *Growth of Commercial Agriculture in Bengal*: 138

[39] Bihar State Archives, Government of Bengal, Revenue, Agricultural Branch, November 1872, Nos., 246-248; February 1873, Nos., 130-131; These files are available at the Bihar State Archives in Patna (India). Henceforth, referred to as "Agriculture."

Simultaneously the government took steps to improve its monitoring of the wages on plantations. Planters in Bengal were not unified within any organization. There was no centralized body through which the government could have initiated industry wide reforms. It was primarily on account of these concerns that the administrators persuaded the planters to form a unified body representing all planters - the Bengal Planters' Association (BPA) in 1877. Subsequently administrators also persuaded BPA to initiate the norm of fixing a minimum payable wage and price for indigo on a yearly basis. Once their association had announced the minimum rates at the beginning of the season all planter-members were expected to respect it. This brought a certain amount of regularity in the nature of wages.

Epilogue

Not all efforts initiated by the government were of a constraining nature as far as the natural indigo industry was concerned. As the events after 1897 showed, the state also undertook positive steps to save the natural indigo industry. Those efforts were made in the context of current state policies towards agriculture in general and agricultural innovations in the colony in particular.

As the planters braced themselves to meet the competition of synthetics they sought the support of the government. There was certain expectancy with regard to state aid. Planters' anticipation of support from the government was based on existing precedents in British India, other British colonies and dominions, and even Dutch and French colonies. The planters invoked those precedents to demand support.

A consideration of those policies and precedents is important in order to situate governmental support for the indigo industry in the two decades after 1897. After all the indigo industry was not “only” a private, profit-making enterprise of Europeans based overseas. It was also an important colonial industry that provided a livelihood for thousands of natives. While the government showed an inclination to monitor wages paid to natives, as shown before, they also did not want the industry to disappear altogether. A thorough understanding of the situation demands a consideration of the inner contradictions of fiscal and imperial imperatives that shaped the apparently contradictory state policies towards the natural indigo industry.

A self-perception of the government’s expanded role with regard to Indian agriculture had emerged by the 1860s and 1870s. The transfer of power from the EIC to the British crown in 1858 and the supervision of the Secretary of State for India by the British Parliament changed the context of decision-making with regard to India. Both Russell Dionne and Deepak Kumar have argued that a series of famines that caused political embarrassment, as well as proving expensive in terms of loss of revenue and welfare payments, set the stage for the evolution of a more comprehensive agricultural policy.[39] A severe famine raged in parts of Bengal and Orissa in 1866. The Famine Commission set up to get an overview of the disaster suggested that the government “take cognizance of all matters affecting the practical improvement and development of the agricultural resources of the country.” [40]

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[39] Deepak Kumar, *Science and the Raj*: 41-42, 96-98; Dionne, Russell Jude, “Government directed agricultural innovation in India, the British Experience.” Unpublished PhD dissertation, Department of History, Duke University, 1973: 21

[40] F G Sly, “The Department of Agriculture in India,” *Agricultural Journal of India* (1906) 1: 1

Indian Governor-General Mayo responded positively to the proposal for setting up agricultural departments. His correspondence with the Secretary of State, the Duke of Argyll, at this time also indicated that the government's outlook towards Indian agriculture had changed. He said, the "Government of India has never held that agricultural improvement is a matter to be left entirely to private enterprise and private interests." Until now the government had merely acted as the pioneer of private enterprise as in the case of commercial crops like tea, cotton, and opium. It had done so by supporting small-scale scientific experiments, farm trials, and even establishing plantations to open the way for private investments to flow in. But in an apparent expansion of the role played by the government until then, Mayo now implied that British government was responsible for improvement of agriculture in India because it was not only the supreme political authority but also the chief landlord in the country.

The momentum culminated in the founding of a new department at the center – Department of Revenue, Agriculture and Commerce, a development that Russell Dionne considers to be landmark. The department was wound up shortly after in 1871, citing financial constraints that the government was facing. Dionne has argued that "although the department folded, those who ruled India had reached a point where they accepted the fact that government was the appropriate agent for agricultural development." [41]

Peter Robb has pointed towards differing perspectives among the colonial officialdom in the 1880s and 1890s relating to agricultural innovations. One important administrator, T W Holderness, argued that a point would be "speedily reached beyond which increased returns from an acre are not to be expected" and thus non-agricultural income must be the salvation of the country. But the dominant trend was represented in

[41] Russell Jude Dionne, "Government directed agricultural innovation in India": 25

the opinion of colonial India's pioneering Revenue Secretary Sir E C Buck. Buck was optimistic about improving agricultural productivity in India, and continued in his official role to promote agricultural development. [42]

The official machinery continued to explore the ways and means for introducing change into native agriculture. Most significant steps were taken in the direction of institutionalization. Another round of famines precipitated the next step towards further expansion of agricultural administration. The Famine Commission of 1880 emphasized the need for agricultural departments in the country and the government once again obliged. A Department of Land Records and Agriculture came into being in 1881 and gradually provincial agricultural departments also emerged across the country. An agricultural chemist from the Royal College of Agriculture in Cirencester, John Augustus Voelcker, was invited to India to suggest measures for improving Indian agriculture. Following his proposal the post of an Agricultural Chemist was created and Walter Leather was hired for a term appointment of five years in 1892. The policies with regard to agricultural innovation were constantly reassessed in government circles. From 1892, for instance, a decision was made to cut down the number of experimental farms under the control of the government as not much was seen to be resulting from those efforts.

A policy of agricultural advance through patronage of laboratories also began to gain ground in colonial India during the last decade of the nineteenth century. There were two assumptions at the core of this policy: first, that conduct of systematic experiments will lead to increase in agricultural productivity and second that government must assume

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[42] Peter Robb, "State, Peasant and Money-Lender in Late Nineteenth Century Bihar: Some Colonial Inputs," in Peter Robb (ed.), *Rural India: Land, Power and Society under British Rule*. (London and Dublin: Curzon Press, 1983): 113

responsibility for patronizing experiments in laboratories and research institutions. At two agricultural conferences officials gathered to discuss what would be the best approach to improve Indian agriculture. There was considerable agreement that the benefits of scientific research must be brought to Indian agriculture. Two possible tracks were discussed – either to set up a limited number of higher centers of learning in the country to generate appropriate knowledge for Indian agriculture or to start at the bottom by making agricultural sciences part and parcel of primary education. The view of E C Buck prevailed: he preferred the latter option. A policy resolution of 1894 stated that the central government would make agricultural science part and parcel of primary education throughout the country. [43]Another resolution followed in 1897 that spoke of the government's plan to top the edifice of vocational education with institutes dedicated to agricultural research of a generic type that would focus on improving all Indian crops. [44] The new policy also favored the setting up of specialized laboratories in different parts of the country. Chemical examiners attached to provincial governments headed some of these. Calcutta University and the office of the Reporter on Economic Products also got their own laboratories.[45]

The government was also no longer averse to the idea of setting up specialized laboratories to protect the interests of agricultural industry if the need arose. The decision

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[43] 'Education Resolution," dated, September 7, 1894, IOR, Home (Education), October 1895, No. 6

[44] Deepak Kumar, "Science in Agriculture: A Study in Victorian India," *Asian Agri-History* (1997) 1: 2: 87-92

[45] The policy of setting up laboratories also became visible in the field of health and medicine. A specialized bacteriological laboratory was set up under the government's auspices at Agra and another dedicated to plague research at Bombay. Cf., Deepak Kumar, Science and the Raj: 104, 167-68

to serve specific industries was made on a case-to-case basis. The first major support from the government was for silk. The indigenous silk industry was in a depressed state and was also being threatened by the spread of pebrine disease. The central government set up a laboratory at Berhampur in 1887 that was exclusively dedicated to conducting experiments on silk. Scientists employed by the government studied all matters related to the propagation of mulberry trees and improving silk worms in addition to investigating the harmful disease. [46] Officials later turned over the control of the sericulture laboratory to business houses.

[46] BSA, Government of Bengal, Revenue (Agriculture), March 1890, File 2-I/3, Nos. 12-24

CHAPTER 3

EARLY RESPONSES OF THE PLANTERS AND THE GOVERNMENT

This chapter focuses on the early efforts made by the indigo planters and the imperial/colonial government to meet the challenge of synthetic indigo that had immediately started eating into the natural's market. These efforts comprised explorations to gauge the precise nature of the challenge. These were also early attempts to devise an adequate response. There was no time to be lost. The adverse impact of the competition from synthetics was already being reflected in the drop in the import of natural indigo into Britain. Board of Trade figures from Britain confirm the declining trend (See Table 3.1 below). The import of synthetic into Britain was rising at the same time.

Table 3.1
Import of Natural Indigo into Britain, 1896-1903

Year	**Volume in cwt**	**Value in Pound Sterling**
1896	89,938	1,533,722
1897	82,526	1,470,574
1898	53,838	890,803
1899	58,977	986,090
1900	33,518	542,089
1901	51,359	788,820
1902	30,471	498,043
1903	18,012	262,775

Source: Board of Trade Returns [1]

[1] The figures have been taken from the issues of *Journal of the Society of Dyers and Colourists* between 1898 and 1904, Vols. 14 – 20

Early Response In London: Gathering Information

The ability of the planters to operate in the British market was constrained by many factors. First of all, the selling line for natural indigo was not integrated. Once indigo left the planters, the planters had little control over its sale. By comparison the synthetic companies (BASF and MLB in Germany) employed a network of salesmen to persuade buyers. Their sales personnel offered special prices to the buyers as part of innovative marketing strategies to attract clients. Sometimes they made the supply of other drugs required by the dyeing companies conditional on the purchase of synthetic indigo. They also offered much reduced prices if the dyers and printers signed contracts to purchase synthetic in the coming seasons.

There were other factors that put natural indigo manufacturers and sellers at a disadvantage. Planters in Bengal did not know the exact price at which consumers bought synthetic indigo, and thus were unable to manipulate their own prices to secure competitive advantages. The German companies and their agents did not readily disclose the production cost and price for synthetic indigo. They did so with a purpose. To give one instance, Zilz and Stott, agents for BASF in London, declined to give the price of synthetic indigo or the total quantity they sold in Britain to Imperial Institute officials, maintaining that it was not in their trade interest to do so. [2] As part of a company strategy, BASF fixed the price for BASF Rein below that of natural indigo. Heinrich Caro, ex-

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[2] Letter from Zilz and Stott, dated, May 17, 1900, addressed to W R Dunstan, Director, Scientific and Technical Department, Imperial Institute. Public Record Office, London, AY4/2047, 100168; These files are available at the Public Record Office at Kew, London; henceforth called "PRO."

manager of BASF, said that, “the price of artificial indigo [at BASF] is regulated by the market price of natural indigo to such a degree as to allow a fair competition.” [3]

It is therefore only logical that one of the first things the indigo planters did was to gather information related to the new product. They concentrated their efforts in England as early as 1898. In September of that year the planters took the initiative to subscribe to a limited company in London, the Indigo Defence Association. Planters realized the need to intervene more directly in the market and to gain access to commercial information. One of the stated objectives of this company was “ to obtain and turn to account information relating to … manufacture, trade, and commerce.” The company would also initiate investigations, scientific and otherwise, buy patents relating to improvements, and complete agreements with the government to benefit the natural indigo trade. The company’s subscription expanded subsequently. In 1900, the company changed its name to The Behar Indigo Planters’ Association. [4]

In early 1900 Begg, Dunlop and Company, one of the largest managing agents of indigo in Calcutta, wrote to the Commercial Intelligence Department of the Board of Trade in London, asking that the facts relating to the comparative merits of natural and artificial indigo be examined and clarified. They were intrigued by rumors about the respective qualities of the two indigos. Claims and counter-claims about natural and synthetic indigo were rampant in the early years. The commercial department in turn forwarded the query to the Scientific and Technical Department of the Imperial Institute

[3] Letter from Heinrich Caro, dated, May 16, 1900, addressed to W R Dunstan, Director, Scientific and Technical Department, Imperial Institute. Public Record Office, AY4/2047, 100168

[4] Incorporation papers of Indigo Defence Association Limited, PRO, BT31/8154/58924/100052

and asked for their professional opinion on the issue. [5] It was customary for the Imperial Institute to undertake investigations of this nature. It had been founded in 1887 to function as the "central school for the arts, manufactures, and commerce of the whole Empire." Especially since the appointment of chemist Wyndham R Dunstan as the director of the Scientific and Technical Department of the Institute, it had been rhetorically called the "Kew of Chemistry." (Kew was the widely acknowledged imperial center for conducting botanical research on flora of all kinds in the British Empire.) Investigating the question of the relative merits of natural and synthetic indigo seemed especially within the remit of the Imperial Institute. [6]

Wyndham R Dunstan gave due attention to all aspects of the question. Dunstan was a qualified chemist and a "leading authority on chemistry of natural products." [7] He promptly dispatched letters of enquiry to several people. He sent a letter to the suppliers of synthetic indigo to British markets, Zilz and Stott, asking how much synthetic indigo they supplied currently and at what price. The agents refused to disclose any information, as pointed out earlier. But Dunstan had other avenues to elicit information. He sent another communication to Heinrich Caro in Germany, ex-manager of the BASF, and asked him to clarify whether synthetic indigo and natural indigo were chemically identical. He also asked if the synthetic dyed as effectively as natural, how synthetic was exactly manufactured, and what was the estimated total output of BASF Rein. Dunstan

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[5] Letter from Board of Trade to the Imperial Institute, dated, March 21, 1900, PRO, AY4/2047/100168

[6] For a comprehensive review of the institutional evolution of the Imperial Institute, see Michael Worboys, "Science and Imperialism in the Development of the Colonial Empire, 1895-1940," chapter 4, unpublished D Phil., University of Sussex, 1979

[7] Michael Worboys, "Science and Imperialism in the Development of the Colonial Empire, 1895-1940," chapter 4, p., 180, fn., 16

belonged to the network of British and German chemists that regularly communicated regardless of the existing trade rivalry between the two countries. Anthony Travis has very recently pointed to the personal channels of communication existing at that time between English and German chemists. [8] Caro confirmed that natural and synthetic indigo were absolutely identical despite the argument of the producers of natural dye that theirs was the “real” indigo. He also disagreed that the presence of additional elements in natural indigo imparted any advantage to dyeing with natural. On the contrary Caro stated that the artificial product imparted a brighter color to clothing. He also claimed that BASF manufactured synthetic indigo from naphthalene and by using the chemical pathway suggested by Carl Heumann. Having retired from the BASF for some time, he had not seen the operational process first hand, and therefore did not have any further precise details about production to share. He argued that the “more economic production” of synthetic indigo had enabled BASF to sell the product at a cheaper price. Lastly, Caro said that though he did not have data on the total output of synthetic at BASF, he knew that the production was on the rise at the firm and also that it was “rumored” that both Hoechst and Basle would shortly take up the production of synthetic indigo. That would, if anything, further flood the market with additional amounts of artificial indigo. [9]

Dunstan also wrote to two other chemists in this regard. The first was Christopher Rawson, who had recently presented a paper on the issue of the relative capabilities of natural versus synthetic indigo at the Society of Arts in London. Rawson was also very

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[8] Anthony Travis, “Heinrich Caro and Ivan Levinstein: Uniting the Colours of Ludwigshafen and Lancashire,” in Ernst Homburg, Anthony S. Travis, and Harm G. Schröter (eds.), *The Chemical Industry in Europe, 1850-1914 : Industrial Growth, Pollution, and Professionalization*. (Boston: Kluwer Academic, 1998)

[9] Letter from Heinrich Caro to W R Dunstan, dated, May 16, 1900, PRO, AY4/2047/100168

knowledgeable about the dyeing techniques employed in the Yorkshire region. For a long time he had been in contact with the community of dyers in Britain and also served in official positions at the Society of Dyers and Colourists at Bradford. Rawson replied that the experiments he had conducted proved that both natural and synthetic indigo were entirely identical chemically. He additionally claimed that in Britain the use of synthetic was so far limited to cotton printing and to those sectors of woolen dyeing where lighter shades were needed. Printing operations did require a higher level of purity due to technical reasons. Foreign solid substances often present in natural indigo were commonly known to harm printing machines. [10]

The third scientist Dunstan wrote to was Hugo Muller. Muller replied that it was perhaps too early to answer the question whether synthetic would replace natural indigo due to the lack of credible trade information on the issue. He said, "To obtain a reliable and unbiased opinion with regard to the behaviour of artificial indigo when used in place of the natural indigo, seems still a very difficult matter." He suggested getting in touch with Prof Hummel, a well-known chemist that studied dyes and dyeing. [11]

On the basis of all the information that he had collected and analyzed Wyndham R Dunstan came to certain conclusions. In his report submitted in May 1900 Dunstan refuted all claims about the superiority of natural indigo over artificial indigo. Dunstan argued that the basic chemical composition of the dye extracted from coal tar or vegetable leaves was fundamentally the same. His report thus called the artificial dye "in every respect identical with the natural blue coloring matter of indigo." Dunstan advised

[10] Letter from Christopher Rawson to W R Dunstan, dated, March 27, 1900, PRO, AY4/2047/100168

[11] Letter from Hugo Muller to W R Dunstan, dated, April 5, 1900, PRO, AY4/2047/100168

the imperiled natural indigo industry in Bengal to focus their efforts on finding a cheaper way of producing the dye and selling it in a form liked by consumers. While he pointed out that BASF would further lower the cost of artificial dye in the future and flood the markets with additional quantities of artificial dye, all this did not mean that the natural indigo industry was necessarily doomed. Dunstan argued that natural indigo could survive synthetic indigo's competitive threat in the market. He called for investigations "on scientific lines" to improve the methods of growth and collection of the indigo plant, the process of extraction of coloring matter from the plant, and the preparation of the final product for sale.[12]

Begg, Dunlop and Company got back to Dunstan, thanking him for the information he had provided. The London branch of the company wrote a letter to Dunstan saying how "indebted" they were for his expert opinion. They could not have over-stated the case. Dunstan's report sealed the debate on some of the questions that had served as stumbling blocks in the emergence of clear agendas within the natural indigo industry. [13]

Dunstan's report also won the approval of officials at the apex of the colonial government in London – the office of the Secretary of State. George Hamilton concurred with Dunstan in saying that, "If the Indian indigo industry is to compete successfully with the Badische (BASF) dye, the process of manufacture and of production must be improved and cheapened after full scientific investigation." The Secretary of State not only forwarded the report to the government in India, but also recommended that in view

[12] For Dunstan's report see Bihar State Archives(BSA), Patna (India), Agriculture, October 1900, File 2-I/3 3-32, Nos. 11-12

[13] Letter from Begg, Dunlop and Company in London to W R Dunstan, dated June 25, 1900, PRO, AY4/2047/100168

of Dunstan's conclusions it would be worthwhile for the local government in India to give "assistance and guidance" to indigo-related research. [14]

Indeed the India Office in London, headed by the Secretary of State for India, closely monitored developments related to natural indigo. [15] From the very beginning this office counseled governments in India and Bengal over steps they should take to safeguard the future of a colonial product. India House used its location at the epicenter of an expansive empire, its access to parliamentary debates, and physical proximity to Western markets to elicit pertinent information on the indigo trade. They readily passed on such commercial information to the planters and officials in India.

For instance, a letter from the office of George Hamilton clarified the situation on the competition between natural and synthetic indigo in France. [16] The letter included a report submitted by Her Majesty's Consul at Marseille that spoke quite pessimistically of the future of natural indigo in France. About ten years ago, according to the report, France imported 1,400 to 1,500 chests of indigo, but in 1899 only 600 chests were imported. Of those 600 chests, 130 originated in Java, 50 in Bengal, and 420 in the Coromandel (Madras coast of South India). Auctions of Bengal indigo had practically ceased at Marseille. A few small buyers imported Bengal indigo directly from Calcutta.

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[14] For Secretary of State's letter, dated 21st June, 1900, see BSA, Agriculture, October 1900, File 2-I/3 3-32, Nos. 11-12

[15] Secretary of State's establishment or the India Office was established after the British crown took over the political authority of the Indian colony in the mid 19th century. Since then the Secretary of State assisted by the Council of India was the principal advisor to the Crown on Indian affairs. For a comprehensive description of the working of the India Office, see Arnold P Kaminsky, *The India Office, 1880-1910.* (Westport: Greenwood Press, 1986)

[16] Enclosure, "Report by Consul Gurney on the competition of Artificial Indigo with Indian Natural Indigo on the French market," Letter from India Office to Governor General of India in Council, dated July 19, 1900, PRO, AY4/2047/100168

While the report pointed out that natural indigo would not die altogether, much of the natural variety that would continue to be used in France would be the cheaper Coromandel variety.

The report argued that the primary reason for the decline of natural indigo in France was price competition. The buyers from Japan and the Levant continued to offer high prices for natural indigo of the Bengal variety, but "European [continental] buyers" were no longer willing to pay a higher price for natural when cheaper synthetic was available. Bengal indigo, which as a rule sold at a higher price than Coromandel indigo, no longer caught the fancy of the European buyers. The report gave details of prices to illustrate the nature of competition. Present prices of synthetic left a huge profit margin for its manufacturers. Costing 10 francs per kg. (3s. 7 1/2d./lb.) to produce, synthetic was being sold at the price of 17.50 francs per kg. (6s. 4 _ d./lb.). Improvements in production and the competition between two firms manufacturing synthetic in France - BASF and Hoechst's collaborator in France, Societe Chimique des Usines du Rhone, - was likely to further bring down the price of synthetic to about 12 francs per kg. (4s. 41/4 d./lb). The report argued that the producers of natural indigo would never be able to offer that price, and therefore their future was gloomy.

The report also cited the opinion of dyers in France on the relative qualities of natural and synthetic indigo. Traditionally silk-dyeing was not done with indigo, and therefore dyers in Lyons did not particularly care for indigo. For producing clear and pure tints in cotton and wool, as in the "Indiennes," the dyers of Marseille preferred synthetic indigo. These dyers particularly appreciated the uniform composition of synthetic that offered "great advantage of facilitating its manipulation; of enabling equal shades of colouring; almost mathematically." On the other hand, natural indigo continued to be preferred for providing background color because the resinous materials and other impurities present in the natural covered the fiber and gave it a metallic sheen.

According to the report at least "one authority" argued that synthetic gave a color that was "more pleasing to the eye." Since the report was based on accounts of dyers and importers it is quite likely that the person cited would have been a dyer or an importer. It would, of course, be more interesting to know how the buyers of cloth in the French market evaluated the comparative richness of color offered by natural versus that offered by synthetic. Also, it would be interesting to note how much the final users valued the durability offered by the natural dye as against the synthetic dye. As a matter of fact, natural offered a much higher level of fastness than synthetic. Of more direct interest to the dyers would be its cheapness and manipulability. To the importers synthetic offered the advantage of consistency of price as against natural whose price varied "wildly" year after another year, and introduced unpredictability in business that they could not control. Representing the perspective of these sections, the report concluded, "Durability has less charm. And if the [synthetic] dye will last the cloth in cotton prints, and in most woolen fabrics except in cloths for uniforms exposed to sun and rain, what advantage can the manufacturer on the continent find in a dearer though better dye, if the cheaper [synthetic dye] is more attractive to the eye, and gives so much greater profit!"

The Planters Consider Manufacturing Sugar

As planters' sales continued to plummet they considered a variety of options to maintain the profitability of their plantations. Planter Rowland Hudson's note of January

1900, proposing a detailed scheme for combining the manufacture of cane sugar with indigo, represents an early response of indigo manufacturers to deal with the problem of competition with synthetic indigo. Hudson planned to use the existing storage facilities, steam engines, and boilers at his indigo factory for combining the manufacture of blue dye with cane sugar. Usually an indigo factory comprised the manufacturing unit surrounded by huge tracts of land for cultivating indigo. By alternately growing indigo and cane on different parts of the landed estate, Hudson's scheme aimed at keeping the manufacturing operations at the indigo factories running all year round. [17]

Hudson argued that the system of changing land between indigo and cane would work well, and be financially rewarding. Cane would be planted in the month of February and brought to factories for processing the next year between January and early April. Thereafter the land would be fertilized with indigo refuse obtained from the previous crop and allowed to lie fallow. Alternatively the land could be rented out to natives to raise an autumn crop. In either case the land would be free to be planted with a fresh crop of indigo in the coming season. Hudson's experience with indigo cultivation had convinced him that a piece of land gave the best output when cultivation of cane alternated with two subsequent seasons of indigo cultivation. While the roots of cane only penetrated to a depth of 8-12 inches, the taproots of indigo went down several feet. Because the two crops extracted nutrients from different depths in the soil, alternating them in the field made sense. After growing to a height of about three feet cane also overshadowed and suffocated weeds in its surroundings, thus preventing an avoidable depletion of soil.

[17] "Note Re Sugar Growing in Behar," by Rowland Hudson, dated, January 1900, BSA, Agriculture, July 1900, File 2-I/3 of 1900

Rowland Hudson's note also provided an estimate of the cost of manufacturing cane sugar and calculated the profits that would accrue. Sugar manufacturing had especially become an attractive proposition after the imposition of duties on the import of 'bounty-fed" sugar from European countries and from Mauritius by the Indian Tariff Act (Amendment) of 1899. Even without having to fertilize lands with artificial manures, on an average, one acre of existing indigo lands would yield 1.5 tons of *sukkur* (unrefined sugar) and 0.5 ton of molasses, which could be sold at the neighboring Sakri Sugar Refinery for £ 13 – 6-0 and £ 1-0-0. Thus the total revenue obtained from one acre of sugar plantation would be £ 14-6-8. The rent of land, cost of cultivation of cane on one acre, and the conversion of the cane juice into *sukkur* and molasses would total £3-0-0. Therefore, Hudson calculated that one acre of land under cane cultivation would give a net profit of £11-6-8. Hudson forcefully argued that his estimate regarding profits from cane sugar manufacturing, based on factoring of prevailing prices, would hold good for a long time to come. He based his optimism about prices on the fact that a huge demand for sugar and its byproducts existed in India. Reduced imports of sugar after the recent imposition of duties would further ensure that the prices stayed at a high level.

Another planter, Francis Murray of the Kurnool Indigo Concern, also expressed optimism about the prospects of sugar manufacturing in Bihar, claiming that it would definitely give a return of 25% on investments. He planned to procure machinery for starting the manufacture of cane sugar at his indigo factory. In early 1900, Murray corresponded with the McOnie, Harvey and Company, a large firm in Glasgow (Scotland) that sold machinery for manufacturing sugar. He visited Glasgow to inspect the machines available at the firm's works. He also began making arrangements for the possible visit of a sugar expert John Wilkie to Bihar who could help him set up his sugar business. A few other planters also contacted the Glasgow based company regarding the possible purchase of machinery to start the manufacture of sugar in Bihar. [18]

Rowland Hudson had already planted different varieties of cane on an experimental basis to ascertain which variety would grow best in Bihar's soil. He wrote to J Walter Leather, Agricultural Chemist to the Government of India, asking for his expert opinion on the feasibility of importing and growing the Barbados variety of cane from the West Indies.

Planters Seek The Assistance Of The State For Queries On Indigo And Sugar Manufacturing

Planters regularly interfaced with the government at the three administrative nodes headed by the Secretary of State in London, the Governor-General of India in Simla, and the Lieutenant Governor of Bengal in Calcutta. In times of need they contacted the executive heads directly bypassing the regular bureaucratic hierarchy. But more routinely they corresponded with the bureaucrats of the Revenue and Agricultural Department at the center and the Revenue Department of Bengal.

In 1899 the Bihar planters made a plea to the Lieutenant Governor J Woodburn to send a government emissary to Java. Planters told Woodburn that according to information available to them, indigo planters in Java had devised very economical ways of manufacturing indigo. Planters wanted to learn about the improvements and adopt

[18] Letter from L W Macdonald to Francis Murray, dated Feb. 14, 1900; letter from Francis Murray to Messrs James Finlay and Company, dated March 23, 1900; letter from Messrs James Finlay and Company to Francis Murray, dated March 26, 1900, BSA, Agriculture, Oct. 1900, File 2-I/3

them locally in order to compete with cheaper synthetic. Woodburn, while sympathetic to the planter's demand, said he could not think of a person with an intimate knowledge of the field. He encouraged the planters to select one of their own to visit Java plantations, a person who would have the ability to understand the nuances of indigo manufacturing. [19]

In March 1900, planter William Hudson wrote to the Revenue and Agricultural Department at the center, asking that the government loan him £80,000 towards buying additional machinery for manufacturing sugar on an experimental basis. When he did not receive a response to his application he wrote another letter in May, once again sending a copy to the Secretary of State for review. This time the Secretary of State sent a reminder to the Governor-General, enquiring if the Governor-General had reached a decision in this regard and requesting to be informed of the "purport of the decision." [20]

The communications between Hudson and the different arms of the government are insightful because they provide a window on the outlook of the state toward private industry controlled by European entrepreneurs on the one hand, and native peasants and labor on the other hand. Hudson firstly justified his claim by pointing to precedents of government support to private industry. He cited the case of the sugar industry in the dominions of Queensland that had received direct financial support from the imperial government. He also cited the recent remarks made by the Secretary of State at the Society of Arts where a public lecture had been organized on the subject of competition between natural and synthetic indigo. The Secretary of State had publicly assured "to do

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[19] BSA, Agriculture, October 1900, File 2-I/3 3-32, Nos., 7-8, "Notes and Orders," pp., 6-7

[20] William Hudson's letter to Under-Secretary of State for India, dated 21st May, 1900, BSA, Agriculture, October 1900, File 2-I/3 3-32, Nos. 9-10

everything they legitimately can to encourage the industries of the [indigo] community." Hudson argued that manufacture of sugar in Bihar presented a "very legitimate opening" for government's assistance. It was a sound business idea in itself. Under the circumstances it would also provide financial relief to the planters that felt the squeeze due to the falling prices of indigo.

Hudson also justified his demand on the grounds that sugar manufacturing on the indigo tracts would lead to "increased employment of labour." In this way he appealed to the sensibilities of the administrators in their role as creators of employment for agricultural labor. He also assured the authorities that the cultivation of sugarcane that he was proposing would take place on land on which the planters had only "cultivating possession," and not ownership rights. Buying of land by the planters since the 1860s had aggravated the problem of landlessness in the area. The government had been increasingly critical of the growing dispossession of peasants.

Initially the Secretary of State and the central government in India favored giving financial assistance to Hudson. But in the end the central government reconciled itself to the views of the provincial government. On matters affecting a local industry it is not surprising that the view of the local government prevailed. The Lieutenant Governor argued that the government could not make a financial loan to "any particular member of the planting community." But he recognized that "the indigo planters as a body had claims on the government," and therefore his administration was open to the idea of giving assistance with enquiries towards improving methods of cultivation and manufacturing of indigo, or substituting it with more profitable crops. [21] The Viceroy in

[21] "Resolution – By the Government of Bengal, Revenue Department," BSA, Agriculture, October 1900, File 2-I/3 3-32, No., 25

India wrote back to the Secretary of State more or less conveying the gist of what his provincial Lieutenant Governor had argued. He said, "loan to individual[s] for establishment of new industry is contrary to government policy." But he also added that the government in India was "anxious" that the prospect of sugar manufacturing in Bihar be explored. [22]

Dunstan's Report And The Sugar Committee: The Response Of Bihar's Governor

The Lieutenant Governor of Bengal was quite convinced that the sugar industry could be revived in Bihar. The planters in Bihar had engaged in sugar manufacturing until about 1850 before switching to indigo. Due to a number of reasons it appeared that sugar could again be made remunerative. There was evidence that considerable new demand had arisen for cheaper kinds of refined sugar among the inhabitants of the region. New machinery was now available that enabled manufacturing at a lower cost. Thirdly, communication had vastly improved with the introduction of the railways in the province. This removed a serious handicap of delays in transit and consequent higher freight charges. Noticing this new opportunity, many peasants in north Bihar had begun cultivating cane. Initial plantations had been on the banks of rivers and streams where the peasants used floodwater to irrigate cane and thus further minimized their costs of cultivation. Going by these indications the Lieutenant Governor reasoned that the indigo tracts in Bihar could be comfortably and profitably turned over to sugarcane production.

In May 1900, he sent a communication to the central government requesting permission to set up a sugar committee. The Lieutenant Governor's encouragement of

[22] Letter from Viceroy in India to Secretary of State in London, dated, July 20, 1900, BSA, Agriculture, October 1900, File 2-I/3 3-32, Nos., 9-10

sugarcane as a new venture appears logical in the context of the realities of agricultural production, the dynamics of labor market, and the nature of synthetic's competition. The cultivation of sugarcane demanded more labor than indigo, and saving employment for the natives was an immediate and primary concern of the provincial government. Revenue officer C. J. Stevenson-Moore, who conducted survey operations in an indigo-growing district of Bihar, commented on the benefits offered by indigo through employment generation for the natives. He noted that indigo was a labor-intensive crop, but also added that tobacco and sugarcane were even more labor intensive. Apart from its superiority in offering additional employment cane also offered the advantage of not exhausting the soil like indigo. [23]Also, there existed no immediate threat of future competition from a synthetic substitute. On the other hand, saving indigo and the future of labor dependent on it required "experiments with regard to the best seed to be used, the most appropriate varieties of the plant, the cultivation of the soil, and the manner of the extraction of the dye, *patiently continued for a term of years*." [24]

The Lieutenant Governor's efforts to set up a sugar committee were welcomed by planters. The private emissary that the planters had sent to Java had returned. He informed them that in Java the application of "science" had improved the prospects of indigo. But he also said that some indigo planters in Java had started growing cane and tobacco to make up for shrinking profits from indigo. Thus the planters enthusiastically supported the government's move to set up a Sugar Committee. In fact, they also offered

[23] C. J. Stevenson-Moore, Final Report on the Survey and Settlement Operations in the Muzaffarpur District, 1892-1899 (Calcutta, 1901): 340, 348-50

[24] "Resolution – By the Government of Bengal, Revenue Department," BSA, Agriculture, October 1900, File 2-I/3 3-32, No., 25, p., 10

to spare E A Hancock, an agricultural expert working for Begg, Dunlop and Company, indigo agents, to serve on the sugar committee. [25]

Even as the administrators in Bihar were in the process of setting up the Sugar Committee they received the communication from the Secretary of State recommending state assistance for scientific experiments on indigo. As described above, the political impetus for supporting scientific experiments initially came from India House in London. George Hamilton was quite persuaded by the scientific report of Wyndham R Dunstan of the Imperial Institute. Against governor Woodburn's provincial outlook, Hamilton, as a metropolitan bureaucrat, also brought a broader imperial perspective to the indigo question. The Secretary of State strongly endorsed Dunstan's counsel that given the importance of indigo to the "Indian Empire" the local government in India must assist efforts to improve the scientific basis of the cultivation and manufacture of indigo. The Governor-General in India concurred and asked the provincial government to take initiatives in this regard. He also suggested that the brief of the sugar committee being constituted be broadened so that they might additionally investigate the problems of the indigo industry. [26]

The reply of the governor clarified the provincial government's policy regarding sponsorship of a market study on sugar and providing a subsidy to planter's experiments. The Lieutenant Governor doubted if any benefits would accrue from expanding the remit of the Sugar Committee. The proposed committee was conducting a feasibility study for

[25] Letter of G H Sutherland of Begg, Dunlop and Company to F A Slacke, Revenue Secretary, Govt. of Bengal, dated, August 22, 1900, BSA, Agriculture, October 1900, File 2-I/3 3-32, Notes and Orders, p., 12

[26] Letter from Under-Secretary, Revenue and Agriculture Department, Government of India to Secretary, Revenue Department, Government of Bengal (with enclosures), dated, July 20, 1900, BSA, Agriculture, October 1900, File 2-I/3 3-32, Nos., 11-12

sugar that required investigation of a particular nature. Besides, he did not want the members of the committee to lose focus and compromise the quality of their investigation of an issue he thought held promise for Bihar. Referring to the conduct of experiments on indigo by the planters he indicated, "the Bihar Indigo Planters' Association is already doing all that is at present possible." Planters had sent an application to his government requesting financial assistance for the conduct of their specialized experiments in August last. In his opinion the best course of action for the government would be to support the planters' experiments through a state subsidy. [27]

On balance, Bihar's governor was more readily inclined to investigate a larger agricultural question befitting his performance of a "public duty." The government looked at itself as the overseer of the commonwealth. As the officials saw the crisis in the indigo industry they responded to the situation by first thinking of available options to recreate employment that could be lost. But that does not mean that they had practically written off the natural indigo industry. They waited for the planters to take the initiative to protect their business. And when the planters turned to them for support, they gave their proposal due attention.

The report of the Sugar Committee, submitted in February 1901, concurred that transferring indigo lands to sugar production would be a sound business idea. It made a detailed survey of land under indigo and sugarcane cultivation in the four indigo growing districts of Bihar, and assessed the results of an increase in sugar production on market. Planters who the committee had consulted claimed that given the imperatives of land

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[27] Letter from Secretary, Revenue Department, Bengal to Secretary, Revenue and Agriculture Department, Govt. Of India, dated, September 4, 1900, BSA, Agriculture, October 1900, File 2-I/3 14, No., 19

ownership patterns and conditions of cultivation, they could readily grow sugar on one-fifth of their land in the short-term. If cultivated on 20% of the land in Bihar devoted to indigo, the committee calculated, an additional 60,000 tons of sugar would be produced.

This marked an increase of 42% in sugar production for the region. The Sugar Committee believed that this extra amount of sugar would not have the effect of over-supplying the market and of depressing prices to an unprofitable level. [28]

Table 3.2
Indigo and sugar acreage in the four districts of Bihar in 1901

DISTRICT	INDIGO ACRES	SUGAR ACRES
CHAMPARAN	86,000	13,000
SARAN	50,000	47,000
MUZAFFARPUR	90,000	8,800
DARBHANGA	90,000	73,200
	Total = 316,000	Total = 142,000

Source: Report of the Committee to Inquire into the Prospects of the Cultivation of Sugar by Indigo Planters in Bihar [29]

[28] BSA, Agriculture, May 1901, File, 2-I/3 8-12, pp., 1-2
[29] BSA, Agriculture, May 1901, File, 2-I/3 8-12, p.1

The members of the Sugar Committee thus identified the possible market for Bihar's refined sugar as being "large" and "an expanding one." For the last four years preceding 1900, India had on average imported more than 170,000 tons of refined sugar annually. An additional 18,000 tons of molasses had landed at the port of Calcutta from Mauritius, which sold in the market at the price of 3 rupees per *maund* (1 *maund* = 80 lbs.). If efficiently produced, Bihar's sugar (besides molasses) could be sold in Calcutta and other nearby port cities on the Bay of Bengal as well as throughout North India, thus capturing part of the market so far monopolized by the imported sugar. The "gray sugar" from Bihar, relatively impure, would find a market in north India because imported sugar sold there at a higher price than on the coast. When completely purified in the proposed central refineries, the indigenous white sugar would be able to compete with the imported white sugar. To facilitate tapping of markets in the north the committee also suggested that a distributing agency be established either at Somastipore or Mokameh to serve as gateway to the north Indian markets.

In the long term, the committee proposed that the planters initiate large-scale production and refining of cane sugar in Bihar on the pattern being followed in the English dominions of Queensland and New South Wales. Inviting the planters to come together to form a syndicate or a company, the committee outlined various elements of the Australian model for the planters to emulate. Local farmers would grow cane under arrangement with the company. The cultivators would be provided with working capital as well as supplied information on the kinds of cane varieties to be grown, nature of soil, and the suitability of the climatic conditions. The company set up by the planters would build cane-crushing mills in different districts to which the cane from nearby districts would be forwarded. The company would also set up one or two centralized refineries where the gray sugar supplied from various mills in the cane-cultivating districts of Bihar would be turned into white sugar.

Realizing, however, that creating the Australian system of sugar manufacturing in Bihar required investing huge amounts of capital and a high level of reorganization of the production system, and therefore that the switch must necessarily be "gradual and tentative," the committee also made recommendations for steps to be taken in the short term. It criticized unequivocally the present methods being used for making sugar by some of the planters on a small scale. The mill currently in use, the "beheea mill," gave a low daily output and also failed to extract all the juice from the cane. The present method of boiling cane juice in an open pan over a fire lit in a hole in the ground was also considered "primitive and inefficient in the highest degree." If a planter grew a hundred acres or more of cane and manufactured sugar using these methods, he would "certainly lose money." The planters' sugar would not be able to compete with sugar produced by the small cultivators who used similar methods, far less with the imported sugar. To these planters, the committee suggested that they assemble on their plantations an improved version of a cane-crushing machine, evaporating pans, and a centrifuge. Such a complex of equipment could be set up at an expenditure of Rs. 5,325, would have a working cost of Rs. 16 daily, and turn out 2 tons of gray sugar every day. At those costs, the planters would be able to make sufficient profit by selling the gray sugar in the local and north Indian markets. The machine on which this calculation was based was capable of servicing cane grown on 200 acres. Slightly larger machines for larger sugar estates could also be acquired for an additional investment.

The Sugar Committee also reiterated the government's stand that it would not provide financial assistance for setting up the sugar industry. The role of the provincial government in the matter was limited to setting up an expert committee to see if the sugar business would be a profitable venture. The committee rejected the case being made by some planters that the precedent of state aid to sugar manufacturers in Queensland be followed in Bihar. It pointed out that financial support in Queensland had been offered as a sop to invite industries to a hitherto unsettled area. Such a case, which formed part of the colonial policy of settling inhabitants in a barren area, could not serve as an example to be followed elsewhere. Making an example of the case of Queensland the committee actually argued to the contrary that the government's provision of financial assistance in Queensland had resulted in financial waste and loss of money. Thus defending the government's refusal of state aid to the planters, the committee implored the planters to independently raise capital for their sugar project.

In the first two decades of the twentieth century, the planters slowly began producing sugar on their estates. The rate of switch from indigo to sugar also depended on other conditions being favorable. The key problem was that of credit. Contrary to the claims of the sugar committee, trade journals suggest that the planters faced a scarcity of capital in setting up production centers for sugar. But, most importantly, at the turn of the twentieth century, a large majority of planters still believed that natural indigo's prospects were bright, and that it was too early to abandon the indigo business.

Epilogue

Even before the introduction of synthetic indigo, the planters in Bihar were not disinclined to the idea of laboratory experiments towards improving the yield of the natural product. Improving productivity through the application of science and technology appeared logical to them.

There were clear reasons behind the initiation of those efforts. Until the mid nineteenth century indigo manufacturing was largely based on mastering the craft of running the production cycle diligently. The best practices in the trade had emerged with experience. Most planters had learnt the art of manufacturing indigo as apprentices with the older planters in India. Whatever little innovation was introduced in manufacturing was based on the counsels of "old hands," rather than on "science."

But from the 1850s and 60s the chemistry of indigo was improving. Edward Schunck did pioneer work on the coloring element within indigo - *indican*, and disproved the earlier theory of Chevreul about "indigo-white." [30] New knowledge gradually spread to the indigo manufacturers in Bihar. The primary medium for the spread of key information in Bihar was Eugene Schrottky – a chemist and a successful planter. A former student of the renowned German chemist Justus von Liebig, Schrottky played a key role in disseminating information on oxidation and fermentation processes during the process of manufacturing. He used his knowledge of chemistry of indigo to offer professional assistance to his fellow planters.

[30] A G Perkin and A E Everest, *The Natural Organic Colouring Matters*. (London: Longmans Green and Company, 1918): 480

Schrottky wrote a pamphlet in 1879 called *The Science of Indigo Manufacture*.[31] During the 1870s and 1880s, Schrottky registered seven patents for introducing specific improvements in fermentation and oxidation processes (See Table 3.3 below) and licensed them to a number of planters. Many of the buyers of the patented processes were large, influential planters with the means to invest and the willingness to take risks with the new processes.

Table 3.3
Eugene Schrottky's patents registered in Calcutta

Date of registration	Short description of the patent
Sep 20, 1877	Use of yeast from fermenting vats and other precipitates in the manufacture of indigo
April 5, 1879	Use of yeast from previous fermentation, of borax, and other alkaloids in the manufacture of indigo
Aug 16, 1881	Use of oxidizing salts in the manufacture of indigo
June 13, 1882	Use of saltpeter, nitrates, and sulfates in the manufacture of indigo
May 7, 1884	Re-steeping of the indigo plant and the use of a perforated base for the fermenting vat in the manufacture of indigo
March 9,1886	Improvements in the re-steeping process and the yeast process in the manufacture of indigo
Aug 12, 1887	Use of carbolic acid and antiseptics in combination with saltpeter in the manufacture of indigo

Source: Board of Trade Papers, Public Record Office, Kew [32]

[31] It has not been possible to locate the original pamphlet. However, Schrottky makes reference to the conclusions of that pamphlet in a publication of a later date. Eugene Schrottky, "Indigo Cultivation and Manufacture," *Indian Planters' Gazette and Sporting News*, February 2, 1907, p., 143. The holdings of this newspaper are available at the National Agricultural Library at Beltsville MD), USA; henceforth called "*IPG*."

[32] "The First Schedule," incorporation papers of the Bengal Indigo Manufacturing Company, Public Record Office (Kew, GB), Board of Trade Papers, BT 31/4628/30398/100052

The same document gives a list of names of proprietors who bought those patents: the proprietors of Kurnoul Indigo Concern in Muzaffarpur (1883), J M Gibbon for Moorlah Indigo Concern in Champaran (1885), Henry Hill for Turcouleah Indigo Concern in Champaran (1886), and George Toomey for Kanti Indigo Concern in Muzaffarpur (1887). [33]

Through the 1870s, many resourceful factories also began to decant and warm water used during fermentation. Schrottky's 1879 pamphlet had referred to the fact that the blue dye was not present in the leaves at the time of harvest. Enzymes present in the sap of the plant initiated the process of fermentation. Subsequently bacterial action also speeded up fermentation of the *indican* present in the leaves. Slightly warm water provided an appropriate condition for steeping to take place. By the early 1890s, the warming of steeping liquor with steam was commonly practiced by the large factories in Bihar. [34]

The impetus for scientific investigations may also have emerged on account of forces that were characteristic of the rural context of Bihar. As we have seen before in the previous chapter, through the 1860s to 1890s wages for workers and procurement prices for indigo had been on the rise. Significantly, the same years also saw an increasing trend of indigo lands going into the private control of the indigo planters. In Muzaffarpur district out of 74,719 *bighas* under indigo 43,202 *bighas* were under *neez* cultivation by the year 1876-77. At the same time out of 54,000 *bighas* under indigo in Darbhanga

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[33] "The Second Schedule," incorporation papers of the Bengal Indigo Manufacturing Company, Public Record Office (Kew, GB), Board of Trade Papers, BT 31/4628/30398/100052

[34] Bihar State Archives, Report on the Administration of Bengal, 1892-93: 26

almost three-fourths were under planters' ownership. The major extension of indigo cultivation in Saran district had also taken under *neez.* The picture was similar for the district of Champaran. Planters had little control over the rising trend in wages and prices. Under the circumstances they used the loopholes in the legal system and their local power and influence to acquire land. Through a better control over land they hoped to achieve a better supervision over the cultivation process and possibly increase yield and quality of the crop.

However, even as the wages continued to rise the process of land acquisition was reaching its limits by the late 1870s. Benoy Chowdhury has pointed towards how limits could soon be set to the process of land acquisition by the planters. The densely populated villages did not have an endless supply of wastelands of which the planters could purchase lease from the landlords. A very aggressive buying up of peasant's lands could also become counter-productive. If peasants lost hereditary occupancy rights to all of their lands they simply moved elsewhere creating a shortage of hands to work those lands. It is precisely on these fronts that the move towards further consolidation of land was thwarted. [35]

Therefore, it is not merely coincidental that the efforts towards engaging scientists and adopting scientific methods first emerged in the 1870s and 1880s. Once it was clear to the planters that productivity gains were no longer possible through bringing additional land under private control they thought of other measures. Achieving higher productivity through the application of science and technology emerged as a clear option.

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[35] Benoy Chawdhury, *Growth of Commercial Agriculture*: 126-27, 136-37

Whatever the impetus, the planters subsequently built on the early efforts of the 1870s and 80s towards the application of scientific knowledge to manufacturing. Encouraged by the efforts of Schrottky, the planters showed an increasing trust in the ability of science to solve their problem. They took significant steps to organize scientific experiments of a chemical and agronomical nature by some of the best scientists in the world at that time. Those explorations and their outcome will form the core of the next two chapters.

CHAPTER 4

SCIENCE AT PLANTERS' LABORATORIES, 1898-1902

Introduction

The period from 1898 to 1902 witnessed a growing effort in India to employ laboratory-based science to reduce the price of natural indigo through yield improvement. Some preliminary experiments were also conducted to make the natural dye more consistent in composition. Synthetic indigo, when first launched on the Western markets in July1897, was available to consumers at a price that was 15 - 25% higher than natural indigo's. [1] But its market price kept dropping consistently as the production cost in the German factories was lowered and the distribution channels were speedily rationalized. [2] The German firms also campaigned in the market that the artificial product would offer advantages to commercial users on account of its higher consistency in comparison to the pre-existing natural colorant. [3] As synthetic continued to capture natural's erstwhile

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[1] Anthony Travis, *The Rainbow Makers: The Origins of the Synthetic Dyestuffs Industry in Western Europe* (London and Toronto: Associated University Presses, 1993): 223

[2] An aggressive salesmanship was also part of the synthetic firms' bid to oust the natural product. An overview of the process by which the German dye companies effectively used a network of salesmen to push their product in foreign markets is briefly discussed by John Joseph Beer, *The Emergence of the German Dye Industry* (Urbana: The University of Illinois Press, 1959): 95-96. Information about the selling strategies of dye companies can also be gleaned from a review of the company records of Calico Printers' Association of Manchester, the large printing conglomerate formed by the federation of 46 printing companies and 13 merchant firms in 1899 and a significant consumer of dyes in the British market. CPA records reveal that the German firms offered especial "contract" prices, made the supply of other colors conditional to the purchase of synthetic indigo, and lowered prices on commitment to purchase future supplies. These records are available at the Manchester Archives and Local Studies, Manchester: M464. Planters responded to the aggressive marketing strategies of their competitors. Their efforts, though dismal in comparison to the scale of market manipulation by the German firms, will form the subject matter of later chapters.

[3] Historians in other cases have documented similar efforts. There exists ample economic literature within the history of technology that dwells on efforts by the manufacturers and sellers

Western markets, its qualities that were understood to give it an edge with the consumers, defined the agenda of scientific investigations in India.

The planters in India, aided by the colonial state, set up laboratories and established agricultural experiment stations, which became the site for the endeavors to improve the natural product. Some of the best-known experts in the field, chemists and agronomists, were employed to conduct scientific research with well-defined targets. The primary goal at these centers was to find ways to improve the yield in the field and factory and thereby reduce the price of the final product: how to enhance output per acre of the indigo crop? How to increase the color bearing ability of the plant? How to enhance the efficiency of the manufacturing process so that maximum dye was extracted from the leaves? Apart from the attempts to enhance yield some efforts were also made to tinker with the constitution of the final product. Could natural indigo be made more uniform in composition? Those efforts, however, were limited in scope and soon given up because a limited understanding of the chemical constitution of the blue dye at that time hindered progress along those lines.

Expanding from an analysis of the strategies of scientific experimentation the chapter also addresses patronage of scientific research in colonial India. It studies the organization of laboratories and agricultural stations in India during the period in question, and principally focuses on the patrons of scientific research – the planters and the colonial government. What motivated the planters to set up and run laboratories

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of substitutes at framing their product's better usability and other advantages vis-à-vis the pre-existing product. One specific example closer to the case of substitution of natural by synthetic indigo is that of celluloid trying to displace rubber: Robert Friedel, *Pioneer Plastic: The Making and Selling of Celluloid* (Madison: University of Wisconsin Press, 1983) beginning 1898? What were the reasons behind the government's decision to provide subsidies to those experiments subsequently? To what extent did the experimenters meet their goals? How tight were the connections between continuing patronage of scientific research and the progress with experiments?

The Drive Towards Science, and Research Strategies

The drive towards laboratory-based science in colonial India was facilitated by several factors. The primary patrons of these efforts, the European planters, had the means and the motivation to exploit science. Working within their organizations, the Behar Indigo Planters' Association or BIPA and the Indigo Improvements Syndicate or IIS, they pooled their resources in order to hire experts from England. Those among them that visited England, attended public meetings at the Society of Arts in London, the Society of Dyers and Colourists at Bradford, the Society of Chemical Industry at Manchester and similar bodies. They were exposed to the debates in the professional organizations about the state of research on indigo. Thus they were sensitized to the claims of experts about the promise of science. On their return to India many of them canvassed support for setting up laboratories to benefit the plantations. Indeed, a majority of planters at the turn of the century put their trust in the ability of scientists to deliver results towards yield and quality enhancement of natural indigo.

The government was also sympathetic with the efforts to set up the indigo laboratories, and made funds available when the planters turned to them. As discussed in Chapter One, by the end of the nineteenth century, the administrators were relatively more willing to be agents of agricultural innovation in India. In some sectors of agriculture they had welcomed the setting up of laboratories. On the question of indigo, the official Dunstan's Report of May 1900 had further set the stage for a positive outlook within the bureaucracy to the idea of scientific research. [4]

Let us begin our analysis of scientific endeavors by briefly reviewing the basic features of the production of the blue dye in colonial India, and identifying the points at which interventions were made. As described in the Introduction, the indigo plant (biological name: *Indigofera tinctoria*) was grown predominantly in the loamy fields of Bihar. As soon as the crop was ripe, the leaves along with the branches were transported to the manufacturing center. The process of dye production was divided into three-stages (see Figure 1 below) that basically involved chemical changes to convert the glucoside *indican* of indigo leaves to *indigotin*, the coloring element. Traditionally, in the first stage, some soluble enzymes might be added to accelerate the process of fermentation.

Figure 1

The Manufacturing Cycle

Fermentation Leaves dipped in water Greenish-yellow solution	***Oxidation*** ***Beating of the solution*** Pulpy precipitate settles down, which is indigo	***Boiling*** Boiling of the precipitate or indigo
Steeping vat	Beating vat	Boiler

[4] For Dunstan's report see Bihar State Archives, Patna (India), Agriculture, October 1900, File 2-I/3 3-32, Nos. 11-12. These files are available at the Bihar State Archives in Patna (India).

The enzymes naturally present in leaves facilitated fermentation. In the second stage, the greenish-yellow solution obtained after fermentation would be drained off to the beating vat. Here the solution would be vigorously beaten for about three to four hours to facilitate oxidation. In the third stage, the precipitate – the blue dye - was boiled and stirred continuously for about two hours. After washing, the insoluble dye was dried and cut in the form of cakes.

The colonial officials and planters attacked the problem from different angles. Firstly, they considered a chemist's role central to the task of streamlining the fermentation and oxidation processes. In a letter to the Lieutenant Governor, dated Aug 13, 1900, F A Slacke, the Revenue Secretary, thought that much good could be done to the cause of protecting native natural indigo industry, "if the Government could find the money for the employment for three years of two really good chemists." The head of the Indigo Improvements Syndicate, G H Sutherland, also thought "the employment of good chemists for two or three years to make scientific researches with a view to improving the methods of manufacture [of indigo] must do good." [5]

The improvement of post-harvest extractive processes was not the only strategy followed in colonial Bihar. Other planters supported an agricultural program focused on the plant in the field. They hoped to improve the output of the indigo plant per acre through the use of the right blend of fertilizers and improved farming and harvesting techniques. They also hoped to enhance the color content of the leaves of the indigo plant by adding nutrients to the soil and varying conditions during the course of plant growth in the fields.

[5] For Slacke's and Sutherland's letters see BSA, Agriculture, Notes and Orders, File 2I/3, October 1900

The planters supported the two approaches equally energetically in the initial years. The chemical laboratory belonging to the BIPA at Mosheri that was later shifted to Peeprah, specialized in the "chemical approach." The other laboratory cum experiment station at Dalsingserai, belonging to the IIS, tried the "agricultural approach."

The Experiments At The BIPA Laboratory

Chemist Christopher Rawson Is Hired In London To Be Sent To India

English dye chemist Christopher Rawson had a long association with indigo, which pre-dated his arrival in India. As a member of the Society of Dyers and Colourists in Bradford and as a practicing chemist he had long experimented with natural indigo. In the very first volume of the *Journal of the Society of Dyers and Colourists* in 1884 he contributed an article describing various methods for testing the purity of natural indigo. He was involved as a professional chemist with the London and Manchester end of the indigo trade. Indigo imported from India was of variable constitution and its color potency also widely varied. Sellers and buyers of the dye in the British markets therefore routinely engaged chemists to fix the price of the dye. Rawson offered his expertise for testing color percentages. He later co-authored a book on dyeing practices, discussing the details of all aspects of manufacturing and dyeing with both natural and synthetic indigo.[6]

The representatives of the Indigo Defence Association, a front office of the indigo planters in London, first spotted Christopher Rawson. They were searching for an appropriate scientist to send to India to work in their indigo laboratory. Because of his

[6] Edmund Knecht, Christopher Rawson, and Richard Loewenthal. *A Manual of Dyeing : For the Use of Practical Dyers, Manufacturers, Students, and All Interested in the Art of Dyeing, Vol 11* (London: Charles Griffin and Company, 1893):798-811

credentials as an expert well versed in all aspects of indigo's chemistry, Rawson appeared well suited for the position. Besides, he was also in touch with the dyers and printers, the primary customers of indigo planters. He could thus bring his understanding of the requirements of the dyeing and printing trade to the task of improvement of the natural dye. IDA hired Christopher Rawson to work for the planters in India.

Before he left for India, Rawson publicly exhorted everyone associated with the natural indigo trade to focus efforts on increasing the percentage of *indigotin* in the natural dye and also giving it a fixed consistency. His experiments with natural and synthetic indigo had convinced him that the two products were chemically identical. Thus he rebuffed earlier claims by a section of planters that natural indigo was the "real" dye and that synthetic indigo was a "poor imitation." Those were anyway the rhetoric of a class of businessmen who, in the absence of clear information about synthetic indigo in the initial stage, instinctively ridiculed the substitute as not being the real thing.

Rawson also undertook a long tour of the establishments of dyers and printers in the Yorkshire region to get a first hand account of the way the commercial users were responding to the two products. Obviously, now the users were comparing the two products on the criteria of price, fastness, ease of application, and quality of color produced before making their purchase decision. What was acceptable before 1897 was no longer acceptable to them. The amalgamated natural blue contained in*digotin*, but also indigo red (i*ndirubin*), indigo-brown, indigo-glutten, and a small proportion of mineral elements. Rawson believed that additional constituents in the plant-derived indigo helped the dye in holding on to the fabric better, and thus made it more "fast" to washing and exposure to sun. He also took particular note of the universal fondness for a red tinge imparted by the natural dye that came from the presence of indigo-red and indigo-brown in it. On the basis of his conversations with the dyers as to what results they were obtaining in their use of the two dyes and from his own expert understanding, Rawson came to the conclusion that the best blue dye would be the one with ninety percent *indigotin* and ten percent indigo-red and indigo-brown. He did not think that synthetic indigo, known to be hundred percent pure, would offer the best value for money as far as dyeing and printing were concerned. [7]

Reaching India in the early summer of 1898, Rawson went on a reconnaissance mission to the various indigo plantations across Bihar, looking closely at the manufacturing practices followed by the planters. The specific factories visited by him were at Motihari, Chylaha, Hurraj, Mirapur, Purnahi, Belwa, Bisambharpur, Barra, Mohowa, Jugowlia, Rajpur, Siraha, and Tataria. He brought his expert's gaze to routine matters of manufacturing operations, things that may have escaped the attention of planters. Indigo manufacturing required extensive use of water for carrying out the processes of fermentation and oxidation as well as for boiling and washing. Factories were thus located close to a stream or a similar source, from where water was drawn and stored in a tank, called *khajana*, on the factory premises. Rawson looked closely at the properties of water being used. How pure was it? What minerals were dissolved in it? Was it hard? How did the quality of water differ from factory to factory and in the different districts? What was the temperature of water when used for steeping? Could any pattern be discerned between the nature of water being used, its temperature, and high or

[7] Rawson's letter to the Indigo Defence Association, London, dated 28 February1898, BSA, Agriculture, File 2I/3, March 1901

low yield? He also looked for patterns of yield in other contexts in order to form his initial conjectures. For instance, he noticed that most planters delayed the beginning of oxidation after the completion of the first stage of fermentation. The process of transferring the liquid to the oxidation tank and getting coolies ready to start beating and thrashing took too much time for his comfort. He conjectured that this delay decreased the efficiency of the process. Having completed his survey of the manufacturing methods, he was confident that he could contribute to streamlining the manufacturing processes and improving yield. He declared with a sense of optimism:

> The yield of colouring matter from a given weight of plant [as manufactured by the planters in India] can be considerably increased. [8]

Rawson At The Planters' Club Laboratory

Rawson finally arrived at Muzaffarpur in June 1898, ready to start his experiments. A temporary laboratory with small "experimental vats" had been hastily built on the premises of the Planters' Club so that the chemist could start his work and give suggestions in time for the current manufacturing season. Rawson immediately began conducting his experiments. The first three reports of Rawson to BIPA in 1898 reveal the direction of his experiments in those months.

In his first scientific report to the Secretary of the BIPA in July 1898, Rawson made two "preliminary" suggestions to the planters. Firstly, he recommended that the process of oxidation start immediately after the completion of the steeping stage. Any

[8] Mr. Rawson's report No 1, dated July 14, 1898, BSA, Agriculture, File 2I/3, March 1901

delay in starting oxidation of the liquor, he elaborated, led to setting in of unwanted and wasteful chemical reactions. Secondly, Rawson asked the planters to wash the indigo precipitate obtained after oxidation with water or dilute hydrochloric acid in the boiler. Dissolving the unwanted mineral elements/impurities in such a manner would firstly increase the percentage of *indigotin* in the dye. Besides, from his prior consultation with the dyers and printers he knew of the latter's reservations against the presence of solid substances in natural indigo that harmed printing machines and also gave imperfect pattern and color. Rawson therefore believed that removing such impurities with water and acid was a small inconvenience for obtaining a product that would be more suited to user tastes. [9]

Rawson's second report to the BIPA of August 1898 provides a window on why he wanted the planters to start the oxidation process as soon as possible after fermentation. The chemical pathway for the conversion of the glucoside in the leaf to indigo-blue was this: during steeping/fermentation, while the leaves were submerged in water, the enzymes and bacteria acted on the glucoside to convert it into *indoxyl*. The liquor containing the dissolved *indoxyl* was passed on to the next tank. During beating/oxidation air (oxygen) was passed through the liquor that changed *indoxyl* into indigo. From what Rawson said in the report, it is apparent that he was guided by the dominant perspective on the chemistry of indigo prevailing at that time – that of the English chemist, Edward Schunk. Schunk first isolated the glucoside present in indigo leaves, *indican* in 1879. He also argued that *indican* was a very unstable compound, and

[9] Rawson's letter to the Indigo Defence Association, dated 31 July 1899; Rawson's letter to the Behar Indigo Planters Association, dated 16 August 1900, BSA, Agriculture, File 2I/3, March 1901; "Mr. Rawson's report No 1," Agriculture, File 2I/3, March 1900

resulted in a variety of compounds as soon as it chemically reacted with other reagents. [10]Rawson stated in his report that the results of his investigation were "in accordance with the researches of the eminent Dr. Schunk made many years ago." He said:

> The colouring principle in the plant is highly susceptible to change; it is decomposed with the greatest facility in various ways. Under the most favourable conditions, indigo-blue is one of the chief products of that decomposition, but under other conditions instead of indigo-blue, brown substances are formed from which it is apparently impossible to regenerate useful colours. [11]

The problem at hand, hence, was to manipulate and control the fermentation process so that *indican* was usefully converted to indigo-blue and nothing else. *Indican* was acted upon by water and bacteria/enzymes. Rawson did not have an adequate understanding of how to control bacteria and their behavior. So he turned his attention to water. Was it the presence of specific minerals in water that was affecting the nature of the change to indigo-blue? Rawson collected thirty-eight samples of water from the planters in different regions and put them to systematic analysis. [12]

But Rawson did not get positive results from the analysis of water as far as the goal of understanding and controlling fermentation changes was concerned. In his third

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[10] Disproving Chevereul's theory of "indigo-white," Schunk had made key findings on the nature of the coloring element in indigo in the mid 19th century. In 1879, he finally isolated the glucoside present in indigo and named it indican. He also disclosed that the glucoside was very unstable in chemical reactions. The original papers by Chevereul, Schunk, and Roemer are cited in Arthur George Perkin and Arthur Ernest Everest, *The Natural Organic Colouring Matters* (London: Longmans, Green and Co, 1918): 480

[11] "Mr. Rawson's Report No. 2," dated August 19, 1898, BSA, Agriculture, File 2I/3, March 1900

[12] "Mr. Rawson's Report No. 2," dated August 19, 1898, BSA, Agriculture, File 2I/3, March 1900

report of September 1898 Rawson acknowledged his failure in following this line of query. In his experimental work he was able to analyze the mineral content of water in the various samples he had been supplied with. But he simply did not have a clue as to which minerals were acting on *indican* and in which way. He said: "An analysis of water is of little or no use unless there exist some means of interpreting the results. Hitherto, to my knowledge, there has been nothing published to indicate what kind of water is most suitable for use in… (steeping) indigo." [13]

Meanwhile the planters were clamoring for results that they could use. In a way, Rawson may have earlier raised their expectations from analysis of water. For planters, of course, changing the type of water being used for steeping presented an easier option towards augmenting production. In most cases, all that it required was changing the source of water – switching from a stream to a well, or from one well to another. Unless, of course, the ground water itself in the entire area was deficient in a particular way. Perhaps that explains the overwhelming response of planters to the idea of sending their water samples to Rawson, and their disappointment in the end, when he said that he could not offer a "definite opinion" on what type of water was more suitable. [14]

In the same report Rawson presented his initial finding about the optimal temperature to maintain during steeping. At that point all that he could offer was the observation based on limited experimental work carried out at the Mosheri laboratory - that when the temperature of water was lower the fermentation-related changes during

[13] "Mr. Rawson's Report No. 3," dated September 26, 1898, BSA, Agriculture, File 2I/3, March 1900

[14] "Mr. Rawson's Report No. 3," dated September 26, 1898, BSA, Agriculture, File 2I/3, March 1900

steeping slowed down, and vice versa. But the planters wanted him to be more specific than that. What was the ideal temperature for steeping? Did there exist a visible or another easily determinable marker to detect when the steeping process was complete so that the planters could decide when to turn over liquid into the next tank for oxidation. Once again Rawson was apologetic.

The third measure on steeping discussed in the report relates to adding milk of lime in an additional vat placed between the fermentation and oxidation vats. Bernard Coventry, a planter and agricultural expert, on whose estates the Indigo Improvements Syndicate (IIS) had set up the second laboratory at Dalsingserai, had patented that method of steeping. The Bihar Indigo Planters' Association (BIPA) had asked Rawson to visit Coventry's laboratory in Dalsingserai, witness the working of the new method, and to report back on its usefulness. Rawson spoke positively of the procedure that involved depositing organic matter present in a dissolved or suspended state in the indigo liquor obtained from the fermentation tank. That ensured that purer liquor passed on to the oxidation tank. Finally, some hydrochloric acid was added to the boiler so that any excess lime was washed out from the final product.

Rawson agreed that the principle employed in Coventry's process was "undoubtedly a good one." In his subsequent reports too Rawson accepted that the addition of an alkali – ammonia, soda, lime, silicate of soda, sodium peroxide – brought favorable results. [15] In fact, the practice of adding alkali gained wide acceptance among

[15] Rawson's report to the Indigo Defence Association Limited, dated, July 31, 1899, p., 1, BSA, Agriculture, File 2I/3, March 1900

the planters in Bihar subsequently, and may be counted as one of the best process innovations introduced to indigo manufacturing in Bihar. [16]

Rawson did meritorious scientific work in another direction – on purifying the natural dye in order to get rid of all substances other than *indigotin* while saving some amount of indigo-red and brown in the dye. He reported on an experiment that he had conducted on refining indigo in the laboratory. The experiment was an "illustration" that some members of the BIPA had been earlier invited to witness. The report provided details that involved heating measured proportions of ground indigo with slaked lime at or near boiling point. Separately, a fixed proportion of diluted bisulphate of soda was heated with zinc powder in near vacuum for fifteen minutes to obtain a hydrosulphite. An effort was made not to let the temperature rise during the chemical change. The two liquids and their sediments were then mixed and brought to the boil for another half hour. When the liquid turned yellow, heating was stopped, and the sediment allowed to settle. The yellow liquid was siphoned off and oxidized with air to obtain indigo of remarkable purity.

This was a long process, and required constant monitoring. Although successful on a laboratory scale, and of definite "scientific" merit, its adoption on the indigo tracts appeared doubtful to begin with. The steps were complex. The next course, that of adapting this process for implementation on a manufacturing industrial scale, was not taken up by either the scientists or the planters. Yet, if nothing else, the experiment shows

[16] This was a process for which Bernard Coventry rightfully claimed credit. He was certainly the first to demonstrate the benefits arising from the addition of alkalis just before oxidation. Coventry was not a professional chemist, but rather an experienced agriculturist and a planter. In that sense the exchanges between Coventry and Rawson represent successful transfer of knowledge between from agricultural field to laboratory.

the sensitivity of the planters and scientists to the issue of achieving consistency at an early stage.

Rawson At The Mosheri Laboratory, 1899-1900

In June 1899, the chemical laboratory was shifted to a more permanent and spacious location at Mosheri, a small sub divisional town not too far from Muzaffarpur. As opposed to the earlier laboratory that only had small experimental vats, the Mosheri laboratory possessed a "miniature factory." One part of this laboratory had two steeping vats of 100 cubic feet each, and beating vats, boiling tanks, drying tables, presses, and everything else of proportionate size as used in actual manufacturing. The other part of the laboratory had two larger steeping vats of 1,000 cubic feet capacity. The set up at Mosheri also provided access to an agricultural farm for sowing and observing the growth of the indigo plant if the chemical experts chose to do so. Also, this season Rawson had returned from England with an assistant of his choice – S. Burtt. Mosheri as a site for experimentation represented quite an advance over the previous chemical laboratory at the Planters' Club. Rawson was quite happy with the arrangements at the new laboratory and said that they would "unquestionably prove to be of greatest value."[17]

In his second year in Bihar, Rawson was able to visit many factories where he observed the results of scientific interventions on a manufacturing scale. Thus in June, 1899 he went to the Sirsiah factory and stayed there for two days to watch the manufacturing operations incorporating the new measures that he had suggested. The

[17] Rawson's report to the Indigo Defence Association Limited, dated, July 31, 1899, p., 1, BSA, Agriculture, File 2I/3, March 1900; we do not have any additional information as to the training and qualifications of Rawson's assistant S. Burtt, except a note in the report that says that the person was Rawson's nephew!

same month he also visited the Dalsingserai concern managed by Bernard Coventry. At Dalsingserai, Rawson additionally made enquiries into the ongoing agricultural trials at that station. In July he was at another factory, Turcouleah. With the assistance of the local proprietor, F. M. Coventry, he made a series of experiments at that factory on a large scale. On the whole he found most results in agreement with his findings made previously in the laboratory, although there were a few unexplainable deviations too. [18]

The experiments and the respective results obtained at Mosheri until the end of 1899 can be divided into three groups – on fermentation, boiling, and oxidation. The experiments on fermentation/steeping were the least productive. The thread on water analysis had led nowhere. Rawson did not yet know which minerals in water fruitfully acted on the glucoside to produce indigo blue and which ones catalyzed wasteful conversions. A key item of information not available to Rawson was the nature and chemical property of the glucoside – *indican*. [19]In such a situation Rawson proposed that the treatment of water and its purification might be beneficial. He gave a detailed proposal for constructing tanks of 1,000 cubic feet capacity that should have perforated pipes at the bottom connected to a Korting's blower or an air compressor. For achieving a purer product he suggested adding chemicals to water through the blower and compressor that were basically used for oxidizing. For a round tank of 14 ft, 9 in. in diameter the construction cost would have been Rs. 1,200 each, and on an average each factory would need two or three of them. He also calculated the prices for blower or compressor and

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[18] Rawson's report to the Indigo Defence Association Limited, dated, July 31, 1899, p., 2, BSA, Agriculture, File 2I/3, March 1900

[19] It may be pointed out in parenthesis that crucial advances in understanding the nature of indican were made by Dutch chemists in the Netherlands and the Dutch Java. However, that information was kept a closely guarded secret and not published in the hope that it would soon offer commercial advantages.

pipes. But, in the end, the scheme sounded quite impractical. He acknowledged that the exact nature of chemicals that would be needed and the amount required for adding to water would have to be determined by an expert on site each time! [20]That was indeed a difficult proposition, and was never followed up.

His suggestions on the boiling stage were more specific, and primarily directed at improving the purity of the dye. This measure basically involved dissolving impurities with an acid. Rawson noted that hydrochloric acid would give quicker results. But on grounds of economy he recommended instead using the cheaper sulfuric acid. He proposed that 5 *seers* of acid for 20 *maunds* of dry indigo would be an appropriate equivalent. In this regard, Rawson also addressed concerns raised by some indigo dealers that the addition of acid in the boiler might compromise the quality of indigo and harm clothes dyed with it. Rawson assured them that those apprehensions were not valid. Any extra acid used in the boiler could be easily washed away and the final product would not retain anything acidic. [21]

The process of using acid in the boiler subsequently became quite widespread. To be able to use acid in the boilers it was necessary that the boiler be coated with lead. Lead lined boilers were not too difficult or expensive to install. Those who were using slaked lime before fermentation, another one of the innovations suggested earlier, were anyway using acid in the boiler to remove the extra alkali. Interestingly, the previously tried

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[20] Rawson's report to the Committee of the Indigo Defence Association Limited, dated February 6, 1900 (although referring to experiments of the previous year): 3, BSA, Agriculture, File 2I/3, March 1900

[21] Rawson's report to the Indigo Defence Association Limited, dated, July 31, 1899, pp., 2-3, BSA, Agriculture, File 2I/3, March 1900

method of "refining" seems to have been given up by this time. Never again was the approach ever discussed at this time or later.

Rawson's most earnest efforts were directed towards improving the efficiency of the second stage in indigo manufacturing – the oxidation stage. With the aim of ensuring faster and more complete oxidation of the solution, he considered passing a current of air using blowers and compressors instead of "beating" with a wheel or manual thrashing as in use until then. He reasoned that blowing air/oxygen through pipes at the bottom of vats would achieve a more complete oxidation. To achieve efficiency in bringing air and liquid into contact with each other he also proposed the use of deeper vats.

In February 1900, Rawson finalized his scheme for an extensive trial to use blowers and compressors at four designated factories. This was his attempt at trying out on a manufacturing scale what he had experimentally observed at the Mosheri laboratory. Different combinations were designated to be tried at four factories in separate locations. Rawson wanted the vat arrangements with the following combinations: [22]

Factory 1 (headquarters)

a) Shallow vats with Korting's blower
b) Shallow vats with Korting's blower and chemicals
c) Deep vats with air compressor
d) Control – Shallow vats and ordinary beating/thrashing

Factory 2

a) Shallow vats with Root's blower
b) Shallow vats with Root's blower and chemicals
c) Control - Shallow vats and ordinary beating/thrashing

Factory 3

a) Shallow vats with Korting's blower
b) Control - Shallow vats and ordinary beating/thrashing

Factory 4

[22] Rawson's report to the Committee of the Indigo Defence Association Limited, dated February 6, 1900, pp: 1-3, BSA, Agriculture, File 2I/3, March 1900

a) Shallow vats with Root's Blower
b) Control - Shallow vats and ordinary beating/thrashing

Some of the equipment would have to be imported from England while some was locally available from Arthur Butler & Company located at Muzaffarpur.

Information on the details of the oxidation trials is, unfortunately, sketchy. On his return from England at the start of the next season, Rawson apparently found the arrangement for the trials faulty. He complained that the size and power of blowers installed was less than half of what he had suggested, and doubted if accurate and useful comparisons could be made. But he managed to complete some trials at Mosheri, wherein he claimed the average yield was higher by 32% compared to that obtained with the ordinary process, and the maximum increase was 42%.[23] In his subsequent reports he continued to implore the planters to reorganize their production set- up around deep oxidation vats fitted with blowers and perforated pipes.

Beginning in early 1900 Rawson had also been experimenting with manures at Mosheri to improve yield in the field. He specifically looked at variations in output of the final product from plants that had been treated with different chemicals/fertilizer in the field. He clarified that while the addition of *seet*, the waste from manufacturing, aided the growth of the plant, it did not help enhance the amount of indigo obtainable after manufacturing. His trials for the season showed that the plots treated with superphosphate and saltpeter produced the best plant as far as its color-giving potential was concerned. [24]

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[23] Rawson's letter to BIPA, dated, August 16, 1900: 1, BSA, Agriculture, File 2I/3, March 1900

[24] Rawson's letter to BIPA, dated, August 16, 1900: 2, BSA, Agriculture, File 2I/3, March 1900

The Dilemma At The End Of 1900

There is a certain gap in the availability of scientific publications and government reports on laboratories for the year 1901. But reports from the end of 1900 give an idea of the dilemmas faced by the scientists at that time.

The use of blowers did not become widespread. Perhaps it is not too difficult to explain this. While the cost of blowers cited by Rawson does not appear to be too high, the change to deeper vats fitted with blowers did require new investment and changes in the factory architecture. Later records suggest that the few prosperous planters who adopted them initially did not get yields anywhere in the vicinity of the high yields that Rawson had claimed to obtain under experimental conditions. Planters' lack of positive response to blowers can be readily explained in terms of the nature of improvement the blowers were promising. Marginal improvement of yield constituted a "scientific improvement" or an "innovation." But that by itself would not have solved planters' problem in the market place. Planters needed drastic not incremental improvements to survive the competition of synthetics. Blowers seemed to offer too little, and thus were largely not adopted.

The solution had to emerge from some other direction. The reports at the end of 1900 are illustrative of the search for solutions elsewhere. If we recall, the fermentation stage had proven to be some thing of a "black box." The fermentative changes had so far defied clearer scientific understanding and therefore precluded the possibility of devising steps to modify them usefully. In a confidential letter written to BIPA in October 1900, Rawson had said:

> If I have said little about the steeping vats in my reports, it is not because its importance has been overlooked but merely for the reason that I have not yet discovered anything of value to communicate. [25]

Rawson believed that there was a scope for a drastic improvement of fermentation. To get a better grip on the fermentation processes he requested the hiring of a bacteriologist. In August 1900, Rawson wrote a letter to the BIPA executive committee, justifying the need for a bacteriologist who could work on perfecting fermentation. In a subsequent letter he suggested that any one of the many bacteriologists attached to numerous breweries in Britain could be hired for the purpose. Those in the wineries had an expertise on the behavior of microbes, enzymes, and the fermentation produced by them.

Rawson backed his demand for the hiring of a bacteriologist with hard calculations. In late 1900, at the meeting of the Society of Dyers and Colourists in Bradford, Rawson presented the following equation: 100 *maunds* (1 *maund* = 80 lbs.) of the *indigofera tinctoria* variety of indigo plant should yield 14.7 *seers* of 60 per cent concentration indigo. In his trials with the same plant only 12.5 *seers* of indigo came after the due manufacturing procedure. He also provided evidence that the other 2 *seers* were getting dissipated during fermentation in the steeping stage. He firmly believed that an improved process of fermentation of leaves would raise the amount of recoverable *indigotin*. [26]Persuaded by his calculations, George Watt, the Reporter on Economic

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[25] "Private and Confidential," Rawson's letter to the Behar Indigo Planters Association, dated 4 October 1900, BSA, Agriculture, File 2I/3, March 1901

[26] Christopher Rawson, " The Indigo Industry," "Prospects of the Indigo Industry," *The Journal of the Society of Dyers and Colourists* (1901): 75-79

Products to the Government of India also supported his recommendation for the hiring of a bacteriologist. [27]

Bacteriologist Cyril Bergtheil At Peeprah, 1902

BIPA hired Cyril Bergtheil, a German trained British chemist, to conduct bacteriological experiments on steeping indigo in Bihar. The BIPA put an advertisement in *Nature*, London, for the job of a scientist to assist Christopher Rawson with their indigo-experiments in Bihar. The advertisement specifically invited candidates well versed in both "chemistry and bacteriology" to apply for the job. Cyril Bergtheil was selected. [28]

Born in London in 1878 to Alice Collins and Louis Bergtheil, the latter belonging to a family of Jewish immigrants to England, Cyril Bergtheil's early education was in London. By the time Bergtheil finished his school, he had decided to make a career in chemistry. Since Germany "was regarded as the best country in which to be trained [in chemistry]," Bergtheil went to live in Germany with his relatives on his father's side. For two years, from 1895-97, he stayed in Nuremberg, studying chemistry at the *Industrieschule*. Coming back to England in 1897, he began working in the chemical laboratory of Professor William Ramsay at University College, London, who at that time

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[27] Christopher Rawson, " The Indigo Industry," "Prospects of the Indigo Industry," *The Journal of the Society of Dyers and Colourists* (1901): 75-79

[28] Cyril Berkeley, *My Autobiography* (privately published, n.d.), pp., 1-6; Cyril Bergtheil, after his immigration to Canada around the time of the World War, changed his name to Cyril Berkeley, to get by the anti- Germen sentiments prevailing there. His earlier surname easily gave away his German ancestry, and he saw sense in dropping it for good. (henceforth "*Autobiography*"). A copy of the autobiography has survived with Prof Mary Arai, granddaughter of the scientist at the University of Calgary in Canada.

became famous working on nitrogen, identifying argon and other rare gases. While with Professor Ramsay, Bergtheil worked on reactions between iodide and iodate leading to the freeing of iodine. But breaking away from this kind of experiment, he decided to get specialized training in agricultural chemistry and bacteriology because both these fields seemed to have prospects for employment at that time. Between 1899 and 1900, Bergtheil went to learn agricultural chemistry in the newly set up Agricultural College at Wye, and also bacteriology. Besides, Bergtheil had nurtured a "great interest" in the subject of the struggle between the natural and synthetic indigo, all of which must have ensured his selection for the job. [29]

Cyril Bergtheil's appointment resulted in a renewed focus on fermentation experiments at the BIPA laboratory, which had been moved from Mosheri to a new location at Peeprah (Champaran district). Bergtheil immediately turned his attention to the fermentation processes in the manufacture of indigo, a process that he understood well due to his previous training in bacteriology. He got the active support of the other scientist at the station, Rawson, who was convinced that the real problem lay with indigo's steeping. Thus the stage was set for a series of experiments toward getting a better understanding and control over processes underlying fermentation in the steeping vat.

Four months later, Bergtheil submitted a report to BIPA in which he responded to planters' concerns, explained how he understood the scientific problem, and deliberated on the strategies he had formulated for handling them experimentally. The planters wanted their scientists to tell them when exactly to stop steeping. Bergtheil responded

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[29] Berkeley, *Autobiography*, 1-6

that the conditions under which steeping was performed, varied widely. The time of actual steeping would depend on the type of plant, where it was grown, how long it had been cut, how it was packed in the vat etc. It was thus not possible to suggest any fixed estimate for the steeping period. [30]

Bergtheil also provided a scientific explanation of the process of steeping/fermentation. The enzymes already present in the leaves and bacteria of the steeping liquor acted on leaves' glucoside, forming a body that on oxidation gave *indigotin*. But the liquor contained several kinds of bacteria, some of which produced the desired change in glucoside, a few that remained non-reactive, and a few others that brought undesirable changes in the glucoside leading to a loss of recoverable i*ndigotin*. It was virtually impossible to pick and choose the appropriate bacteria while removing others. To achieve "uniformity in working" of steeping, therefore, Bergtheil decided to adopt a process in which all bacteria would be killed, producing a "sterile" environment, and then bring about the chemical changes involving glucoside by enzyme action alone. Either antiseptics or plain heating could kill bacteria; since the antiseptics were expensive, heating appeared to be a better option.

Indeed, Bergtheil disclosed that trials conducted at the Peeprah laboratory had confirmed that when heat was used during steeping, fermentation became "more speedy and complete." Three alternatives existed to use heat: First, steam the plant and then conduct steeping with warm water or water at ordinary temperature. Second, boiling water could be used to destroy both bacteria and enzymes, and then the greenish-yellow liquid could be oxidized by especially cultured enzymes. The second option appeared

[30] "Bacteriologist's Note I" Cyril Bergtheil, dated 9 August 1902: 2, BSA, Agriculture, December 1903, File 2-I/7 3

tortuously long and expensive. Lastly, warm water at a temperature of 150 – 160 F could be used for steeping. Bergtheil told his clients that experiments were currently underway to determine which was the best and most economical way of using heat for fermentation.[31]

Rawson's Growing Hopelessness At Peeprah, 1902

In 1902 Rawson's experiments at Peeprah went in three directions. Firstly, he perfected his patented "ammonia gas process," which required passing of ammonia gas through the liquor to achieve oxidation. Instead of oxidizing with air/oxygen, as was done previously, the ammonia gas process achieved oxidation with the help of ammonia. In the current season he demonstrated two sets of experiments with ammonia. The report provides the following results:

Table 4.1
Average output result of 12 days with 100 *maunds* of plant

Process	Total weight in *seers* produced in the vat
Ordinary process	9.80
Ammonia gas process	12.00
Increase per cent	22.5

[31] "Bacteriologist's Note I" Cyril Bergtheil, dated 9 August 1902, BSA, Agriculture, p., 2, December 1903, File 2-I/7 3

Table 4.2
Average output result of 3 days with 100 *maunds* of plant

Process	Total weight in *seers* produced in the vat
Ordinary process	11.27
Ammonia gas process	12.78
Increase per cent	13.5

Rawson claimed that the process was "decidedly the best process which … [had] hitherto been put forward." Rawson also began work on two other types of experiments, but stopped work mid way realizing that the cost of inputs were too high relative to the increase in yield that would result from them. One of those was the "hot water process" and the other the "persulphate" process to obtain indigo blue from leaves. The cost of obtaining a very large amount of steam and the high price of ammonia persulphate put a stop to these efforts.

The planters were getting impatient with the results of Rawson's efforts. His more recent recommendations – blowers, deep vats, steaming of plant, the persulphate method had not found many takers. The results were not consistent to begin with. Or, the returns from the innovations did not justify the costs required for introducing them. The Inspector General of Agriculture Mollison's comment, dated September 1902, sounded warning bells by foretelling that the planters were not likely to continue funding his chemical experiments.

> Mr. Rawson and his assistants have accomplished striking work. ….. Yet very few useful results have been obtained ….. The cost of applying Mr. Rawson's suggested improvements exceeds the value of increase of produce at existing market rates. [32]

During the rest of the year Christopher Rawson conducted experiments to complement the efforts of Bergtheil on steeping. He alluded to some steeping experiments conducted at Peeprah to test the impact of an antiseptic, a disinfectant carbolic acid, and mercuric chloride on the steeping process, which did not give definitive results. On certain days, when conditions turned out to be perfect, he believed that the output from current methods of fermentation was "not more than 10 per cent below the theoretical." But at most other times, the extraction from fermentation "was far from complete." He knew that the hope for any real improvement lay with steeping. But he was getting pessimistic. He said, "The steeping process is receiving every possible attention but the difficulties of regulating the operation are very great." [33]

Aside from talking about the scope and status of experiments on yield improvement, very significantly, Rawson also briefly alluded to the unfinished task of removing impurities from the natural dye. Rawson had been cognizant of the need to match the purity of synthetic dye, which was sold in either 100% concentration of color, or in a 20% concentration in a neutral base. In either case, the synthetic product

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[32] See Mollison's notes cited in BSA, Agriculture, December 1903, File 2I/8 3, Notes and Orders: 2

[33] "Notes on Experimental Work done at Peeprah During the Morhan Mahai 1902," By Christopher Rawson, dated 11 August 1902,": 4, BSA, Agriculture, August 1903, File 2I/7

contained only *indigotin*, the color, and nothing else that could act on the fabric. Also, the percentage of color in the synthetic dye was fixed. Chemical experiments at the Planters' Club, at Mosheri, and Peeprah had led to recommendations for improving purity (or the percentage of color in natural dye) by adding slaked lime before oxidation and by washing with acid in the boiler. On the other hand, the trials on refining had proved impractical for adoption due to the high cost of materials. In that context, Rawson's admissions are illustrative. They put in a perspective the relative futility of previous efforts in India with regard to improving the consistency of color, as against the efforts to improve the output of the dye.

Did the scientists have a realistic chance of improving percentage of *indigotin* in natural dye beyond the mark of 60-65% - the upper limit for color in the "best variety Bengal indigo"? And what were the implications of that for the future of natural indigo? Rawson's comments, once again, are insightful. The addition of slaked lime and acid wash, by Rawson's own admission, were most useful in cases where the dye was particularly impure. Their effectiveness in other cases where the purity was already expected to be 60-65% was marginal at best. At the same time, Rawson stated that improvement of percentage and obtaining natural dye of near 100% purity was a legitimate agenda if the collapsing market had to be protected:

> It is now generally admitted that in order to compete more successfully with artificial indigo the quality of the natural product should be materially improved although for many purposes there are dyers who much prefer to use 60 to 65 per cent natural indigo to pure indigotin. It is not likely in the future

> that there will be a great demand in European and American markets for indigo of low quality. [34]

But he did not really have a plan to inspire confidence on the issue of purity and consistency. He briefly mentioned that he had consulted with the London Committee of BIPA in the beginning of the year. After due consultation with them " an experimental piece of apparatus" had been ordered that had recently arrived in Calcutta. He believed that the apparatus could help produce indigo with 80-85% purity at a nominal cost. Never again did he mention anything else about this experimental apparatus. In all likelihood either the experiments were never conducted or did not give replicable results.[35]

Christopher Rawson's contract with the BIPA came to an end in March 1903, and the BIPA did not renew it. This does not seem unusual given planters' dissatisfaction with the fact that none of the measures suggested by him recently were found to be sufficiently successful for application. Rawson himself may well have lost faith in the possibility of further improving the natural dye. His lack of trust in natural's prospects against the synthetic is reflected in the fact that on his return to Britain in 1904 he took up employment with the BASF, the manufacturers of synthetic indigo.

The newcomer Bergtheil, however, was more positive. He did not share Rawson's pessimism. He carried on residual experiments on the fermentation stage of indigo manufacturing. 1903 was a key date in terms of the reorganization of indigo laboratories in India. Peeprah laboratory was closed down, and some staff at Peeprah including Cyril

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[34] "Notes on Experimental Work done at Peeprah During the Morhan Mahai 1902," By Christopher Rawson, dated 11 August 1902,": 4-5, BSA, Agriculture, August 1903, File 2I/7

[35] Notes on Experimental Work done at Peeprah During the Morhan Mahai 1902," By Christopher Rawson, dated 11 August 1902,": 5, BSA, Agriculture, August 1903, File 2I/7

Bergtheil and biologist H. M. Leake were transferred temporarily to the Dalsingserai laboratory. Later in 1904 Bergtheil was appointed the Imperial Bacteriologist and also allowed by the government to lead the newly set up indigo laboratory at Peeprah the same year. [36]A longer discussion of the reorganization of laboratories in terms of the issue of patronage will appear later in the Section Four of this chapter.

The IIS Laboratory At Dalsingserai, 1899-1902

Let us now shift focus to the other laboratory set up by the planters where parallel efforts were being made to enhance the yield of indigo. The IIS had set up an experiment station at Dalsingserai in 1899 to carry out agricultural experiments to improve indigo. In contrast to Rawson's and Bergtheil's experiments, which largely focused on post-harvest extraction processes, the experimenters at Dalsingserai set their sights on improving the output of the indigo plant per acre and the percentage of the coloring principle in the leaves. In 1900, the IIS additionally built a chemical laboratory at Dalsingserai with the aim of augmenting the efforts of agronomists there.

Improving Output Through Better Cultivation Practices

Between 1899 and 1901, experiments and trials were made at Dalsingserai under the leadership of scientist E. A. Hancock and planter Bernard Coventry. We do not possess any additional information about Hancock's educational and professional training beyond the fact that he was an "agricultural chemist" who had been invited from England

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[36] "Notes on Experimental Work," By Christopher Rawson; "Bacteriologist's Note I" Cyril Bergtheil, dated 9 August 1902; Agriculture, December 1903, File 2-I/8 3, No. 59 and Notes and Orders

by the IIS. Bernard Coventry, on the other hand, was an experienced planter, entrepreneur, and innovator. Not a professional scientist, Coventry was more of a "tinkerer." He offered his indigo estate for the conduct of experiments and trials, and in fact, collaborated with Hancock. We also know that he had initiated the use of slaked lime in the vats, and won a patent for it. Rawson, as earlier mentioned, spoke highly of that procedure and recommended its use during manufacturing.

Under the leadership of E A Hancock and Bernard Coventry the experts at Dalsingserai achieved useful results in establishing optimal cultivation practices. Most of the success in the earlier phase came from trials with different manures. A hundred and twenty plots spread over nearly a hundred acres of land were put under indigo to ascertain the result of application of different combination of manures. Besides, as the note of E A Hancock explained, the experimenters also perfected the best possible methods of planting and crop rotation. [37]

Further experiments with the use of manures enabled the scientists at Dalsingserai to provide concrete suggestions to the planters. Through tests of the local soil and by experimentally observing the effect of the addition of different minerals on the growing indigo plant, the scientists recommended the application of two categories of manures - the primary manures and the secondary manures. Coventry, Hancock, and others fundamentally suggested adding phosphoric acid in combination with nitrogenous fertilizers and potash. Also having noticed that indigo leaves with a higher content of the coloring matter invariably also contained a high percentage of magnesia, the scientists

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[37] E. A. Hancock, Note on the Work of the Indigo Improvements Syndicate at Dalsingserai. BSA, Agriculture, May 1901, File 2-I/3 1-7, Nos. 3(b)-3(c); IIS's letter to Revenue Secretary, Government of Bengal, dated January 31, 1901, BSA, Agriculture, May 1901, File, 2-I/3 1-7, Nos. 1-2

additionally advocated adding sulfate of magnesia to indigo lands. They claimed that by applying the above two categories of manures to indigo plants in the month of December, an increase in the indigotin content in the leaves between 45 per cent and 63 per cent could be obtained. [38]

The Search For Better Seeds

The experts at Dalsingserai also invested efforts in regulating the flow of seeds to the indigo farms, and in improving their quality by conducting systematic experiments and trials. Seeds for the indigo lands had traditionally come from the North-West Provinces and the United Provinces where indigo was grown by a large number of small-scale farmers. Dealers based in those areas purchased the seeds from individual farmers and sent them to Bihar. No systematic effort had ever been made to monitor the quality of seeds produced. Over a period of time this neglect in selection had led to deterioration in the seed's quality. Planters realized that a problem existed with the quality of seeds supplied to them that needed deft handling.

Before 1901, Bernard Coventry made efforts in the direction of accumulating data on the indigenous variety, *Indigofera tinctoria* and the foreign variant *Indigofera arrecta*. To test the productivity of the indigenous breeds he sent seeds of the Madras, North-West Provinces, and Oudh varieties to the Royal Botanic Gardens in Calcutta to be grown under a horticulturist's supervision. Coventry also procured a small quantity of seeds of the Natal variety from South Africa and the Java variety from Southeast Asia and sent them to Calcutta to get their productivity compared with the indigenous varieties. The

[38] "Rhea and Indigo Experiments, Results at Dalsingserai," *Englishman*, dated January 28 1902, BSA, Agriculture, August 1903, File, 2I/7, newspaper reports

preliminary tests suggested firstly that the foreign varieties gave a higher output of leaves per acre, and secondly, that the Natal and Java varieties were of similar origin. The Javanese had apparently replaced the Guatemala species grown previously with the South African variety a long time before and since then the Natal variety had been acclimatized to grow to its full potential.

By 1902, Coventry began more extensive trials to compare the productivity of the *tinctoria* and the *arrecta* varieties at Dalsingserai. In his efforts with the Indian varieties, Coventry first applied himself to finding out the location of origin of different seeds and then categorized them according to their potency. His trials showed that the seeds of the more western Multan germinated more quickly with a lesser amount of moisture. However the advantage of easier germination was lost due to the scarcer amount of leaves on the plant. Thus he suggested to the planters that they use seeds from the more eastern sources of supply, preferably those from southeast Punjab and North West Provinces. In support of these efforts the research station's biologist, H M Leake and Captain A T Cage, curator of the Calcutta Herbarium visited upper India to get precise information on the sources of supply of different seeds. The Bengal government came forward to partially fund the trip of Leake and Page that took place in September and October 1902. [39]

Coventry's second set of trials was conducted with the Natal variety of indigo seeds, the *arrecta* variety. Once again the colonial government supported Coventry's efforts by partly funding the visit of private entrepreneur H A Baily to Natal in July 1902

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[39] Letter of L E B Cobden-Ramsay, Revenue Under Secretary, Bengal to Commissioner of Patna Division, dated September 15, 1902; letter of Superintendent, Royal Botanic Garden to Revenue Secretary, Bengal, containing the report of Captain Cage, BSA, Agriculture, November 1902, File, 2I/11 1-5, Nos. 63-67

to procure seeds from South Africa. Baily sent a message that, if the planters in Bihar were willing, a supply line could be established for sending Natal seeds on a regular basis. There were, however, no takers for this proposal. The import of seeds from another continent was an enormous enterprise requiring employment of people, establishing supply lines, monitoring quality during transit, and dispensing to a large number of customers. The purpose of importing a sizeable quantity of genuine Natal seeds having been considered, the planters moved on. Foreign variants needed acclimatization, and it is in that direction that their efforts were directed.

Coventry tried to find out the best way to grow the *arrecta* variety in Bihar. At the end of his trials he pointed out that the Natal variety would not germinate in the month of March, the usual time for sowing in Bihar, but rather between June and July given its especial characteristics and the climate of Bihar. He also discouraged planters from practicing transplanting as was the practice in Java, and additionally suggested sowing with ordinary drill or broadcast at the rate of 6 *seers* per acre. [40]

Perfecting The Rotation Crops

The experimenters at Dalsingserai also focused on crops other than indigo. The initial attention to other crops came on account of their importance to the planters as rotation crops. Planters knew well that the indigo lands began suffering from "indigo sickness" after repeated sowings of indigo. When turned over to other crops in between, they regained their fertility and gave a better output. But gradually the planters also

[40] "Natal Indigo Seeds," Agriculture, December 1902, File 2I/6, 9-25, Nos. 1 – 19; for the conversion rates, see letter from Eugene C. Schrottky, Indian Planters' Gazette and Sporting News (February 8, 1908). The holdings of this newspaper are available at the National Agricultural Library at Beltsville MD), USA; henceforth called "IPG."

became interested in crops other than indigo because such crops fetched a good price in the local market, and helped compensate for the diminishing margin of profit on indigo. Responding to these needs, the scientists at Dalsingserai turned their attention to sugarcane, and more elaborately to the fiber, rhea. Bernard Coventry carried out detailed investigations to ascertain the profitability of cultivating rhea and exporting it to Europe. He calculated the average cost of manufacture for a ton of rhea at £10, and of bailing, insuring, and selling it in Europe at £ 5. Since the average price for rhea in Europe stood at £25, planters could make a profit of £10 for every ton of rhea produced. Since a ton of rhea could be obtained on 2.5 acres of land, the average profit for the planters, if they switched to rhea, would be £4 for an acre. Coventry also asserted that the prices for rhea would hold fast in the coming few years. [41]The efforts of Bernard Coventry in this regard also won the praise of colonial officials. Such efforts were seen as making useful contributions toward combining the manufacture of indigo with other cash crops. [42]

Planters, The Bengal Government, And The Re-Organization Of Indigo Laboratories, 1900-1902

Moving beyond the content and direction of scientific experiments, and the expertise of chemists and agronomists, this section will instead focus on the re-organization of the indigo laboratories in India from 1900. That year marks a departure point in terms of funding and sponsorship of scientific experiments. Started primarily as a

[41] "Note on Rhea," Bernard Coventry, BSA, Agriculture 1903, File, 2I/7

[42] See Lieutenant Governor's comment praising the efforts of Bernard Coventry for promoting the manufacture of rhea and W B Hudson for sugar manufacturing on indigo tracts. "Planters' dinner at Mozafferpur, speech by Sir John Woodburn," Englishman, January 24, 1902, BSA, Agriculture, August 1903, File, 2I/7, newspaper reports

planters' enterprise, the laboratories began to be co-funded by the government from that year. From 1903, planters stopped funding the two laboratories. They solicited the government's support for carrying forward the work at their laboratories. The Bengal government stepped in, providing funds for the laboratories while leaving the actual responsibility for the conduct of experiments with the planters. From 1904 onwards the government became the primary sponsor of indigo experiments. The period 1900-1903 provides a convenient vantage point to address issue of patronage for science in the changing context of diminishing results from the laboratories, plummeting profits for the planters, and the government's desire to start its own agricultural research station at Pusa. In this section patronage of science in colonial India will be studied by focusing on specific questions: Under what circumstances did the planters demand government support? Why did the government feel obliged to support them? Did the involvement of the bureaucrats change the orientation of indigo experiments? Lastly, what re-kindled all round hopes in indigo experiments after 1903?

The Planters Turn To The Government For Subsidy

From 1900 forward, citing declining profits, the planters made a claim for a state subsidy for their chemical and agricultural experiments. They invoked precedents of various sorts to demand funds. The government had after all provided assistance to laboratory experiments on tea. Why not to indigo then, they argued. "It is understood that in Java, for instance, and also in America, the Government give[s] very great financial assistance in scientific research, whole department[s] …[are] maintained by it," pointed out E Macnaghten, BIPA's Secretary in his letter to the government, imploring them to help out with scientific experiments on indigo. He also argued that the benefits of such scientific research would not be limited to the indigo industry alone. "Knowledge" emerging from the laboratories would after all also be disseminated to thousands of natives that worked on the plantations - thus bringing overall benefit to the entire province. [43]

The administrators in Bihar were positively inclined to help out planters. Apart from the general political and economic reasons for supporting the indigo industry, the officials also had close personal ties with the planters. Revenue officer C. J. Stevenson-Moore, who conducted survey operations in an indigo-growing district, rightly commented that the indigo industry had brought into being "a large community of honourable Englishmen joined together by a common bond of interest." Planters promptly came to the aid of the colonial government "in times of danger and difficulty." [44]Planters helped the bureaucrats with the performance of several administrative tasks.

A few administrators like the Revenue Secretary F A Slacke strongly supported the planters' case for a state subsidy. He went on to plead the planters' case for state aid within the administration for scientific investigation. In an official communication to the Lieutenant Governor, he pointed out that in Java, where indigo planters also faced the problem of competition with synthetic indigo, the colonial government had come forward to help the Dutch planters. He rhetorically argued:

[43] Letter from E Macnaghten, BIPA to Revenue Secretary, Government of Bengal, dated, Aug 7, 1900, BSA, Agriculture, October 1900, File 2 I/3 3-32, No. 13

[44] C. J. Stevenson-Moore, *Final Report on the Survey and Settlement Operations in the Muzaffarpur District, 1892 to 1899*. (Calcutta: Bengal Secretariat Press, 1901): 340, 348-350

> If such a petty Government as the Dutch consider[s] such expenditure by the State essential, there would probably be a strong reason for getting Imperial assistance here [in Bengal]. [45]

Without disrupting the plan for initiating agricultural research under its own control, the government showed willingness to fund planter's private research. In the long-term the government intended to initiate research at Pusa on all agricultural crops including indigo, sugar, jute, and oilseeds. It was planned that the benefits of that research would accrue to all farm-based industries in India. But since the problem faced by the indigo industry required immediate attention, a policy decision was taken to finance indigo experiments conducted by the planters for three years. While the details and modalities of fund disbursement would be worked out later, towards the end of March 1900 the government communicated its decision to the planters that it had decided in principle to fund their experiments for the next three years. [46]

The Government Imposes Its Own Regime On Indigo Research

Important changes came to mark the organization of indigo research following the commitment of government funds for the conduct of indigo experiments. On grounds of economy, and based on their assessment of what kinds of experiments and which experts would benefit the indigo industry most, the government officials compelled the planters to introduce changes in their program of indigo research. The bureaucrats also persuaded

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[45] Notes and Orders, BSA, Agriculture, November 1900, File 2 I/3 29-30, Nos. 154-156

[46] F A Slacke's notes, dated Feb 12 and March 3, 1901, Notes and Orders, BSA, Agriculture, May 1901, File 2 I/3 1-7; Slacke's letter to the Secretary, BIPA, dated, March 27, 1901, BSA, Agriculture, May 1901, File 2 I/3 1-7, No. 4

the two planter bodies to merge and constitute a joint research committee to oversee the functioning of the laboratories. Let us turn our attention to the changes made to the organization of indigo research as a result of a partnership with government.

In August 1900, BIPA first wrote to the Bengal government requesting financial assistance for the employment of a bacteriologist. The government acceded to that request for support, allotting _500 to the planters. BIPA came back in November with a request for additional funds to enlarge the scope of its experiments. This time BIPA attached a scheme drawn out by its in-house scientist, Christopher Rawson. In addition to Rawson and his assistant working at the time, the scheme asked for aid to employ a Research Chemist, an Agricultural Chemist, four Assistant Analytical Chemists, a Botanist, and an Entomologist. [47]

The Indigo Improvements Syndicate also wrote to the Government of India and the Government of Bengal in January 1901 and requested a grant of Rs. 40,000 for the next three years. The Syndicate wanted to use the money to appoint a chemist in its existing laboratory at Dalsingserai to support the analyses carried out by the agricultural experts there, and to set up another laboratory and experimental farm in Punjab and the North-Western Provinces to cultivate improved indigo seeds. [48]

The response of federal bureaucrat George W Watt, the government's Economic Reporter, to the BIPA request for government funds in November 1900 reflects key

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[47] Letter from E Macnaghten, BIPA to Revenue Secretary, Government of Bengal, dated, Aug 7, 1900; Response of E Lister, Revenue Under-Secretary, Government of Bengal to the General Secretary, BIPA, dated, October 8, 1900, BSA, Agriculture, October 1900, File 2 I/3 3-32, Nos. 13, 28; BSA, Agriculture, November 1900, File 2 I/3 29-30, No. 154-55; IIS's letter to the Government of Bengal, dated January 31, 1901, in BSA, Agriculture, May 1901, File 2-I/3 1-7, Nos. 1-2 & 3(a)

[48] IIS's letter to the Government of Bengal, dated January 31, 1901, in Agriculture, May 1901, File 2-I/3 1-7, Nos. 1-2 & 3(a); Notes and Orders, BSA, Agriculture, May 1901, File 2 I/3 1-7

aspects of the official outlook on the engagement of experts to improve indigo – an outlook that came to mould the organization of laboratories and scientific research on natural indigo. Watt found the scheme "far too liberal" in terms of number of experts demanded. He remarked:

> Mr. Rawson [who had drafted the proposal for BIPA] proposes a larger scientific staff to investigate indigo alone than is in the employment of the Government for all branches of the agriculture and industry of the entire empire. [49]

To bring the proposal in line with what would be considered "expedient" within government circles, Watt suggested a substantial curtailment of the scope of the proposal. Against Rawson's original demand for a Research Chemist and an Agricultural Chemist, Watt recommended that the planters aim for the employment of one additional chemist and an assistant chemist. Watt also considered the demand for a separate botanist and entomologist extravagant. Instead, he suggested that the planters hire a biologist to perform the functions of these two specialists. He pointed out that the recently appointed entomologist to the Indian Museum and a soon to be appointed mycologist to the Botanical Survey in Calcutta could offer specialized advice to the planters in Bihar when needed. A biologist, Watt thought, would be sufficient to the task of selection of the right varieties of plants and in establishing optimal cultivation practices for indigo.

Secondly, Watt suggested an equitable emphasis on the chemical and agricultural branches in the ongoing investigations at the BIPA laboratory. Looking especially at the

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[49] G W Watt's letter to Secretary, BIPA, demi-official, dated, Jan 31, 1901, Notes and Orders, BSA, Agriculture, May 1901, File, 2I/3, 1-7, Nos. 1-8

poor state of knowledge about the indigo plant Watt called for additional agricultural experiments and trials.

> By far the most important task over and above chemical and mechanical improvements in the manufacture of indigo is the study of the plant itself and the improvement of stock by selection on parallel lines with the chemical investigations already discussed… It is, in my opinion, a disgrace to the industry that so little should be known of the botany and agriculture of a plant upon which so much capital has been invested. [50]

In that light, Watt thought that additional efforts by the BIPA's scientists towards selection of higher yielding varieties under the supervision of a biologist would be fruitful. This suggestion was indeed in line with the agricultural focus of experiments at Dalsingserai.

Thirdly, George Watt expressed concern about the way indigo experiments were being organized. He specifically objected to the functioning of BIPA and IIS independently of each other despite working towards the same goal of improving indigo. Watt recommended the amalgamation of the IIS with BIPA to facilitate the efficient conduct of indigo experiments. The two bodies, Watt thought, should jointly design a concrete program of research and pool the maximum funds that they could generate. Thereafter, to make up the shortfall, they should approach the provincial governments of North West Provinces, Punjab, and Madras besides the government of Bengal. Since indigo was also grown and manufactured in the other three states, the governments of

[50] G W Watt's letter to Secretary, BIPA, *op. cit*

those states could be expected to offer monetary support to a unified and rational program of research on the cultivation and manufacture of indigo.

The provincial bureaucrats had, independently of Watt, long demanded the fusion of the research programs of BIPA and IIS to avoid what they thought was a “duplication” of experiments taking place in planters’ laboratories. The first occasion for the bureaucrats to review the organization of indigo experiments came when the planters approached the provincial government for partial funding of their experiments. Now that the planters had come back to ask for a larger financial contribution, the officials assertively asked the two planters’ bodies to coordinate their research. They communicated to the planters that government funds to support indigo experiments would be given to them only on the condition that the two planter bodies merged. After due discussion between BIPA’s members in India, non-resident members living in Britain, and the representatives of Calcutta agency houses and brokers, the secretary of the BIPA announced the amalgamation of the two organizations in March 1901. [51]

The state level administrators also played an important role in finalizing the details of the planters’ research program. Initially the planters were unhappy with the cut-back to their program as suggested by the government officials. But in the end they revised their proposal in line with the broad outlines of George Watt’s scheme, which had been endorsed by provincial officials. In their unified research program the planters proposed to conduct experiments at two centers - the manufacturing experiments at

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[51] See notes of Secretary F A Slacke, Under-Secretary L E B Cobden-Ramsay, and lower staff, Notes and Orders, BSA, Agriculture, May 1901, File, 2I/3, 1-7, Nos. 1-8; Letter of E Macnaghten, Secretary, BIPA to the Revenue Secretary, Government of Bengal, dated March 9 1901; F A Slacke’s letter to Secretary BIPA, dated, March 27, 1901, BSA, Agriculture, May 1901, File, 2I/3 1-7, Nos. 3(b), 3(c), and 4

Peeprah under the leadership of Christopher Rawson and the agricultural experiments at Dalsingserai headed by E A Hancock. The two arms would be centrally supervised by a research committee comprising seven members – four indigo planters representing the four Bihar districts, two representatives of the Calcutta agency houses that traded in indigo, and one representative of the buying brokers. The group would be headed by a secretary. The planters also deviated from the original scheme prepared by Rawson in which they had proposed to hire a research chemist, an agricultural chemist, a botanist and entomologist. In line with Watt's recommendations, the revised scheme dropped the demand for the agricultural chemist and in place of the botanist and entomologist proposed to hire a biologist. [52]

Finally, the officials played an important role in settling the budget and fixing norms for apportioning the research money. Firstly, they lowered the aggregate cost of the indigo experiments in the revised proposal. The planters' proposal had envisaged an expense of Rs. 150,000 with even contributions from the planters and the government – while the government would make a contribution of 75,000, the planters belonging to the erstwhile BIPA and IIS would contribute 50,000 and 25,000 respectively. The bureaucrats scaled down the total budget to 125,000, putting their own contribution at 50,000 per annum and the share of the planters at 75,000 on the principle of two-fifths and three-fifths contributions respectively. On the question of the apportioning of funds, it was decided that two-thirds of the funds would meet the expense of experiments at Peeprah while one-third would go to Dalsingserai. The bureaucrats also clarified that the government's share of the research money would be forthcoming only after the

[52] Biologist H M Leake was employed by the Research Committee who later joined the Peeprah station in 1902 and moved to Dalsingserai in 1904.

Accountant General confirmed that the planters had submitted their share to the central research committee. Once planters agreed with the terms of contribution and disbursement of funds, the way was cleared for the joint funding of experiments at Peeprah and Dalsingserai from April 1, 1901. [53]

The Planters' Contribution To Laboratories Tapers Off

The planters continually fell short of meeting their financial obligation to the central research committee. In the calendar year 1901, the amalgamated association did not provide its full contribution, citing its inability in receiving the subscriptions from the planter-members. As a result, the government too reduced its share based on the agreed principle of two-fifths from the government to match three-fifths from the planters. The earlier commitment to provide funds for the joint research program was also compromised as the planting community became beset with group politics and regional alignments. The planters from the western districts – those in Champaran, Saran, and Muzaffarpur who were mostly members of the erstwhile BIPA wanted their contribution to go towards supporting the experiments at Peeprah only. A section of the planters, especially those belonging to the Darbhanga sub-committee, wanted their subscription to go to fund the experiments at Dalsingserai. By the middle of 1902, the amalgamated association formally split.

Most trading groups, those who had formerly been members of IIS, raised money independently to support research at Dalsingserai. Although unhappy with the split, the

[53] Extract from the proceedings of a General Committee Meting of the Bihar Indigo Planters' Association held at Muzaffarpur on the 8th December 1900," BSA, Agriculture, January 1901, File, 2I/3 28-29, Nos. 40-41; BSA, Agriculture, May 1901, File, 2I/3 1-7, Nos. 3(b), 3(c), 4-8, Notes and Orders

bureaucrats continued their financial support for the indigo experiments. The BIPA, which had now separated, again fell short of contributing the amount due on them for 1902. Later the BIPA members came back to the government, requesting additional money for the payment of salaries to experts at Peeprah. The planters and traders owing allegiance to the former IIS also failed to raise sufficient money to pay for the expenses already incurred at Dalsingserai.[54]

In a situation where the planter organizations were unable to provide funds, the government agreed to engage with groups of planters still willing to contribute. In a meeting with the Lt. Governor J Woodburn in June 1902 some planters explained why the planter organizations had failed in meeting their financial obligations. On behalf of the BIPA, planter H. Hudson pointed that the planters had been incurring losses due to the prevailing low prices of indigo. In such a situation the BIPA was unable to make the obligatory contribution for the experiments as decided in the agreement with the government earlier. He pleaded that the government bring the Peeprah and Dalsingserai experiment stations under its control and take overall responsibility for the experiments with the support of those planters that wished to contribute. Other members of the BIPA present on the occasion, J B Norman and L I Harrington, supported the views of Hudson. Bernard Coventry, an erstwhile member of the IIS, expressed interest in continuing the experiments, and hoped that the government would support the efforts at Dalsingserai. Given the inability of the planter organizations to stand by the previous agreement the Lieutenant Governor decided on an alternative modus operandi. Henceforth the

[54] Letter of L Hare, Commissioner, Patna to Revenue Secretary, Bengal, dated, May 12, 1902, BSA, Agriculture, June 1902, File, 2I/3 of 10-14, Nos. 66-67; Notes and Orders, dated, December 2, 1902, pp. 3-4, BSA, Agriculture, December 1902, File 2I/8, 15-16

government would give funds to specific laboratories on being assured that the planters and traders had made sufficiently strong efforts to keep the experiments running there. [55]

The funds from the indigo interests, whether from planters or traders, continued to taper off through 1902. The BIPA completely stopped funding the Peeprah experiment station from January 1, 1903, and began to wind up its operations. Bernard Coventry barely managed to keep the operations running at Dalsingserai. Coventry's current trials were largely funded with the help of carry over money from the previous year, with contributions from the Calcutta based trading interests, and subscriptions of a few planters around Dalsingserai. Begg, Dunlop, and Company, the honorary secretaries of the IIS, suggested to the government that an exception should be made to the earlier rule of three-fifths and two fifths contribution from planters and the government, and that matching funds should be awarded to Dalsingserai. By early 1903, the station was at the end of its resources and its closure seemed imminent. [56] Only the grant of government funds in March 1903 gave a fresh lease of life to the laboratory at Dalsingserai. [57]

The Question Of Patronage

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[55] Revenue Secretary W C Macpherson's note, dated June 3, 1902 and Lt. Governor J Woodburn's note, dated, June 9, 1902, Notes and Orders, pp., 6-7, BSA, GOB, Rev (Agr.), June 1902, File, 2I/3 of 10-14

[56] Letter from Begg, Dunlop and Company to Commissioner, Patna Division, dated, May 6, 1902; Notes and Orders, pp., 4-5, BSA, Agriculture, June 1902, File, 2I/3 of 10-14; Revenue Secretary W C Macpherson's note, dated June 3, 1902, Notes and Orders, pp., 6-7, BSA, Agriculture, June 1902, File, 2I/3 of 10-14

[57] Letter of A Earle, Revenue Secretary to Commissioner, Patna, dated, March 21, 1903, Agriculture, December 1903, File, 2I/8 3. The developments that led to disbursement of funds for continuing the Dalsingserai laboratory will be discussed in the next chapter.

The previous sections have clarified two aspects of patronage of science in colonial India: one, that when faced with market competition the planters showed willingness to set up laboratories and sponsor scientific experiments. The colonial government, too, showed willingness to support indigo experiments. The administrators looked at the class of European planters as political allies and genuinely wanted to help their efforts with scientific investigation. As the protector of the commonweal, they also wanted to save an important colonial industry that generated revenue and employment. Both planters and bureaucrats certainly did not betray any innate "conservatism" as far as a positive attitude towards the employment of science was concerned.

Let us turn our attention to re-consider the issue of patronage of scientific research by asking why the financial contribution from the planters continued to taper off till it stopped from the beginning of 1903. Any assessment of the falling contribution from the planters to scientific research on indigo must include a consideration of the state of that industry in the period. The total export of indigo from India had come down from a peak of 187,000 cwt in 1895 to 60,000 cwt in 1903. The fall in export reflects a widespread divestment by the planters; a large number of planters had quit indigo and gone into sugar and food crop production. Obviously this large section of planters no longer sent their quota of funds to the indigo laboratories, thus bringing down the total amount of planters' contribution.

Table 4.3
Quantity of natural indigo exported from India and average price, 1895-1905

Year	Total export (in cwts.)	Total value (in Rs.)	Price (In Rs. and Paise /cwt.) 1 Rupee = 100 Paise
1895-1896	187,337	53,545,112	285.82 (i.e. Rupees 285 and Paise 82)
1896-1897	169,523	43,707,570	257.83
1897-1898	133,849	30,574,019	228.42
1898-1899	135,187	29,704,781	219.73
1899-1900	111,420	26,925,107	241.65
1900-1901	102,491	21,355,808	208.37
1901-1902	89,750	18,522,554	206.38
1902-1903	65,377	12,056,819	184.42
1903-1904	60,410	10,762,026	178.15
1904-1905	49,252	8,346,073	169.46

Source: ***Indian Planters' Gazette and Sporting News*****, September 8, 1906: 299**

The indigo industry in India was indeed in a sorry state. Those planters that stayed in business increasingly felt the financial squeeze as the price fetched by natural indigo in the international market continued to drop. Director of Commercial Intelligence Noel Patton's Review of the Trade of India for 1906 gives indigo's export figures for the previous ten years from Indian ports, from which the average price fetched by natural indigo between 1895- 1905 can be deduced (see Table 4.3 above). As the prices dropped and consequently profit margins kept shrinking, the planters pleaded for a "free ride," – they sought and received government's support for continuing their experiments.

At the same time, the planters' stoppage of funds to Peeprah and Dalsingserai laboratories from 1903 also shows a certain lack of enthusiasm with work being done at those laboratories. The logic behind investment in scientific research was precisely to stop the slide in profits. If planters believed that science at their laboratories held clear promises to revive profitability, they would have continued to support those experiments. To find a definitive answer to this question we must again review the work performed at the chemical and agricultural laboratories. What had these laboratories achieved for the indigo industry? In what respects had they failed the planters?

The experiments conducted within the planters' laboratories between 1898 and 1903 had met with a mix of success and failure. Science had certainly resulted in yield improvement through perfecting the post-harvest extractive strategies and cultivating strategies. Quantifiable data is lacking as to how much yield improvement had precisely resulted. But a number of general remarks prove beyond doubt that the initial work at the planters' laboratories had proved to be beneficial in this regard. In his notes J. Woodburn, the Lieutenant Governor of Bengal reported the planters as saying that Christopher Rawson's "discoveries" had caused to "increase enormously the output of leaf and the output of dye." E. A. Hancock's experiments at Dalsingserai, it is reported, had also led to an increase in the indigotin content of the leaves.

However, among the most notable failures of scientists at this stage was their inability to produce indigo of a uniform quality. Rawson's attempts to refine indigo, first at Mosheri in 1901 with the help of slaked lime, and later at Peeprah in 1902 were successful in principle, but totally inapplicable on an industrial scale due to the complicated nature of the chemical reactions involved or their high costs. Anthony Travis has argued that the dyers and manufacturers in the Western markets switched to synthetic indigo because it maintained the uniformity of its color from batch to batch. Peter Reed has also counted the "consistency" of synthetic indigo as the single most important factor that attracted the dyers worldwide. Scientists found achieving consistency in natural indigo to be a particularly intractable problem. The researchers seemed to have reached a ceiling in their attempts to give Bihar's indigo the same level of consistency as given by factories to the artificial indigo through controlled chemical processes. [58]

The situation widened the gulf between the scientists and their patrons in India. Time was running out for the planters. While their scientists in laboratories continued to maintain that natural indigo had not yet passed into the realm of a "failed technology," most traders found the rhetoric of the scientists difficult to practice and live by. In the face of declining export of indigo from India and shrinking profits, the planter-businessmen found scientists' promises to deliver in future irrelevant. They needed immediate results that the scientists were not in a position to offer. It is this different reading of the situation between the scientists in laboratories and the planters that brought about the imminent closure of the laboratories, not planters' "distrust" in science or scientific research.

[58] "Mr. Rawson's report No 3," Agriculture, March 1901, File 2I/3; "Notes on Experimental Work done at Peeprah During the Morhan Mahai 1902," By Christopher Rawson, dated 11 August 1902" BSA, Agriculture, August 1903, File 2I/7; Anthony Travis, Rainbow Makers: The Origins of the Synthetic Dyestuffs Industry in Western Europe. Bethlehem: Lehigh University Press, 1993: 224; Peter Reed, "The British Chemical Industry," *British Journal for the History of Science* (1992) 25: 116

Epilogue: Eugene Charles Schrottky, The Java Variety

Perhaps it would be useful to note here that 1903 was not a year marked only by hopelessness in the efficacy of science and scientists. Just when planters within the indigo organizations withdrew support to indigo laboratories, others persuaded Eugene Schrottky to resume his trials with the manufacturing process. Schrottky returned to India from Java in 1896, and took a break from indigo experiments to teach botany and chemistry classes at the Grant Medical College in Bombay. Several planters implored him to resume his indigo experiments and trials in 1903. [59]

In 1903, Schrottky investigated a new process of fermentation at the Burhurwah outwork of the Turcouleah Indigo Concern. In his initial experimental trials he claimed to have obtained an output of 15 *seers* of indigo, analyzing 72.75 % indigotin, from 100 *maunds* of the plant. This compared very favorably with the usual output of 8-9 *seers* of indigo, testing 60-65% indigotin, from the same amount of the plant. Some planters responded with disbelief to Schrottky's claim of obtaining such a high yield, asking, "could he give us substantiated figures and state when and where he made his trials?" Later that year, Schrottky moved to Peeprah to repeat his trial with the *khoontee* crop at the factory of planter A W N Wyatt. He failed in replicating the high yield results of Turcouleah, which were carried out with the *morhun* crop. The German chemist blamed the inferior quality of indigo plant and the defective fermentation vat at Peeprah factory for the failure of his second trial. He also admitted that the process needed modifying in order to be applied to the *khoontee* crop, an aspect of his new invention that he was then

[59] Eugene Schrottky's letter to Behar Planters' Association Limited (February 1907), NAL, *Indian Planters' Gazette and Sporting News* (March 16, 1907): 297-301

turning his attention to. In subsequent years Schrottky continued to work towards perfecting his process, which he thought held promise for the future. [60]

The year 1903 provides a convenient point to end the chapter. The developments of the previous years had resulted in stoppage of funds from the planters to the two laboratories. Chemist Christopher Rawson, a very important figure in the indigo experiments being conducted in India so far, left for England in the beginning of the year expressing hopelessness with the progress of his experiments.

But even as the planters were exasperated with the returns from the existing laboratories, there were other developments in parallel that sustained hope. It was in 1898 that for the first time seeds of a new variety of indigo plant, the Java variety, were imported by a group of entrepreneurial planters to be tried out on their private estates in Bihar. Initial trials by this handful of planters seemed to indicate that the new breed was capable of a much higher yield. That excited the planters who asked their agricultural experts at Dalsingserai to further investigate if the new breed was actually capable of higher yield consistently, and if it could be successfully grown year after year in the local environs. The experts were optimistic, although they were still encountering a few problems related to the seed's germination. More seeds of the Java variety were grown in Bihar and more extensive cultivation of the new breed undertaken by the planters. Over these years the experts also confirmed that the new variety, if successfully cultivated, could give at least 50% higher yield than the native variety. At least theoretically this was

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[60] Eugene C Schrottky, "Extract from circular letter to Behar Planters, dated, the 14th September, 1903," NAL, *Indian Planters Gazette* (February 27, 1904): 284; for the planters' suspicion of the scheme see, NAL, *Indian Planters' Gazette* (March 12, 1904): 344; for Schrottky's response to the planter's letter see NAL, *Indian Planters' Gazette* (March 19, 1904): 377- 378; In subsequent years Schrottky performed more experiments and explained the nature of his "glucosode" process. A study of those efforts will be included in the next chapter.

the most drastic improvement in yield that had ever seemed possible to the planters since the beginning of efforts in India to improve the yield of natural indigo after 1897. The question now was to solve the problems related to the acclimatization of the new breed. But at least the planters were provided with a glimmer of clear hope.

Thus Java indigo rekindled optimism. The planters increasingly believed that they had a definite tool in the new variety to beat the competition from synthetic indigo. Based on this optimism they persuaded the government to fund their new research program that was qualitatively different from the previous one. A study of the developments leading to the establishment of new laboratories and agricultural stations and the nature of scientific explorations at those centers will form the subject of study for the next chapter.

CHAPTER 5

THE GOVERNMENT LABORATORIES, 1903-05

1) *Introduction*

This chapter focuses on the indigo laboratories supported by the government's funds in India between 1903 and 1905. Even as the Peeprah laboratory closed down in early 1903, the colonial administrators stepped in to support the other indigo laboratory cum agricultural station at Dalsingserai. They hoped to transfer the ongoing agricultural experiments and trials at Dalsingserai to a new station that they soon planned to set up at Pusa. The Pusa Station was supposed to focus on all crops including indigo. Subsequently discussions continued among the officials in Bengal, at the center, and in the office of the Secretary of State in England over what kind of station Pusa was going to be, which inevitably delayed its inauguration. Bureaucrats basically debated to resolve questions like under whose control the new station would be – the center or the province, and which crops would the station focus on. Money also had to be provided for Pusa and final approval for its opening had to be sought from the Secretary of State. In these circumstances the provincial officials went ahead to set up a new indigo laboratory at Sirsiah in late 1904 realizing that the problems faced by the indigo industry could not wait for the resolution of issues related to Pusa. Later the Sirsiah Station was allowed to continue as a center exclusively devoted to indigo under the control of the provincial government. An Imperial Agricultural Institute was inaugurated at Pusa in 1905, which developed into British India's first and leading agricultural resource center emphasizing research, education, and outreach programs covering *all* crops in colonial India.

The administrative decision to continue the Dalsingserai Station and later set up the Sirsiah Station got entangled in complicated ways with the goal of the metropolitan and central government officials to start the Imperial Agricultural Station at Pusa. The Bengal government owned the Pusa estate. Initially they had hoped to start their own agricultural station at Pusa. They wanted to turn Pusa into a center of excellence devoted to supporting agricultural progress in the region. Later, when the central government showed interest in setting up a far larger "imperial" center under the central government at the same site, the provincial bureaucrats more than welcomed that proposal. They offered to make land available to them for the purpose hoping that the location of a prestigious center in the province would also benefit regional agriculture. In that context, this chapter focuses on the bureaucratic debates at the imperial and at the provincial level to understand the impulses behind the decision to support the three laboratories and agricultural stations all of which were situated within the sub-division of Bihar.

The existing literature on the subject has considered all official efforts leading to the establishment of indigo laboratories and, more importantly, the Pusa Station, as efforts basically directed at securing the interests of the European planters. Why was Pusa set up in the Bihar sub-division in the middle of indigo tracts? Why was Bernard Coventry, the head of the indigo station at Dalsingserai, appointed to lead the Imperial Agricultural Institute at Pusa? Based on these two facts historian Deepak Kumar has considered all such efforts as being primarily directed towards benefiting foreign capitalists, not native agriculture. [1]

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[1] Deepak Kumar, *Science and the Raj*: 152-158; Deepak Kumar, "Science in agriculture: A study in Victorian India," *Asian Agri-History* (1997) 1 No. 2: 91-92

Such arguments are only partly true. A consultation of the official records describing the bureaucratic debates enables an understanding of the style of functioning of the colonial bureaucracy as an additional factor determining the nature of decisions taken with regard to the indigo industry. Metropolitan, imperial, and provincial concerns on the question of indigo improvement or overall agricultural progress in the colony were different, which made the administrators often act at cross-purposes. In the extremely bureaucratized set-up in colonial India the motivations and consequent decisions taken at the three levels had major consequences. A study of that process is insightful not only for understanding the nature of policies adopted with regard to indigo experiments and the indigo industry, but also for furthering our current understanding of the late colonial state in India. As we shall see below, they reveal the preparedness of metropolis and the central government to undertake agricultural research in India for its own sake. At the same time in so far as these efforts took some attention away from the patronage of indigo laboratories, they also point towards the changing nature of the colonial state that was trying to re-define its relations with the European economic interests based in India.

Besides discussing the bureaucratic motives this chapter also follows the scientists and their work in the laboratories. What goals did the scientists pursue? Which research strategies were preferred by different experts and why – chemical or agricultural, intervention in the vat or in the field? The dilemma over chemical and agricultural experiments was probably the most important one confronting the scientists and the administrators in colonial India at the beginning of the period in question. By 1905, however, it had been practically decided to focus solely on agricultural experiments in India. Whatever little experimental and analytical work of a primarily chemical nature had remained was transferred to the University of Leeds in 1905. This chapter will disclose the reasons for abandoning the chemical experiments in India, a decision that emerged out of the experience in the laboratories between 1903 and 1905.

The Juxtaposition Of Pusa And The Indigo Laboratories In Bureaucratic Decision-Making

The Proposed Alliance Between The Government And The Planters For Research Prior To 1903

The bureaucratic way of evaluating economy and administrative expediency had its typical dynamics. The officials of the agriculture department in colonial India did not always look at their obligation to promote indigo experiments independently of their obligation to promote scientific research on all agricultural products. As government servants they tried to balance the interests of an important industry, indigo, with that of all other agricultural crops. In doing so they aspired for economy in their efforts. They often found themselves asking if a way could be found so that the government's money was spent in a manner to bring optimal benefit to indigo as well as other crops.

The administrative machinery also abided by its own internal dynamics. Professional rivalries, personal energy, and motivation of key administrators and imperial figures determined what policy decisions were made with regard to experiments on indigo. Additionally, regional goals and commitments also influenced the decisions of the officials. For instance, on numerous occasions the provincial bureaucrats in Bengal went out of their way to argue with the central bureaucrats the case for the protection of the indigo industry based in the region.

In early 1901, when the planters approached the government for the second time requesting additional financial support for their indigo experiments, some officials wondered if they could forge an alliance between the private indigo interests and the government towards starting the Pusa station. The idea was to pool all available resources to initiate a comprehensive agricultural research program that would address the needs of all crops including indigo. Especially the federal agricultural bureaucrats favored this route.

This question was discussed at a confidential meeting on March 6, 1901, when a group of central agricultural bureaucrats including George Watt, the Advisor on Economic Product and J E O'Connor, the Director-General of Statistics met with the Revenue Secretary of the province of Bengal, F A Slacke. O'Connor strongly emphasized the necessity of combining the work of private indigo stations with the agricultural station that they were planning to set up. George Watt supported the suggestion citing the example of the initiatives taken in Ceylon where the government and the tea industry had come together to conduct scientific research. A similar arrangement for collaboration between the government and the industry could be worked out in Bengal, too, and placed under a Board of Control comprising of the representatives of the government and the indigo associations, he argued. [2]

The provincial Secretary, Slacke, agreed that the proposal for an alliance was a sound one. However, in his subsequent letter to the Lieutenant Governor of Bengal, J

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[2] Confidential, "Minutes of the Proceedings of Meeting held at the office of the Revenue Secretary to the Government of Bengal, on 6th March, 1901, to consider the question of an Agricultural Research Institute at in the district of Darbhanga," Government of India, Proceedings of the Department of Revenue and Agriculture for 1903, February, 1903, File No. 72 of 1902, Serial No. 1, India Office Library, P/6592 (These files are available for consultation at the British Library in London under the general rubric of India Office Records. Henceforth these files are referred to as: IOR, GOI, Proc. Rev & Agr

Woodburn, he pointed out that working out the modalities for such collaboration would take time. Besides, many other financial and executive issues remained to be resolved before the Pusa could go on stream. He begged to differ from the line advocated by the central government officials that the idea of collaboration with the planters should be pursued, and that a decision about a subsidy for their experiments should be put on hold. He pointed out that the indigo industry was in a crisis and the planters' experiments required immediate help from the government. His argument prevailed. Thus the Bengal government went ahead to provide financial support to the indigo planters from 1901. [3]

A Provincial Station At Pusa?

The proposal to start an agricultural station at Pusa was first initiated by the Bengal government. The provincial bureaucrats made a case that the province was a large one and that the existing agricultural stations at Dumraon, Burdwan, and Chittagong were too small and therefore not sufficient to meet the requirements of agricultural improvement in the province. In a letter to the Secretary of the Revenue and Agriculture Department at the center these officials also lamented the fact that the office of the Director of the Agricultural Department in Bengal was both understaffed and short of an adequate number of agricultural experts on its rolls. In fact, they rhetorically argued that the department was worse off than at the time when it was first opened in 1885. It was also comparatively deficient than similar departments in other provinces. Thus they made

[3] Revenue Secretary, F A Slacke's letters to Lieutenant Governor, dated Feb 2, 1901 and March 14, 1901, Notes and Orders, Government of Bengal, Revenue (Agriculture), File 2 I/3, 1-7, May 1901. These files are available at the Bihar State Archives in Patna (India). Henceforth, these files have been referred to as BSA, GOB, Rev (Agr.).

a case for the sanction of a large research station at Pusa that would be devoted to improving the quality of all crops in the province and in the region. The Lieutenant Governor was willing to provide Rs. 50,000 out of the state's budget for this purpose. He pointed out that since other provinces in north India could utilize the results from the station, the central government and the government of the neighboring United Provinces should also provide supplementary funds for its establishment and operation. [4]

The central government had its own plans to set up an Imperial Agricultural Station in India. This came out of considerations totally unconnected with indigo. In a letter seeking sanction from the Secretary of State in England the Indian Viceroy, Lord Curzon, pointed out how the plan for a centralized station was within the remit of long-term official plans for agricultural improvement in India. With that aim the government had appointed an Inspector General of Agriculture in 1901 "as a first step towards the more active prosecution of the policy of scientific and practical enquiry and experiment in agricultural matters," the Viceroy's letter noted. In continuation of the same plan it was now considered imperative that the Inspector General have his own team of experts and a well-equipped laboratory at a central station. [5]

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[4] Letter from W. C. Macpherson, Officiating. Secretary, Government of Bengal to Secretary, Govt of India, Department of Revenue and Agriculture, dated June 30, 1902, "Utilization of Government Estate of in Darbhanga for Agricultural Experiments," No. 9, File no. 72, Serial no. 1, IOR, GOI, Proc. Rev & Agr, Feb 1903, P/6592

[5] Letter from the Viceroy's Council to the Secretary of State for India, dated June 4, 1903, "Establishment of an Experimental Farm in , Darbhanga," No. 7, Serial No. 2, IOR, GOI, Proc. Rev & Agr, July 1903, P/6592

Lord Curzon, American Philanthropy, And The Accelerated Drive Towards A Central Agricultural Station At Pusa

The plan for the Pusa Station now got a new twist. The central government had initially thought of locating their new station in Dehradun, a hill-station with a colder climate. The government's agricultural chemist was already stationed there. The cold weather of Dehradun was considered conducive to the conduct of experiments on agricultural crops, especially the bacteriological ones. In the meantime the officials of the Bengal government wrote pointing to the availability of the 1,284 acres farm at Pusa, and also of providing Rs. 50,000 from their budget for their provincial station with assistance from the central government. The government officials at the center looked at the proposal within the parameters of their own plans. Could they utilize the same site for setting up their own station? A committee established at the center to inspect and report on the suitability of the site gave a favorable report. Most importantly, the government officials considered the availability of the large farm at Pusa to be a distinct advantage over the hilly Dehradun since the results obtained at the station by the experts in the laboratories and experimental plots could also be tested at the adjoining large farm. Thus they gradually leaned towards the choice of Pusa as a site for the central station.

The central government accepted the offer of the Bengal government for the site, and their money, and then contributed their own resources towards Pusa. But they also got the provincial government to agree that regardless of their support with land and finances the station would be an "imperial" one and that the central government would exercise complete control over it. They clarified to them that the provincial government did not have the staff with the requisite training to supervise and manage an institution of the size they were contemplating. Besides they also considered that it would be wrong on the part of the central government to invest so much "imperial" resources into an institution and then leave it in the hands of a provincial administration. The imperial government in fact decided that they would turn Pusa into the headquarters of the central government's agricultural department. The Bengal government accepted the proposition, being more than happy that an establishment of that size was going to be located in the region. Thus the way was opened for the establishment of Pusa. [6]

The year 1903 saw more concrete steps being taken in the direction of starting the central station. For the first time it seemed possible that the planned agricultural research station would become a reality. The establishment of Pusa got tied up with the personal pride and motivation of a very important imperial figure in India. Support for the idea of a research station at Pusa came from the very top of political and administrative establishment – from Lord Curzon, British India's eleventh viceroy. Lord Curzon is widely known to the historians of modern India for his unpopular act of bringing about the administrative division of Bengal, an act that provoked a nationalist uprising – what has been called the Swadeshi movement in the historiography. [7] But even his detractors in England and India acknowledged Curzon's contributions in initiating a series of reform in the fields of general administration, police, agriculture and revenue collection, *and* science.

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[6] Letter from the Viceroy's Council to the Secretary of State for India, dated June 4, 1903, "Establishment of an Experimental Farm in , Darbhanga," No. 7, Serial No. 2, IOR, GOI, Proc. Rev & Agr, July 1903, P/6592

[7] For a discussion of Curzon's role in the division of Bengal that turned out to be a hugely unpopular step with the masses see Sumit Sarkar, *The Swadeshi Movement in Bengal, 1903-1908* (New Delhi: People's Publishing House, 1994)

Curzon was a science enthusiast. He had a vision of scientific research that would enable an optimal utilization of the agricultural resources of the colony. He worked relentlessly towards this goal, not even letting the scarcity of funds dampen his efforts. He canvassed for support. Finally, an American philanthropist, Henry Phipps, donated £20,000 to Curzon for the establishment of "a laboratory to determine the economic value, and the medicinal qualities of the plants of India – or to be used in any other way that promises enduring good to India." It was decided to use that money to set up the Pusa Station. As plans settled for establishing the Pusa station Henry Phipps, encouraged by the efforts of the colonial administrators, donated an additional £10,000. [8]

Curzon put his personal pride behind this project, and did everything he could to bring the project to a successful completion. He envisioned the agricultural station to be "a centre of Economic Science," meaning that the researches carried out there should bring economic benefits to Indian agriculture. His topmost bureaucrats in the Viceroy's Council, including Sir Denzil Ibbetson, the Lt Governor of Punjab and John O Miller, Secretary of Revenue to the central government, joined in the efforts to bring to completion what came to be called in official circles "the Pusa scheme."

The Secretary of State in London approved the Indian Viceroy's plans for establishing the station at Pusa. He commended the initiative of the Viceroy in this regard

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[8] Letter from the Viceroy's Council to the Secretary of State for India, dated June 4, 1903, "Establishment of an Experimental Farm in , Darbhanga," No. 7, Serial No. 2, IOR, GOI, Proc. Rev & Agr, July 1903, P/6592; Letter from Curzon to Henry Phipps, dated January 28th, 1904, No. 225, Letter from J. O. Miller to Henry Phipps, No. 227, Letter from Henry Phipps to Curzon, dated March 12, 1904, No. 301, The Lord Curzon: Correspondence with Persons in England and Abroad Commencing from July 1901 (confidential), European Manuscript, F111/182, India Office Records (the British Library, London). Henceforth referred to as IOR, Curzon Papers; Letter from Curzon to Henry Phipps, dated, April 27, 1905, No. 28, Letter from Henry Phipps to Lord Curzon, dated, July 24, 1905, The Lord Curzon: Correspondence with Persons in England and Abroad Commencing December 1904 (confidential), European Manuscripts, F111/183, IOR, Curzon Papers.

echoing the necessity of agricultural research and education in the colony. He agreed that the new research cum college at Pusa would serve the stated purposes well. [9]

The Dilemma Faced By The Bureaucrats In 1903

Indigo Versus Other Crops: Explaining The Colonial Agenda

In 1903 the central colonial officials at Simla and in the province (Bengal) were generally at odds as to how they should apportion their resources between the indigo laboratories and a centralized agricultural research station dedicated to research on all native crops that they planned to set up shortly. On the one hand, the officials were motivated to support the experiments of the indigo planters of European origin. On the other hand, the bureaucrats in India were also excited with the prospect of setting up an agricultural research station at Pusa in Bihar that they hoped would become the backbone of agricultural progress in colonial India. A study of how the bureaucrats resolved their dilemma is insightful because it provides an opportunity to evaluate the nature of the late colonial state in India.

As argued in Chapter One, the colonial state reflexively adjusted to the new political and fiscal realities. At the end of the nineteenth century the colonial officials generally watched the growing tide of national movements in the subcontinent with alarm, especially in Bengal, which was one of the epicenters of native political resistance. The last thing the administrators wanted was a restive plantation labor force and aggrieved indigo contract-cultivators. Thus when the problem of competition from

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[9] Letter from the Secretary of State, dated Aug 14, 1903, Selections from Despatches Addressed to the Several Governments in India by the Secretary of State in Council, 46th Series, Part II, 1st July-31st December, 1903, India Office records (British Library, London), V/6/350. Henceforth referred to as IOR, Despatches.

synthetic indigo first arose in 1897, the state forbade the purely exploitative way of wage reduction on the plantations by the European planters to reduce the cost of the natural dye. The way that support for Pusa deflected resources away from indigo laboratories provides an additional opportunity to study how the colonial state was re-defining its relationship with European economic interests based in India. Thus it supports the larger argument made in this dissertation that the technological history of the natural indigo industry of British India provides an opportunity to evaluate the nature of the late colonial state in new terms.

It is in this context that the debates occurring among administrators about Dalsingserai laboratory and Pusa research station assume extra importance. Deepak Kumar, the historian of science in colonial India, has analyzed the response of the agricultural bureaucracy in the setting up of indigo laboratories simply as an effort to advance the sectional interests of the "colonialists." The enterprise of the European planters, after all, fitted well into the overall colonial agenda of the exploitation of native resources for the benefit of the metropolis, and by the foreigners. It was therefore only natural that the colonial administrators should support planters' efforts, he has argued. In fact, Kumar goes on to accuse the administrators of partisanship in selecting Pusa as a site for the new station on agricultural research and education. Embedded in the indigo tracts, and headed by the ex- indigo expert from the Dalsingserai laboratory, Bernard Coventry, the setting up of Pusa, Kumar argues, was inspired by the wish to help out indigo planters. [10]

[10] Deepak Kumar, *Science and the Raj*, pp., 152-158; Deepak Kumar, "Science in agriculture: A study in Victorian India," *Asian Agri-History* (1997) 1 No. 2: 91-92

There is a certain truth to Kumar's general line of reasoning. The administrators and planters belonged to the same political and economic "class" even if their acts were not always in harmony. To deny that would be to deny the existence of a colony and of colonialism. They also belonged to the same social group. The planters had social and personal ties with each other and with members of the British civil services that extended within their networks back in the home country.

But there were also countervailing interests at work that generated conflicts between the government officials and planters, and complicated the synergies between the process of governmental decision-making and the requirements of indigo business. It is indeed in calling everyone simply a "colonialist" that the anti-colonial discourse fails to capture the complexity of factors at work. For instance, it does not account for the difficulties that the planters encountered in persuading the administrators to subsidize their indigo experiments. Nor does it capture the spirit of public policy measures leading to the establishment of the Pusa station that were intended to serve the general good of *all* farmers going beyond merely the sectional interests of the European indigo planters. Indeed the study of records related to the setting up of indigo laboratories and the Pusa station disturbs the earlier picture painted by historians like Deepak Kumar and allows an alternative explanation of the bureaucratic efforts made in this regard.

The Planters Ask The Government To Take Over Dalsingserai

As pointed out at the end of the previous chapter, in the beginning of 1903 the planters stopped providing funds for the Peeprah and the Dalsingserai Station. In a private meeting with the Lieutenant Governor J Woodburn at the hill station Darjeeling earlier in June 1902, a group of planters explained that the planters' bodies were facing difficulties in persuading their members to send subscriptions, and that it was thus impossible for the organization to provide the money that they had earlier committed to support the laboratories. Thus they suggested that the government take over the Dalsingserai Station and take responsibility for continuing the experiments in progress there. [11]

There is a danger in reading too much into the stoppage of funds from the planters. The significance of the fact that the planters halted the supply of funds through their organizations BIPA and IIS can be considered in two ways. Does such a lack of willingness to provide financial support in 1903 indicate the planters' lack of faith in science? Second, did the passing over of the management of laboratories from the planters' hands into government's control have a long-term effect on the nature of indigo experiments?

The assumption about planters being anti-science is contradicted by the fact that the planters continued to be partners in research with the government for several years after 1903. They had a qualified response to the type of work being done at the two laboratories. As far as Peeprah Station is concerned, it would be fair to say that the lack of returns from this laboratory had frustrated the planters. But they were optimistic about the outcome of work being done at Dalsingserai. That was in keeping with the nature of the Dalsingserai Station that specialized in agricultural experiments. The planters were

[11] Revenue Secretary W C Macpherson's note, dated June 3, 1902 and Lt. Governor J Woodburn's note, dated, June 9, 1902, Notes and Orders, pp., 6-7, BSA, GOB, Rev (Agr.), June 1902, File, 2I/3 of 10-14

hopeful that the agricultural trials could prove rewarding in terms of the adaptation of the foreign breed of the Java plant for cultivation in India.

But the planters now wanted to be “free-riders” in the scheme of scientific research currently in progress. In other words, they wanted public funds for their experiments. In a way there was nothing new about the planters’ demands for public funds. From the very beginning they had maintained that they were entitled to the government’s financial support for research whose benefits were going to be industry wide. The government first provided limited subsidy to the indigo experiments in 1900. In 1901, the government made much more money available to the planting organizations in the ratio of three-fifth contribution from the planters to two-fifth from the government. Facing financial losses and in the absence of any immediate returns from the laboratories, in 1903 the planters requested the government to take full financial responsibility for their indigo research program.

An entitlement to public funds by the planters was not considered an oddity – not in the way the planters perceived the question, nor in the way the government defined its role. From the very beginning the planters had claimed that an important industry on which the livelihood of thousands of Europeans and natives depended, was threatened. In such a situation it was only appropriate for the government to provide all types of support. Besides, the planters assumed that the government had to perform the role of a primary provider of scientific infrastructure based on which private entrepreneurship could prosper. And indeed the government readily accepted that argument.

The year 1903 turned out to be a watershed in organizational terms. Although the planters were delegated the operational control of the Sirsiah Laboratory, the administrators gained a deciding voice over the type of experiments to be conducted in the laboratory. Which experts were to be appointed? What research trajectory was going to be preferred? The government offices and bureaucratic deliberations became additional elements shaping the resolution of these questions. The future of indigo experiments in India after that date was thus additionally influenced by how the government officials perceived the problem.

The future of the indigo laboratories remained uncertain at the beginning of 1903. The planters had stopped their contribution, and there were no concrete plans under consideration to save the laboratories, or replace them. Only a fortuitous combination of circumstances and steps, as we shall see below, ensured the survival of the Dalsingserai Station.

The Agricultural Bureaucracy And Dalsingserai

To understand the survival of the Dalsingserai center beyond 1903 as a laboratory supported on government's funds it is important to understand the type of work being performed there. More precisely, it is also important to bear in mind how the "agricultural" laboratory at Dalsingserai had come to win the favor of the agricultural bureaucracy in Bengal, especially compared to the treatment the "chemical" laboratory at Peeprah had recently received.

At the provincial level, there was no slackening in the commitment to help with indigo experiments. But the officials in the beginning of 1903 differentiated between the chemical laboratory at Peeprah and the agricultural station at Dalsingserai; they evaluated the usefulness of the work at the respective laboratories differently. The provincial bureaucrats seemed to have accepted the position by now that there was little hope of improving the extractive processes beyond what Rawson had already achieved at Peeprah. They thought that future prospects for improvement largely lay in improving the output of the crop in the field and the percentage of color in the leaves.

Some of this optimism from agricultural experiments was certainly linked to the prospects that the newly imported Java variety was showing. Besides, many of the administrators also thought that the salvation from the problem of competition from synthetic indigo for the planting community chiefly lay in divesting into other agricultural crops. Mollison's note, widely cited in the relevant orders and circulars of the government of Bengal, provides a snapshot view of the current official perspective on indigo research in India. The note from the Inspector General for Agriculture in India said:

> Indigo should not be neglected, but in my judgment laboratory investigation regarding crops[,] which can profitably take the place of indigo are much more important if the main object is to help the interest of the planting community. [12]

The agricultural bureaucracy at the provincial level largely endorsed the policy as outlined in Mollison's notes.

The Dalsingserai station, then, seemed to be a better site for pursuing the agenda of the provincial agricultural bureaucracy than Peeprah. From the beginning the chemical laboratory had focused on improving the post-harvest extractive processes. Its head, Christopher Rawson, was a trained chemist. In contrast the Dalsingserai station was a

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[12] Mollison's notes as cited in BSA, GOB, Rev (Agr.), December 1903, File 2I/8 3, Notes and Orders: 3

“composite” laboratory cum field station attached to the private indigo estate of an indigo planter, Bernard Coventry. From the very beginning the experts at Dalsingserai had combined the experiments on indigo with those on other crops like sugarcane and the fiber rhea in particular. Coventry himself, described in agriculture department files as “a trained agriculturist,” enjoyed a better rapport with the agricultural officials than Rawson. It is no wonder then that Coventry’s station won the race against Peeprah for official funds.

Meanwhile, as the drive towards setting up such a federal station for agricultural research at Pusa gathered momentum, it crossed paths with the commitments of the provincial administrators to patronize indigo laboratories. Central bureaucrats, Ibbetson and Miller in particular who were trying to advance Curzon’s agenda, wanted to raise as much resources as possible for Pusa. They tried to rope in Bihar’s governor, J A Bourdillon in their efforts. They asked that the provincial administration turn over funds earmarked for the indigo laboratories in the provincial budget for Pusa.

In support of Coventry’s efforts at Dalsingserai and partly also in deference to the wishes of the central government officials, the new Lt Governor of Bengal, J A Bourdillon, ordered a new grant. As shown by his personal communication with Sir Denzil Ibbetson, the Lt Governor of Punjab, Bourdillon had for some time been considering support to the Dalsingserai station. If the Peeprah laboratory closed, as it seemed it would because of lack of initiative from the BIPA, Bourdillon had assured Ibbetson that he would divert all of government’s funds apportioned for the improvement of indigo to Dalsingserai. [13]

[13] Sir Denzil Ibbetson’s letter to Lt Governor, J A Bourdillon, dated March 10, 1903, BSA, GOB, Rev (Agr.), December 1903, File, 2I/8 3, Notes and orders

Another section of the bureaucracy, mostly comprising officials at the federal level, favored the continuation of Dalsingserai experiments on totally different grounds. They wanted to retain the personnel at that station simply so that they could be re-employed at the Imperial Agricultural Station at neighboring Pusa in 1905. The Secretary of Revenue to the federal government, John O Miller, bypassed the provincial government to contact Bernard Coventry and asked him to submit to him directly a budget towards continuing the experiments at Dalsingserai for the current year. Miller later forwarded that budget to the provincial revenue officials requesting its approval.

Miller did not have a long-term interest in the experiments at Dalsingserai, which is proven by the fact that when Coventry submitted a demand for supplementary funds for the continuing experiments there, Miller turned down his request. He pointed out that the previous support for the station was purely of a temporary nature. Sir Denzil Ibbetson's letter to Bourdillon, who was also in the forefront of efforts to start a federal research station at Pusa, also discloses similar intentions. Ibbetson stated that there would be no point subsidizing or taking over the operations at Peeprah, a laboratory "which is concerned solely with [the] manufacture of indigo." As contrasted with the primarily chemical experiments at Peeprah, the agricultural experiments at Dalsingserai appeared more useful to Ibetson in terms of his plans of shifting experts from there to the central agricultural station at Pusa. He recommended immediate financial help to Coventry:

> It is important that he [Coventry] should get [to retain] some of those employed there, as we know them to be good men, and, above all, they have the experience of the Indian conditions, the want of which so hampers a man

new from England. And if you cannot give money *at once* I fear that the work must be stopped, the staff dispersed, and a great opportunity lost.

The conflating of the interests of the bureaucrats wanting to protect the indigo industry through agricultural experiments, and those wishing to centralize agricultural research at Pusa, ensured the provision of funds temporarily to Dalsingserai for the year 1903. The new secretary of revenue, A Earle communicated the decision to advance government's monetary support to Dalsingserai. [14]

Cyril Jonas Bergtheil And His Experiments, 1903

Bergtheil's Future Employment: With BIPA Or The Government?

At the time of the closing down of BIPA's Peeprah laboratory on 1st January 1903, Cyril Bergtheil's future employment in India looked uncertain. The term of Bergtheil's contract with the BIPA had not ended. But short of funds the BIPA was not in a position to either keep the laboratory running or retain Bergtheil. The BIPA functionaries first turned to the Department of Agriculture requesting further grants in order to be able to pay Bergtheil's salary for a few additional months. They also suggested to the government that Bergtheil and biologist H M Leake could be possibly employed at Dalsingserai that had been taken over by the government. They submitted that they would be able to pay remunerations due on Bergtheil for the intervening period if the government could offer him employment at Dalsingserai in the near future.

[14] See the reference to J O Miller in the letter from Bernard Coventry to Commissioner, Patna, dated, May 1, 1903, BSA, GOB, Agriculture, December 1903, File, 2I/8 5-17, Nos. 67-68; Sir Denzil Ibbetson's letter to Lt Governor, J A Bourdillon, dated March 10, 1903, BSA, GOB, Agriculture, December 1903, File, 2I/8 3, Notes and Orders; letter of A Earle, Revenue Secretary to Commissioner, Patna, dated, March 21, 1903, BSA, GOB, Rev (Agr.), December 1903, File, 2I/8 3

Sympathetic to planters' financial plight S L Maddox, the head of the Department of Land Records and Agriculture, argued with senior officials that Bergtheil be re-employed at Dalsingserai. [15]

The provincial government in consultation with Bernard Coventry offered to re-employ H M Leake at the Dalsingserai Station from 28 November 1903, after his contract with the BIPA came to an end on 20 November 1903. However, the Revenue Secretary turned down the request for hiring Bergtheil to work at Dalsingserai, calling the proposal "impracticable." Instead he suggested that if the BIPA was not in a position to pay the salary due to Bergtheil, they should terminate the contract with him prematurely, and compensate him for the early termination of his services. They advised the BIPA to come to an amicable solution with Cyril Bergtheil that would be mutually agreeable to the two parties. [16]

It is not difficult to see why the provincial bureaucrats did not commit to hire Bergtheil. The qualifications of biologist Leake seemed more suitable for the type of agricultural experiments in progress at Dalsingserai as well as in tune with the future plans of conducting agricultural research at Pusa. In contrast, Bergteheil's credentials were established more as a bacteriologist dedicated to research on indigo. The plans for future indigo experiments were still in a state of flux. The provincial administrators were still not sure whether the indigo laboratory was going to be located at the Pusa Station to

[15] Letter from Secretary of BIPA, E Macnaghten to Commissioner of Patna Division, dated, April 9, 1903, BSA, GOB, Rev (Agr.), December 1903, File 2I/8 5-17, Nos. 64-65; letter from S L Maddox to Revenue Secretary, Bengal Government, dated, July 13, 1903. copy of letter from Cyril Bergtheil to E Macnaghten, dated, June 26, 1903, BSA, GOB, Rev (Agr.), December 1903, File 2I/8 5-17, Nos. 70-71

[16] Letter from A Earle, Revenue Secretary, Bengal Government, dated, 14 August, 1903, to the Director of the Department of Land Records and Agriculture, BSA, GOB, Rev (Agr.), December 1903, File 2I/8 5-17, No 75.

which they had volunteered to contribute, or if it was going to be housed in a separate indigo station. It was perhaps too early in the day for the bureaucrats in Bengal to commit to Bergtheil's employment even though they appreciated his credentials as a man well versed in work with indigo.

It is interesting to note that around the same time the chemist currently at Dalsingserai, William P Bloxam, asked that a bacteriologist be employed at that station to work on the manufacture of indigo. However, he explicitly stated in his letter of request that Bergtheil be not considered for the position. In Bloxam's opinion it was important to understand the role that microorganisms present in soil played in the growth of the indigo plant. All the manure related experiments to date in India had been based more or less on "the rule of thumb." A bacteriologist, he thought, could be helpfully associated with the efforts to find appropriate manures and fertilizers. But he did not want Bargtheil to be considered. First of all, Bloxam thought that Bergtheil was trained as a chemist rather than a bacteriologist. Secondly, Bergtheil in Bloxam's opinion was "too inexperienced" to do the work Bloxam was proposing. [17] Bloxam's argument that Bergtheil was not a bacteriologist or that he was inexperienced are difficult to accept as facts. There are reasons to believe that Bloxam's negative opinion of Bergtheil was colored by his personal dislike and professional rivalry with Bergtheil. Indeed the differences between these two scientists persisted in the following years and left their mark on later scientific controversies.

Bergtheil's Experiments In A Temporary Location At The Sirsiah Factory

[17] Bloxam's "demi-official" letter to Bernard Coventry, dated May 1, 1903, BSA, GOB, Rev (Agr.), December 1903, File 2I/8 5-17, No 60-60 1/2

BIPA first began negotiating with Bergtheil if he would agree to prematurely terminate the contract of service that he had signed with the planters' body. BIPA was in disarray organizationally and its members were debating if BIPA's office should be totally folded up. The organization was unable to ensure that the members paid their subscriptions and was as a consequence facing a financial crunch. It could not even conduct routine matters on a day-to-day basis. Paying a salary to scientists then simply seemed impossible. Under the circumstances its office bearers turned to the government hoping that it would bail them out by employing Bergtheil at Dalsingserai. When the government refused to oblige, they began negotiating with Bergtheil to come to an agreement over his early termination.

Bergtheil was not very enthusiastic about his early retirement from the job. He mentioned that he had barely been in employment for close to a year, and that he was not contemplating taking up a job in England in the near future. While he wondered what kind of compensation the organization could offer to him, he leaned towards abiding by the original agreement. [18]

BIPA shifted Bergtheil to the Sirsiah factory temporarily where he continued his work. Not surprisingly a reference to his relocation to Sirsiah or to the work done by him during that period does not find mention anywhere among the government records. The bureaucrats had more or less washed their hands of this episode, and asked BIPA to resolve the issue of Bergtheil's continued engagement and work on their own. However, Bergtheil's privately published and circulated autobiography describes the events of these

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[18] Copy of letter from Mr. C. Bergtheil to Mr E Macnaghten, Secretary, Bihar Indigo Planters' Association, dated the 26th June, 1903, BSA, GOB, Rev (Agr.), December 1903, File 2I/8 5-17, Nos. 70-71

months and also provides a broad outline of the nature of experiments conducted by him there.[19]

Bergtheil tells us that the laboratory in Sirsiah was based at a "disused factory." The owners of the factory at Sirsiah had probably abandoned manufacturing operations there. It was not uncommon to find several such factories in Bihar at that time because planters were abandoning the indigo business by dozens every year. Bergtheil was actually quite pleased with the facilities for work and personal comfort at Sirsiah. The station had separate bungalows for himself and his two assistants. One of his assistants was Richard Victor Briggs, a chemist who had earlier worked with Christopher Rawson at Peeprah. The other was a general superintendent who helped with supervising the loading of vats in the experimental factory. The latter may have been a native.

Trained as a bacteriologist, Cyril Bergtheil continued to work on perfecting the fermentation processes in the manufacturing cycle. Those were the processes he knew best. Besides, he did not share the pessimism of his previous co-worker at the Peeprah laboratory, Christopher Rawson, that the fermentation processes could not be perfected with the available scientific knowledge. Bergtheil's *Autobiography* provides a compressed account of his work at the laboratory in Sirsiah where he subsequently went on to work for a total of nine years. [20] He also published a paper in the *Journal of the*

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[19] Cyril Berkeley, *My Autobiography* (privately published, n.d.): 9-10. A copy of the autobiography survives with Cyril Berkeley's granddaughter, Prof. Mary N Arai, a marine biologist based at Nanaimo in Canada. Henceforth referred to as: *Autobiography*

[20] Bengal Government established a permanent indigo station at Sirsiah in 1904 and retained Bergtheil at that station, as will be described later in the chapter.

Chemical Society that specifically describes the scientific experiments at Sirsiah in 1903.[21]

Bergtheil's work mostly revolved around studying what he called "enzymic fermentation" of the indigo leaves. He wanted to get a better understanding of the process that could possibly lead to knowledge of the favorable conditions for streamlining the method of steeping. He was thus building on the work accomplished in the previous year at Peeprah. His earlier report had documented that the presence of microorganisms (bacteria) in water and air, and the enzymes in the leaves, catalyzed the process of steeping as practiced in India. He was now turning his attention to the enzyme contained in the plant specifically.

Bergtheil's explorations were also partly inspired by a new "theoretical interest." The bacteriologist was at this time also getting occupied with the question as to how much *indigotin* was actually recoverable from the leaves. Working towards that he aimed to isolate the enzyme present in indigo leaves and the glucoside on which this enzyme acted, then use known quantities of the two to derive quantitative values.

Bergtheil faced problems in isolating the enzyme and the glucoside for the analytical side of his work. Preparing an extract of the enzyme in an active form that would readily act on the indigo leaf extract proved difficult initially. The enzyme was only partly soluble in cold water. Bergtheil found a lead through reviewing the work of another scientist working locally in India on foliage enzymes – Harold Mann. Mann had been working at the behest of the Indian Tea Association, the central government, and the

[21] Cyril Bergtheil, "LXXXIX The Fermentation of the Indigo -plant," *Transactions, Journal of the Chemical Society* (1904) LXXXV: 870 -892

governments of Assam and Bengal on tea experiments since 1899. [22] Mann had recently proposed in a published paper that the difficulty in extracting the enzymes from tea leaves was due to the presence of tannin, and that this problem could be overcome by fixing tannin with some reagents. On following the procedure in the case of indigo leaves, Bergtheil got encouraging results; he thought that the concentration of the enzyme in his enzyme extracts (and not the enzyme per se) was large enough for his experimental purposes. [23] His attempts to isolate the glucoside were less successful. After repeated attempts to isolate the glucoside failed, he came to agree with the proposition of Edmund Schunck, first published in 1855, that the glucoside present in indigo leaves, called *indican*, was far too unstable chemically to be isolated. It is worth pointing out that Bergtheil was aware of the works of Henri ter Meulen and Hoogerwerf published in Amsterdam in 1900 in which they described a procedure for isolating the crystalline *indican*. However, Bergtheil failed in replicating the experiments of the Dutch chemists, and instead decided to proceed in his analytical work using the "crude extract" of *indican*. [24]

Bergtheil did not let these bottlenecks in analytical exploration impede or slow down his work. With his less than precise specimens Bergtheil formed his tentative conjectures about the efficiency of the manufacturing process currently in use in India.

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[22] Deepak Kumar, *Science and the Raj*: 155-156

[23] It may be stated that the Dutch chemists by this time had already made considerable progress in terms of isolating and identifying the properties of the indigo enzyme, and named it indimulsin. Although initially these chemists did not intentionally publish this information hoping that it could be used for the benefit of the Java based indigo industry, by 1903 some of this information had definitely been published in journals. Bergtheil seems quite unaware of that information.

[24] Cyril Bergtheil, "LXXXIX The Fermentation of the Indigo -plant," *Transactions, Journal of the Chemical Society* (1904) LXXXV: 873 -877

These results convinced him that there was scope for improving output from steeping. He then went on to experimentally determine and recommend that a temperature between 46 and 51 degrees Celsius was ideal for maintaining optimal efficiency of the steeping processes. He also made other suggestions about whether acidity or alkalinity accelerated or impeded the fermentation process.

The Experiments At Dalsingserai, 1903-04

The insistence of the officials on enlarging the scope of research resulted in an additional focus on crops like sugar, rhea, and jute at Dalsingserai. As early as February 1901, the provincial government's Sugar Committee had indicated that the planters had the option of switching to sugar production. Later, throughout 1902, Coventry's trials with rhea had demonstrated that the planters also had the option of substituting indigo with rhea. At a time when the chemical experiments with indigo seemed to have hit a ceiling at Peeprah, the bureaucrats persuaded the experts to put additional focus on crops other than indigo.

Chemist William Popplewell Bloxam, biologist Hugh Martin Leake, and a newly appointed jute expert R S Finlow were brought together to work at Dalsingserai. Leake, who had been brought from the Peeprah laboratory, conducted his biological experiments. Bloxam, who had been appointed at Dalsingserai under the joint research program as finalized in 1901, conducted chemical experiments on indigo.

Leake At Dalsingserai

Leake was trained as a biologist. He had a degree from Christ's College at Cambridge in England where he had studied botany, zoology, chemistry, and geology. He was later a fellow of the Linnean Society in London. Before coming to Dalsingserai he had been the biologist for BIPA.

Leake used his expert understanding of the conditions of plant growth to modify some of the continuing experiments at Dalsingserai. He characterized Coventry's methods for applying fertilizers in his previous trials at Dalsingserai as being inadequate and reminiscent of those "in vogue in England some fifty years ago." Keeping in mind that indigo was a legume requiring a lot of nitrogen during growth, he drew on the current knowledge of biological sciences to suggest the application of two types of manures – carbonaceous manures in combination with a small quantity of sodium nitrate or ammonium sulfate; while the former would ensure the legume's long-term requirements of nitrogen the latter would supply the element in the short-term. The basic aim of improving the supply of nitrogen was to create a conducive environment under the soil for an effective functioning of the nodule bacteria in the plant's roots.

Again, basing his prognosis on the primary characteristic of indigo as a legume, which required the action of nitrogen fixing bacteria in its underground nodules, he called for a deeper investigation of soil mechanics. He made tentative suggestions regarding the preparation of field for the plant. A minimum of ten to twelve percent moisture in the second inch below the surface would ensure germination of the seed and the continued good health of the indigo plant. But the heat generated from the tropical sun and the resultant evaporation made retaining moisture in the sub soil a challenging task. Leake suggested "consolidation" of the land immediately after the use of the plough, and leaving a loose surface of dry or nearly dry soil at the top. Making the lower soil compact and ensuring a complete rupture with the layer of very loose and dry soil at the top would decrease capillary action that sent moisture upward and made it come into contact with dry air. Leake maintained that more trials were required to determine the depth at which the rupture point should be located. [25]

Leake also helped with Bernard Coventry's continuing attempts to classify indigo seeds supplied from different regions, and to regulate conditions for the cultivation of Java-Natal indigo. He conducted very extensive trials in the field with indigo supplied from different centers located to the west of Bihar and determined their respective potency. He also addressed the frequently encountered problem of development of a hard seed coat in Natal indigo, which prevented its proper germination in Bihar. Developing a hard seed coat was a problem that, Leake noted, appeared even in other *leguminosae* such as clover. Seed turning "hard" was particularly frequent in the case of Natal seed under Indian conditions; sometimes as many as 95% of the seeds developed the impenetrable seed coat. Leake recommended physical scratching of the seed coat, called "scarifying," as a solution to this problem. But the process being tedious, and requiring ample time and labor for processing, Leake applied himself to finding economical ways of treating Natal seeds on a large scale.

Lastly, Leake and Bloxam together made some effort towards localization of the color-yielding substance in the plant - *indican*. Their experiments in this regard were of a preliminary nature. They were totally independent of the parallel efforts of Bergtheil in

[25] W Popplewell Bloxam and H M Leake, with the assistance of R S Finlow, *An Account of the Research Work in Indigo, Carried out at the Dalsingh Serai Research Station From 1903 to March 1904.* (Calcutta: The Bengal Secretariat Book Depot, 1905): 1, Section I, 1-6 and Section IV, 36-42 (henceforth "Bloxam and Leake")

the same direction at Sirsiah, and quite preliminary compared *even* with those of Bergtheil. [26]

Further, to study the behavior of microorganisms present in the soil and in the nodules in a systematic manner, the scientists at Dalsingserai requested that a trained bacteriologist be employed. However, government officials turned down the request for the appointment of a bacteriologist and for building a separate laboratory dedicated to bacteriological experiments, pointing out that in view of the plans to shut down the Dalsingserai station it made no sense to expand its operations. [27]

Bloxam At Dalsingserai

At Dalsingserai, W P Bloxam designed his experiments differently from Rawson and Bergtheil. Rawson and Bergtheil had conducted vat experiments in the factories, tinkering with the fermentation, oxidation, and boiling processes and suggesting specific measures to improve yield. In addition, Bergtheil had in 1903 explored the question as to what amount of color could be theoretically extracted from the leaf. But these endeavors for Bergtheil were more in the nature of running a check to see if his current focus on the fermentation processes was the right line of query. Bloxam, quite distinctly from Bergheil, made a study of these questions the central focus of his efforts.

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[26] Bloxam and Leake, 29-42; A G Green, "William Popplewell Bloxam," *Journal of the Chemical Society Transactions* (1914) 105: 1197; W P Bloxam, *Report to the Government of India, Containing an Account of the Research Work on Indigo Performed in the University of Leeds, 1905-1907* (Published by Order of His Majesty's Secretary of State for India in Council, 1908): 116

[27] Bernard Coventry's letter to Revenue Secretary, Bengal and Commissioner, Patna, enclosing the letter of demand from Bloxam, dated, May 1, 1903, BSA, GOB, Rev (Agr.), December 1903, File 2I/8 5-17, Nos. 60-60 1/2; Revenue Secretary, Bengal, A Earle's letter to Bernard Coventry, dated, June 2, 1903, BSA, GOB, Rev (Agr.), December 1903, File 2I/8 5-17, No. 66

Bloxam too believed that the primary task at the hands of the chemists was to maximize the percentage of recoverable *indigotin.* But, having reviewed the works of his predecessors, Bloxam came to the conclusion that the appropriate approach to the problem lay in establishing, first of all, the total *indigotin* that could be obtained from any specimen of green indigo leaf. Then, in order to record at which stage in manufacturing the losses in recovery were taking place, one needed to accurately check the output of *indigotin* at different stages in the manufacture of indigo. Knowledge of these two facts could serve as a focusing device for guiding the future efforts of the experimenters. Bloxam's entire work at Dalsingserai was designed to meet these two goals. His analytical explorations did not stop there. Bloxam's strategy towards deriving the theoretical values of recoverable and recovered *indigotin* in turn encouraged him to test the accuracy of tests being used in India and abroad to measure *indigotin* percentages, and even to explore aspects of the "pure chemistry of indigo." Indeed, he argued that the task of enriching *indigotin* percentage must await a fuller understanding of the "pure chemistry of indigo," which according to him was presently in a state of confusion.

Within these parameters Bloxam principally invested his efforts at Dalsingserai in accomplishing two things. On the one hand, he prepared elaborate samples of indigo from different stages of the production process - from the leaf to the final indigo cake. It was planned that these samples would be subjected to precise tests for measuring the percentage of *indigotin*.[28]

Secondly, Bloxam tried to develop a precise test to measure the percentage of *indigotin* in the natural dye. He first tried to obtain pure *indigotin* for validating the tests that were currently being used. Bloxam entertained a great deal of skepticism about the

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[28] Bloxam and Leake: 14-28

nature of chemical reactions during the administration of the permanganate test - the most widely used test for measuring the purity of dye in India. He suspected that residual impurities in the amalgamated dye were getting estimated as *indigotin*, and therefore, that inflated values of *indigotin* content were being reported. He also doubted if the factor for titration in the permanganate test had been fixed using absolutely pure *indigotin.* In order to resolve his dilemma regarding the dye tests Bloxam made substantial effort towards obtaining sufficient amount of pure *indigotin* for the experimental work. He initially procured two samples of "BASF Rein" from Britain, which were supposed to be 100% pure. But on analysis with the Kjeldahl's test (for measuring the weight of nitrogen and to determine the purity of *indigotin*), he found the two samples to be of 91.88% and 90.85 % purity. Thereafter Bloxam conducted very detailed experiments aimed at obtaining pure *indigotin* in the laboratory. He began by treating finished indigo cake with reagents that revealed the presence of components in addition to *indigotin*.[29] On treatment with acetic-sulfuric acid Bloxam managed to obtain indigo of 96% purity. He got still purer indigo (98.71% purity) by sublimation of indigo in cake obtained from the vats. While these purification processes did not permit their use on a commercial scale, they left Bloxam with a sizeable amount of extremely pure indigo for his analytical experiments.[30]

As Bloxam began his validation experiments by using pure *indigotin*, he first reported problems with the accuracy of the permanganate test. In his preliminary trials he got inconsistent results on applying the permanganate test repeatedly on pure *indigotin* whose composition was constant and known. First proposed by Mohr in 1856, the generic

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[29] Bloxam and Leake: 15

[30] Bloxam and Leake: 16-25; Bloxam, "Our Present Knowledge of the Chemistry of Indigo," *Journal of Chemical Society*, (1905) 87: 975

Permanganate Titration method had been modified several times since. The version currently in use in India had been introduced by Rawson initially in 1885 while still in England, and subsequently modified by him in 1899 when in India. Rawson's version required dissolving *indigotin* in sulfuric acid at 70-80F, and then diluting the sulphonated *indigotin* to the concentration of 1 in 10,000. The suspended impurities from the resulting *indigotin* disulphonic acid were removed by adding a precipitant, barium chloride. Finally, to get an estimate of *indigotin*, titration of a known volume of the sulphonated *indigotin* solution (or the acid) was carried out with oxidizing agent potassium permanganate (N/50 strength). Rawson had predicted that 1cc. of permanganate would be required to oxidize 0.0015 grams of *indigotin* (as present in the sulphonated form), and based on this factor, the amount of permanganate "consumed" by the solution indicated the total weight of *indigotin* in the dye. Starting with pure indigo whose percentage he knew, Bloxam obtained 50cc. *Indigotin* disulphonic acid containing 0.05 gm. of *indigotin*. By Rawson's calculation 33.3 cc. of N/50 potassium permanganate should have been sufficient to oxidize the solution. However, in practice, Bloxam was frustrated in not being able to determine the "end point" in the reaction; the indigo solution used 50 cc of permanganate and still Bloxam did not detect any signs of excess permanganate that should have been left after completing the oxidation of sulphonated *indigotin*. Thereafter, Bloxam added adequate quantities of permanganate to three samples of *indigotin* disulphonic acid separately and left them to react for one minute, 15 minutes, and 30 minutes respectively. He found that with an increase in time, the disulphonic acid solution reacted with higher proportions of permanganate, based on which he obtained different values for *indigotin* percentage. By pointing out that the results of the test varied on different occasions Bloxam asserted that the inferences based on them were "*altogether useless and misleading.*" He called for more accurate tests and for establishing more standardized conditions for their administration so that the progress made towards improving the manufacturing process could be accurately gauged. [31]

Not everyone appreciated the significance of work completed at Dalsingserai by Bloxam. The planters were especially lukewarm in their response to Bloxam's chemical experiments. Bloxam admitted this in his report:

> I know that objection has been made that the results obtained from this station have not been of immediate utility to the planter, but have been too academic in character.[32]

Bloxam's Exit From India

In December 1903, Bloxam wrote to the officials in the Department of Land Records and Agriculture of Bengal requesting that they consider an extension of his employment for another year. His current service contract was due to expire at the end of March next. And Bloxam explained that the work that he along with his assistants had

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[31] Bloxam and Leake: 26-28; For the original espousing of the permanganate test see, Mohr, ",” *Dinglers Polytechnisches Journal*, cxxxii: 363; Christopher Rawson, "On Testing Indigo, With Notes on a Yellow Compound found in Java Indigo," *The Journal of the Society of Dyers and Colourists*, 15 (May 1899): 128-129

[32] Bloxam and Leake: 45

been carrying on was in an unfinished state. It would require another year to bring that work to a successful completion. [33]

On the basis of his work completed over the past year Bloxam made certain claims and promised more definitive results in the future. The current methods of measuring percentage of color in the natural dye were erroneous, they overstated the efficiency of the manufacturing process, and were therefore distracting everyone from what should be the legitimate agenda for scientific explorations, he argued. Bloxam believed that the present processes of manufacturing in India only extracted 8-12% of the color present in leaves. He pointed out to the government officials that he was now working to develop two new tests – one for deriving the total recoverable color from the leaves and another for testing *indigotin* percentage in the finished dye. Those tests when applied on his specimens would prove his conjectures about low efficiency and re-direct the efforts of the experts in the appropriate direction. He thus argued that the results of his work had the potential to save the market for natural indigo by providing key information related to efficiency.

Additionally, Bloxam highlighted the fact that the work in progress would eventually bring unmatched "scientific reputation to all here concerned." He pointed out that dye testing and indigo chemistry were critical areas for scientific research. A successful completion of the difficult research had the potential to bring fame not only to his team, but also to the government as the sponsor of such work.

[33] Letter from W P Bloxam to the Director, Land Records and Agriculture, Bengal, dated, December 3,1903, Proceedings of the Government of Bengal, Revenue Department for the month of July 1904, P/6793, India Office Records, British Library, London. Henceforth these records are referred to as IOR, GOB (Rev).

Bloxam was now facing problems in generating interest for his work among patrons. Many in official circles as well as within the community of planters in India doubted the usefulness of his project in saving the indigo industry of Bengal, Bloxam's personal enthusiasm for his research work notwithstanding. Even before he approached the government Bloxam had contacted indigo business interests in Calcutta asking if they would be willing to fund his work for another year. They had declined. Important officials and other influential people that were in important decision-making positions in India were also not persuaded about the usefulness of his research program.

S L Maddox, the Director of the Department of Land Records and Agriculture, criticized Bloxam's entire approach. The opinion of Maddox was critical since he was at the head of the structure of agricultural bureaucracy in the province. He said disparagingly: "It would seem more promising if Professor Bloxam would hold out hopes not so much of determining the quantity of the blue in the plant nor of proving that the present methods of extraction of the blue were faulty, as of inventing new methods for the extraction of a far higher percentage of blue." [34] The co-manager of the Dalsingserai concern, F M Coventry, a planter himself, also wondered what good would come out of Bloxam's research program. In comparing the work of biologist H M Leake on the germination of the Natal variety of indigo seeds with that of Bloxam, he noted that the

[34] Letter from S L Maddox, Director, Land Records and Agriculture, Bengal to Revenue Secretary, Government of Bengal, dated, January 25, 1904, Proceedings of the Government of Bengal, Revenue Department for the month of July 1904, No. 144A, Nos. 4-5, File, 2-I/8 1, IOR, GOB (Rev), P/6793

latter's work 'could probably not be put to immediate practical use." [35] Thus Bloxam was fast running out of patrons in India who would be willing to fund his work.

It is then not surprising that the Lieutenant Governor, in consultation with J Mollison, the Inspector general for Agriculture in India, decided to withdraw official support to Bloxam's work at Dalsingserai. The Revenue Secretary dispatched a letter to that effect to the Director of Land Records and Agriculture asking him to make arrangements for Bloxam's departure and for taking control of the assets at Dalsingserai. [36] The government's decision practically put a seal on Bloxam's stint in India.

Unsavory and bitter controversies broke out between Bloxam and the agricultural bureaucrats before the scientist left India. Much of the difference of opinion between Bloxam and the officials rose over proprietary rights to the scientific specimens prepared at Dalsingserai and about how and when the technical report on the work done at Dalsingserai should be published.

Bloxam and his assistants had collected about 700 specimens of plant indigo from different stages in the manufacturing process. Once it had been decided that Bloxam would be leaving India the officials demanded that the indigo specimens be left behind. Their reasoning was that those samples were the result of work done on the government's money and therefore they were public property. They wanted the samples to be surrendered to the officials so that anyone else taking over the research work on indigo under the government's employment subsequently could make use of them.

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[35] Letter from F M Coventry to the Director, Department of Land Records and Agriculture, Bengal, dated, January 20 1904, Proceedings of the Government of Bengal, Revenue Department for the month of July 1904, No. 144A, Nos. 4-5, File, 2-I/8 1, IOR, GOB (Rev), P/6793

[36] Letter from A Earle, Revenue Secretary, Government of Bengal to the Director, Department of Land Records and Agriculture, Bengal, No. 6, File 2-I/2 2, Proceedings of the Government of Bengal, Revenue Department for the month of July 1904, IOR, GOB (Rev), P/6793

Bloxam was bitterly offended by this suggestion. He had painstakingly catalogued and labeled the specimens. He also nurtured the ambition to make use of them to bring his current research on indigo testing to a successful end, publishing his findings. He pointed out to S L Maddox that it was a well-established custom in all scientific establishments that experts had the first right to scientific specimens and materials collected by them during their work at an institution. He cited the convention followed by the Board of Admiralty in England in his own case. Bloxam had worked at the laboratory of the Royal Naval College at Greenwich for 12 years. In the end when he decided to move from that laboratory he said he had been allowed to remove his specimens. [37]

The other controversy was over the demand by the government that Bloxam should present "a full technical report" on the results obtained by him at Dalsingserai. In a subsequent letter A Earle, the Revenue Secretary, asserted that the chemist and the biologist at Dalsingserai should submit "as full a report as possible" on their respective works. He also demanded that Bloxam explain in his report the nature of his specimens and the ways in which his samples could be used in any follow up research. Of course, he believed in the "right of the Government to the specimens." He also asked Bloxam to surrender the pure *indigotin* that he had been able to obtain at Dalsingserai. He noted that the government planned to continue indigo experiments at Pusa. The indigo specimens and pure *indigotin* were likely to be used by the experts in the country after he left. [38]

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[37] Letter of S L Maddox to Revenue Secretary, Government of Bengal, dated, March 6, 1904, No. 1T-A, No.9, File 2-I/2 4, Proceedings of the Government of Bengal, Revenue Department for the month of July 1904, IOR, GOB (Rev), P/6793

[38] Letter of A Earle to the Director of Land Records and Agriculture, Bengal, dated, March 15 1904, No. 10, File 2-I/2 5, Proceedings of the Government of Bengal, Revenue Department for the month of July 1904, IOR, GOB (Rev), P/6793

Bloxam did not want to give away "his" specimens and he was not prepared to publish a full technical report on his findings immediately for the government. He explained that he intended to continue his current work on the chemistry of indigo after returning to England. He had already applied to the Davy-Faraday Research laboratory of the Royal Institution in London for a position there. As soon as he had finished the last remaining bits of his current work, he intended to submit the findings to the Chemical Society. [39]

Bloxam believed that he had obtained the "most valuable and far-reaching experimental results," which would have a bearing on the knowledge of the "pure chemistry of indigo." The application of that knowledge would in turn bring benefits to the natural indigo industry. Since he was a member of the Chemical Society, Bloxam argued that the columns of the Society's journal were the "proper place" where such chemical discoveries should be first published. If he included his findings in the report to the Government of Bengal, he might lose "priority of claim to be considered the discoverer of the novelties." He belabored to explain to the bureaucrats in Bengal the norms of the Chemical Society that would usually not publish any paper the subject matter of which had appeared elsewhere. Thus he explained that he stood to lose professionally in abiding by the request of the government to publish a full technical

[39] Extracts from Bloxam's letter in Letter of S L Maddox to Revenue Secretary, Government of Bengal, dated, March 6, 1904, No. 1T-A, No.9, File 2-I/2 4, Proceedings of the Government of Bengal, Revenue Department for the month of July 1904, IOR, GOB (Rev), P/6793

report on his work. He assured them that he would turn over to the Government a comprehensive report soon after he had presented his findings at the Chemical Society. [40]

The Bengal bureaucrats relented as Bloxam refused to be accommodating on these points. He adamantly refused to turn over the pure *indigotin* or the indigo samples. In a personal meeting with S L Maddox, Inspector General J Mollison, and F M Coventry, he defiantly stated that he was also not bound to disclose any discoveries made at Dalsingserai to the government because he was primarily "bound by the rules of his Society to publish them in the first instance to that Society." Thus Bloxam strongly defended his identity as a research chemist, his primary association with his professional society, and his obligation to abide by the norms of his Society. The bureaucrats were left with little choice. Maddox wrote to the Revenue Secretary, " Mr Mollison and I do not see how we can compel him to make a full report on his … discoveries, and Mr Mollison is of the opinion that the samples of indigo are useless to any expert successor." Indeed without Bloxam's presence and without any explicit reference left by him the samples could hardly have been put to use by another expert. Under the circumstances Maddox suggested to the Secretary that Bloxam be given money for his passage to England, and another six months to turn over a complete report to the Government of Bengal. Once that report was received Bloxam could be paid Rupees 3,000 as a remuneration for it. The Revenue Secretary agreed with the proposals since he did not have any other option. [41]

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[40] Bloxam's letter to the Director, Department of Land Records and Agriculture, Bengal, dated, March 27 1904, Proceedings of the Government of Bengal, Revenue Department for the month of July 1904, IOR, GOB (Rev), P/6793

[41] Letter from S L Maddox to Revenue Secretary, Bengal, dated, March 29 1904, Nos. 14-15, File, 2-I/2 9; Letter from A Earle to S L Maddox, dated, March 29 1904, No. 16, File 2-I/2 10, Proceedings of the Government of Bengal, Revenue Department for the month of July 1904, IOR, GOB (Rev), P/6793

Bloxam was not totally without supporters. He had cultivated a constituency for himself in England among his peers. Two of them – British chemists William Ramsay and Arthur Green - were instrumental in getting him employed to do future work on plant indigo in England. On their initiative, as we shall see in the next chapter, the Secretary of State in London and the India Office hired Bloxam and sponsored the continuation of his experiments at the Dyeing Department of the Cloth Workers' Research Laboratory of University of Leeds in England.

Such a step was anyway in keeping with the imperial government's policy of centralizing scientific research on colonial products at numerous centers in Britain. Much of such research was undertaken at the Imperial Institute of the United Kingdom, the Colonies and India, and in specific university departments and research centers across Britain. On the British Indian government's pay rolls, Bloxam continued to work at Leeds on experiments related to indigo under the supervision of Arthur G Green, one of the best known experts on vegetable colors. Bloxam carried forward his work at Leeds, the results of which he finally submitted in a report of 1908.

The Decision Towards Setting Up An Indigo Laboratory At Sirsiah And A Seed Farm In 1904

The Lieutenant Governor's Consultations At Pusa: Its Significance

The next round of steps by the government with regard to indigo are traceable to a crucial meeting that took place at Pusa on February 18 1904 wherein the Lieutenant Governor of Bengal held discussions with senior officials and a group of planters. The Inspector General of Agriculture, as well as Bengal officials - head of the Board of

Revenue, Director of the Land Records and Agriculture, and Revenue Secretary - were present at the meeting. Planters E Macnaghten, Webb, and Studd were also invited to attend.

The officials met with a sense of urgency since they were facing the prospect of a "hiatus" in the scientific experiments on indigo. It had been decided to discontinue work by chemist Bloxam. And it seemed it would be another two years before the laboratories at the Pusa Station could become operational, where they had hoped to continue the indigo experiments. [42]

Before we discuss the details of what transpired at this meeting it is important to emphasize the exceptional commitment shown by the provincial bureaucrats towards continuing laboratory experiments on indigo. Earlier they had collaborated with the central bureaucrats to draw up the blue print of a plan that would facilitate the conduct of indigo experiments at Pusa. Now that the inauguration of Pusa was being delayed, there seems to have occurred a turnaround in their thinking. They now wanted a new laboratory as soon as possible for indigo under the support of the provincial government. They were willing to provide funds from the provincial budget for that.

That the aforesaid meeting was held at Pusa is also significant. Pusa was the office of the new Inspector General of Agriculture in India, J Mollison. The post of the Inspector General was created in 1902, an initiative that marked the crystallization of a centralized infrastructure for scientific research on agriculture. Mollison quickly became an important voice on all matters relating to agricultural research in India. That the

[42] "Note on the Prospects of Indigo, Sugarcane and Cotton," No. 19, File 2-I/2 13, Proceedings of the Government of Bengal, Revenue Department for the month of July 1904, IOR, GOB (Rev), P/6793

meeting to decide the future of the indigo experiments in Bengal was held in the office of Mollison indicates his growing individual authority, as well as the institutional authority of the new office at the center that he occupied. On this occasion the provincial bureaucrats were seeking Mollison's opinion on what kind of experiments were required and on the appointment of future experts. In future too Mollison's opinion would bear its mark on the decisions taken by the Bengal bureaucrats on indigo experiments.

Re-Thinking On Rawson

The officials that gathered at Pusa were distressed that the services of chemist Christopher Rawson had been dispensed with the previous year, and that the former had left the country. The Lieutenant Governor regretted that he had not been able to retain him. "I should have employed him under the Government of Bengal, had it not been for the delay which would be incurred in obtaining the sanction of the Secretary of State [in England]," he said. [43]

The Lieutenant Governor and Mollison agreed that Rawson had done useful work in India during his previous stint, and that there was scope for a person of his qualifications to do more. The governor noted that the great advantage of Rawson over Bloxam was that while "both were thoroughly scientific men," the former also had a "thoroughly practical turn of mind." Bloxam's experiments, while "scientifically interesting," were not conducive to the improvement of indigo or to agricultural research.

[43] "Note on the Prospects of Indigo, Sugarcane and Cotton," No. 19, File 2-I/2 13, Proceedings of the Government of Bengal, Revenue Department for the month of July 1904, IOR, GOB (Rev), P/6793

Thus they proposed to invite Rawson again to India to undertake experimental work on indigo.

Plans were discussed to approach and invite Rawson. The governor disclosed that Rawson was looking for employment back in England. Therefore he needed to be approached soon and to be asked if he would consider coming back to India. Mollison "strongly" supported the idea. He said he would do all he could to help with the task of getting Rawson from England. For one, he undertook to employ Rawson later at Pusa when the establishment there took off. That would guarantee a continuous employment for Rawson in India. The planters' representatives also agreed with the proposal. They promised to make available to Rawson on his arrival a local factory in Bihar where he could conduct his investigations. Together the governor and Mollison drafted a letter of invitation to Rawson and dispatched it the same day. A brief telegram was simultaneously sent to Rawson to serve as an advance notice of the detailed letter to follow.

On the Lieutenant Governor's request, at the meeting Mollison also enlightened the indigo planters on the prospects of growing cotton and sugarcane. Mollison's presentation to the planters was intended to be instructional. The Inspector-General was particularly upbeat about the chances of sugar manufacturing and thought that it could be remunerative if the planters artificially irrigated the crop to get higher yield. The governor on his part disclosed what the government was doing to extend irrigation in the region. Two irrigation schemes in the neighborhood of Ottur were being implemented. A proposal for a third channel of irrigation, originating from the river Jamwari/Gandak and headed to the Dholi area, also an indigo-growing tract, was being actively considered by the government.

Rawson's Refusal To Come To India

Christopher Rawson turned down the invitation to come to India. [44] In the trade journal, the *Indian Planters' Gazette and Sporting News* we get the information that Rawson instead accepted a job with BASF. The latter used him for propaganda purposes. We hear of Rawson being used by the company to promote sales for synthetic indigo in Persia. As someone earlier associated with the task of improving natural indigo, his voice in favor of the synthetic substitute would have gone a long way in winning new customers for synthetic indigo. [45]

On the advice of the Revenue Secretary, S. L. Maddox attended the meeting of BIPA's executive committee on March 27 1904. He informed them that Chrisopher Rawson had refused to come down to India. He wanted to know the planters' opinion on the general direction in which they would in the circumstances want scientific explorations on indigo to proceed. [46]

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[44] "Proposal to Continue Mr Rawson's Work and the Establishment of An Indigo Seed Farm," Note by the Director of Land Records and Agriculture, Bengal, No. 59, File, 2-I/2 15, Proceedings of the Government of Bengal, Revenue Department for the month of July 1904, IOR, GOB (Rev), P/6793

[45] This information was also confirmed in a personal communication with Prof Jeffrey Johnson of Villanova University. References also appear in his unpublished paper.

[46] "Proposal to Continue Mr Rawson's Work and the Establishment of An Indigo Seed Farm," Note by the Director of Land Records and Agriculture, Bengal, No. 59, File, 2-I/2 15, Proceedings of the Government of Bengal, Revenue Department for the month of July 1904, IOR, GOB (Rev), P/6793

Ten of the most important Bihar planters, including E Macnaghten, T Barclay, J Wilson, and G Richardson, represented the planters' perspective to S L Maddox. The planters had come to believe what Rawson had apparently alluded to in his communication – that no material improvement in the manufacturing processes was probable, but that on the agricultural side there was "room for great improvement." The planters said they would greatly appreciate the government's assistance in the setting up of a seed farm and nursery. They recommended that Mr Gollam, the Superintendent of the Government Gardens at Saharanpur, who had for four years been experimenting with indigo seeds from all parts of the country and with Natal seeds, be invited to head the seed farm. They also recommended that an expert be associated with him who could do any laboratory tests that may be required. The planters supported Cyril Bergtheil's appointment to work with Gollam. They thought that since Bergtheil had been conducting agricultural experiments including those to solve the problems associated with the germination of the Java seeds, he should be an appropriate choice.

The planters in Bihar had traditionally favored importing seeds grown in the neighborhood of Delhi, which was located to the northwest of Bihar. In planters' experience, the seeds grown on irrigated *banga* lands, and especially those coming from the Delhi region gave best results. They knew of a Darbhanga planter who had relocated to Dasna near Delhi, one R E Flavell who now managed the *zamindari* there on behalf of his proprietors. The planters wondered if the government could use its good offices to persuade Flavell to grow seeds for the planters in his zamindari and sell it to the Bihar planters. [47]

[47] "Proposal to Continue Mr Rawson's Work and the Establishment of An Indigo Seed Farm," Note by the Director of Land Records and Agriculture, Bengal, No. 59, File, 2-I/2 15,

Inspector General J Mollison and Director of Land Records and Agriculture S L Maddox met Flavell at Dalsingserai to ask if he would agree to grow seeds on his proprietor's land. Flavell was open to the idea. He asked that the planters use their contacts with the Calcutta based indigo merchants to procure Java seeds. He was willing to grow the seeds and sell them to the planters at an agreed upon price.

The officers were still scurrying around to put together a team of experts to work on indigo. They turned to H M Leake and R S Finlow, the biologist and the jute cum indigo expert who had been working at Dalsingserai. In a meeting with Mollison and Maddox that took place on March 27, the two experts declined to work on indigo. They said that they would either work under W P Bloxam on indigo, or if independently employed, they would start work on indigo only after Bloxam had presented his findings to the Chemical Society in England. [48]

Mollison's Perspective Prevails: Way Opened For The Appointment Of Bergtheil And R V Briggs, And The Setting Up Of A Seed Farm

Once again S L Maddox called a meeting that was attended by Dalsingserai manager F M Coventry, BIPA Secretary E Macnaghten, and J Mollison to discuss the next course of action. The discussions at the meeting and the subsequent exchange of

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Proceedings of the Government of Bengal, Revenue Department for the month of July 1904, IOR, GOB (Rev), P/6793

[48] "Proposal to Continue Mr Rawson's Work and the Establishment of An Indigo Seed Farm," Note by the Director of Land Records and Agriculture, Bengal, No. 59, File, 2-I/2 15, Proceedings of the Government of Bengal, Revenue Department for the month of July 1904, IOR, GOB (Rev), P/6793

correspondences among them clearly reveal the decisive voice of Mollison in the choice of experts and in determining the nature of experiments to follow. [49]

Mollison disagreed with the opinion expressed by the group of planters at the previous meeting that not much could be gained by investing efforts in improving the manufacturing processes. On the contrary he argued that "inquiries into the chemistry and bacteriology of indigo should be vigorously pursued." E Macnaghten supported the stand taken by Mollison saying that at the last meeting he did not have the "voting rights" and was therefore unable to express his reservations against the opinion that there was no point in trying to improve manufacturing. Mollison further suggested the engagement of Bergtheil and Briggs, a recommendation that Maddox accepted and forwarded to the Revenue Secretary for approval.

Mollison also more or less laid out the program for the type of trials to be undertaken with seeds in the future. His stress was on "selection." He asked that as far as the native variety was concerned, the plants that excelled in leaf growth and in giving maximum leaf area should be selected. For the Java variety, he proposed that untreated seeds of that variety should be planted and those giving favorable results should be singled out for propagation. This was because he believed that the germination capacity of the seeds was an inheritable quality. He also advised crossbreeding among the selected varieties in order to improve the pool. He promised to send an expert to Dasna who he thought could help with the selection and crossbreeding experiments. On the other hand, he shot down the idea of employing Gollam, saying that the growing of different varieties

[49] "Proposal to Continue Mr Rawson's Work and the Establishment of An Indigo Seed Farm," Note by the Director of Land Records and Agriculture, Bengal, No. 59, File, 2-I/2 15, Proceedings of the Government of Bengal, Revenue Department for the month of July 1904, IOR, GOB (Rev), P/6793

of plants to collect seed at Dasna, as proposed, was not such a specialized activity as to require the assistance of an expert.

S L Maddox asked BIPA to take responsibility for procuring the Java variety of seeds with the assistance of indigo merchants based in Calcutta and forward it to Dasna for planting. He also asked the planters to enter into an agreement with R E Flavell, and propose a budget for their seed farm. The budget was then to be sent to J Mollison. Once the Inspector General approved it, it was to be submitted to the Revenue Secretary for sanction.

The government of Bengal readily approved Mollison's recommendation as forwarded by S L Maddox. They immediately dispatched letters to Bergtheil and Briggs inviting them to come to India to carry out experiments on the bacteriology and chemistry of indigo. They also approved the proposal for starting the Dasna farm in the same form as Mollison proposed it. [50]

Concluding Remarks

A self-evident aspect of the scientific efforts during the period in question was that the government officials assumed the power of decision-making. What experiments were to be conducted and by whom was primarily decided by the bureaucrats. While the planters' perspective was always solicited in these matters, it would not be wrong to say that the planters became junior partners in the decision-making process. Did that have an impact on the nature of experiments and their results? Or, if one may ask the

[50] Revenue Secretary A Earle's letter to the Director, Department of Land Records and Agriculture, Bengal, dated, March 30, 1904, No. 60, File, 2-I/2 16, Letter No. 2068 Agriculture, Proceedings of the Government of Bengal, Revenue Department for the month of July 1904, IOR, GOB (Rev), P/6793

counterfactual question - would the results of the scientific experiments have been different if they had been conducted under the management of the planter-businessmen?

There is another set of questions related to the general colonial conditions that also needs to be addressed. Did the overarching colonial context bring any difference to the nature of experiments? Were there constraints in a colony related to the level of resources available, even if the colonial state was responsive and willing to invest resources for protecting the natural indigo industry? Those questions resonate with arguments about the "locality" of the scientific knowledge. Colonial conditions represented one aspect of that locality. The narrative on the scientific experiments leading up to 1908, the focus of the next chapter, will engage with the question of colonial context and its impact on the indigo experiments.

CHAPTER 6

THE SIRSIAH LABORATORY IN INDIA AND THE CLOTHWORKERS LABORATORY IN LEEDS, 1904-08

Introduction: A Hazy "Research Frontier"

The present chapter covers the years 1904 to 1908, the two being key turning points in the history of natural indigo experiments. 1904 witnessed a demonstration of the renewed commitment of the Bengal bureaucrats towards scientific explorations on indigo leading up to the establishment of a new research station at Sirsiah. Between 1905 and 1908, the national government sponsored chemical experiments on natural indigo by chemist William Popplewell Bloxam at the Clothworkers' Laboratory in the University of Leeds. Besides, a handful of planters independently supported the experiments of the freelance chemist, Eugene Schrottky across several indigo factories in Bihar during this period.

Whatever their respective reasons may have been, the metropolitan (in England), imperial (in Calcutta/Simla), and provincial (in the province of Bengal) bureaucrats, who were the primary sponsors of experiments on indigo, in effect ended up bifurcating the research program for indigo during the period in question. The key scientists William P Bloxam and Cyril J Bergtheil were placed in two separate laboratories on two continents. While chemist Bloxam conducted his experiments at a laboratory in the University of Leeds in England, bacteriologist Bergtheil was stationed at Sirsiah in India. One had access to the scientific resources in a metropolis while the other expert's work was influenced by the demands placed on him by his local patrons. The physical distance between the scientists also had a material impact on the nature of scientific discourse taking place between them.

The third stage of experiments between 1904 and 1908, especially in the last three years, was also marked by extremely contentious debates among scientists in which the they *publicly* contested the findings of their colleagues. Each one argued in favor of his explanation of chemical reactions underlying the manufacturing processes and discounted the version favored by another. On the basis of their different analyses they also recommended different strategies for improvement.

Borrowing tools from the Laboratory Studies literature within the field of Science and Technology Studies, this chapter interprets these scientific debates as those occurring among experts working on a "research frontier." [1] The scientific basis of the process of manufacturing for natural indigo was not understood yet, and therefore uncertainty existed as to what were the "scientific facts." In such a situation the scientists tried a variety of approaches and debated the nature of experiments being conducted. For instance, Eugene Schrottky worked on fermentation processes and claimed success in determining and controlling the nature of chemical reactions. Cyril Bergtheil, however, could not replicate those experiments and their results. Between 1906 and 1908, chemist Bloxam at the University of Leeds and bacteriologist Bergtheil in India could not agree on the validity of assay tests and on the fact as to how much color the plant leaves could theoretically yield. Did their differences arise from the separate and dissimilar technical frames of analysis that they employed? Were their experiments and inferences impacted

[1] Relevant literature detailing the concept of "research frontier" would be most typically be represented by: Harry Collins, *Changing Order: Replication and Induction in Scientific Practice*. (Sage: Beverly Hills, 1991)

by their location in different institutions? Was personal pride a factor inhibiting the building of consensus among the researchers? The chapter will argue that all three were partly true and thus the chapter will imply that technical, institutional, and personal factors cannot be separated in accounting for the process of the formation of scientific knowledge in this instance. Thus part of the chapter reverberates with the existing literature on the social construction of scientific knowledge.

As far as the history of scientific experiments on indigo is concerned, the year 1908 again turned out to be an important one. That year Bloxam published his scientific report on the process of indigo manufacturing that was generally considered to constitute a significant advance in scientific knowledge by the community of chemists in England. But the patrons of indigo experiments in India and England largely ignored the report. Despite claims about the scientific merits of Bloxam's results, the national government in England decided against continuing Bloxam's work. The planters and the government in India also did not follow up on the recommendations made in the report. Thus 1908 provides a useful cut off point for ending the present chapter on indigo laboratories.

Peter Reed, a historian of chemistry, when alluding to Bloxam's findings of 1908, has criticized the planters in India for their failure in pursuing the recommendations of his report. This is why he has called the planters "conservative." [2] It is precisely this kind of misunderstanding that can be avoided by a more careful study of the process of formation of scientific knowledge. This chapter will consider the rhetorical authority of key scientists in India, and the nature of experiments currently in progress in the Indian laboratories to explain why Bloxam's views did not gain acceptance.

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[2] Peter Reed, 'The British Chemical Industry and the Indigo Trade', *British Journal of History of Science* (1992) 25: 113-125

Lastly, the arguments made in this chapter will also engage with the prodigious literature on the nature of colonial science by specifically highlighting how the colonial context constrained access to scientific information and therefore the inferences of experts, and scientific work generally in the colony. On what basis did William Bloxam in England make knowledge claims contrary to those by Cyril Bergtheil in India? The chapter will argue that Bloxam's privileged access to scientific information and his borrowings of critical specimens from the Dutch scientists -glucoside *indican* and indigo enzyme *indimulsin* - were crucial factors that account for the divergence in the direction of experiments on natural indigo. Thus the chapter further develops the thesis about the "locality" of scientific knowledge by displaying the impact of different levels of information on the work carried out by the experts in the metropolis as opposed to that in the colony.

Developments Leading To The Inauguration Of Sirsiah

Bergtheil's Engagement For Pusa/Sirsiah: The Metropolitan, Imperial, And Provincial Perspectives

In early 1904 the metropolitan bureaucrats at India House in London and the central government officials in India were busy selecting experts to employ at the Pusa Station. They first approached Cyril Bergtheil while he was vacationing in England in early April and offered to him the post of an Agricultural Bacteriologist at Pusa. [3]

[3] Letter of Cyril Bergtheil to Secretary, Revenue and Statistics Department, India House, dated, April 19 1904, No. 939, R&S, dated, April 22 1904, No. 21, Serial No. 19, Government of India, Proceedings of the Department of Revenue and Agriculture for 1904, May, 1904, IOR, GOI, Proc. Rev & Agr, P/6826

The British imperial policy on agricultural research in colonies in general, and in India in particular, had its own dynamics. Let us remember that the Imperial Institute was established in 1893 in London as a centralized institution to conduct basic and applied scientific research on products across all of the Empire. The Institute was built and maintained on revenue supplied by the colonies. As a matter of fact, British India bore a major part of the cost of the Institute's establishment, and continued to provide an annual grant for its running. In the initial years a significant part of studies undertaken at Imperial were related to products from India - raw materials like rubber and coal, or plant products like fibers, oilseeds, medicinal plants, tanning agents, indigo etc. But very soon the colonial administrators based in India began to show dissatisfaction with the work performed for them at Imperial. One of them complained in 1902 that of the 16 instances when scientific cases had been referred to the Institute, only in 2 cases had beneficial results been received. The reluctance to make use of Imperial's expertise was also in keeping with a goal that was fast emerging in British India - to establish a local infrastructure for science, especially in the fields of agriculture and health. Thus very soon the Imperial Institute began diverting its focus away from Indian products on to the products of Crown colonies that were slow in developing their own scientific infrastructure. [4]

The impetus for the establishment of local infrastructure for agricultural R&D in India emerged over the long-term in response to the resistance of the native population to repatriation of Indian revenue to institutions like Imperial located in the metropolis. Bureaucratic misgivings also arose over the outsourcing of scientific investigations. The

[4] For a description of the establishment of the Imperial Institute and its functioning in the early years see Michael Worboys, "Science and Colonial Imperialism in the Development of the Colonial Empire, 1895-1940,"Unpublished D Phil, University of Sussex, 1979: 144-160

bureaucrats in the departments of agriculture started leaning towards a policy of conducting agricultural research locally in the colony itself. A perception gradually arose that even if the experts were trained in the West, they needed to develop knowledge of local conditions in order to contribute effectively. The bureaucrats then insisted on bringing the scientists over to India and sponsoring their experiments in the colony. Indeed the agro-climatic zones in a large, tropical country were not only very different from the temperate climates in the West, but also varied regionally. The stationing of experts in the colony was found to be useful. By the late nineteenth and early twentieth century an imperial policy was emerging that favored the creation of indigenous institutions for agricultural research in India.

The official correspondence between London and the Viceroy's office in India bear testimony to the strong commitment of the officials in London and Calcutta/Simla to start Pusa and initiate agricultural research in India. They put Pusa before everything else. Therefore, when the Bengal bureaucrats wrote to the Secretary of State to spare Bergtheil for the regional laboratory in Bengal on indigo, the former, in consultation with the central government, were quite reluctant to agree.

On hearing from the Bengal Government, India House dispatched a letter to the Government of India asking if relieving Bergtheil to work on indigo temporarily would compromise the plans for agricultural research and education at Pusa. The buildings and laboratories for Pusa were still being set up. It did not appear that the station at Pusa could go on stream very soon. In light of the slow progress in the creation of infrastructure the officials in India reported back that the station would not be ready until

October, and therefore that the agricultural bacteriologist could be dispensed with until then.[5]

Bergtheil too wrote to India House independently after he received a communication from the Bengal Government who had contacted him directly. He mentioned that the Bengal Government had invited him to come to India to carry forward the research work on indigo from the point where Chritopher Rawson had left. Bergtheil was also invited to bring R V Briggs, the expert who had worked before with Rawson and later with Rawson and Bergtheil at Peeprah. He was assured a laboratory at Mosheri, and a guaranteed service of two years on indigo. The letter also mentioned the possibility that after two years he might be transferred to Pusa to continue the work on indigo.[6]

Bergtheil was in a dilemma. He did not want to forego the opportunity of an assured, permanent job with the Government of India at the Pusa Station. At the same time he was also attracted to the idea of working on indigo under the Government of Bengal. He had been working on the product for sometime, his project was unfinished, and he was hopeful of obtaining more positive results. Thus he proposed to the officials at India House two possible courses. One, if the metropolitan and imperial officials could keep their offer for the job of bacteriologist on hold, he would be willing to work on indigo for two years and then join Pusa as the Agricultural Bacteriologist. Two, he could accept appointment as Agricultural Bacteriologist with immediate effect and also work

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[5] Telegram, dated, April 16 1904, from Viceroy to the Secretary of State, No. 20, Serial No. 18, Government of India, Proceedings of the Department of Revenue and Agriculture for 1904, May, 1904, IOR, GOI, Proc. Rev & Agr, P/6826

[6] Letter from A Earle, Secretary, Government of Bengal to Cyril Bergtheil, dated, March 31, 1904, Enclosed, Letter of Cyril Bergtheil to Secretary, Revenue and Statistics Department, India House, dated, April 19 1904, No. 939, R&S, dated, April 22 1904, No. 21, Serial No. 19, Government of India, Proceedings of the Department of Revenue and Agriculture for 1904, May, 1904, IOR, GOI, Proc. Rev & Agr, P/6826

on indigo as an added responsibility. Incidentally the letter from the Bengal Government had suggested that after two years they might manage to have Bergtheil employed at Pusa where he could continue to work on indigo – thus envisioning a situation of dual responsibility for him. [7]

The central government in India asserted their position on the issue in unambiguous terms, and it was their decision that prevailed. Their position, as compared to that of regional bureaucrats, clearly de-focused indigo The imperial office at Calcutta/Simla thought that the best plan would be to immediately employ Bergtheil at Pusa, and to allow him to work at the indigo laboratory on deputation. They did not consent to relieve him for a period of two years as requested. Actually they did not commit to any time period, implying that Bergtheil could be recalled whenever Pusa was ready to receive him, and as soon as his services were required there. They also told the Bengal bureaucrats in no uncertain terms that once Bergtheil reverted to his position of Agricultural Bacteriologist “he would be required to drop his special indigo work.” The Bengal bureaucrats, not having any alternative, agreed with that line, the Government of India made a recommendation to that effect to the Secretary of State, and Bergtheil was appointed the Agricultural Bacteriologist. [8]

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[7] Letter of Cyril Bergtheil to Secretary, Revenue and Statistics Department, India House, dated, April 19 1904, No. 939, R&S, dated, April 22 1904, No. 21, Serial No. 19, Government of India, Proceedings of the Department of Revenue and Agriculture for 1904, May, 1904, IOR, GOI, Proc. Rev & Agr, P/6826

[8] Telegram No. 688, dated, May 14, 1904, from Government of India, Revenue Department to Government of Bengal, Revenue Department, No. 20, Serial No. 22; Telegram, dated, May 18, 1904, from Government of Bengal, Revenue Department to Government of India, Revenue Department, No.23, Serial No. 21; Telegram, dated, May 19, 1904, from Viceroy to Secretary of State, No. 24, Serial No. 22; Letter from Secretary of State to Government of India, Revenue Department, dated, July 1, 1904, No. 21, Serial No. 26, Government of India, Proceedings of the Department of Revenue and Agriculture for 1904, May, 1904, IOR, GOI, Proc. Rev & Agr, P/6826

Bergtheil arrived in Bombay. On July 9, 1904, two separate but simultaneous notifications by the government announced his employment as the Agricultural Bacteriologist and his deputation to work for the Bengal Government. [9]

The officials in the province acted swiftly to get the laboratory work started as soon as possible. Bergtheil, accompanied by R V Briggs, who probably came together with him from England, reached Muzaffarpur. On reaching Mosheri they found the pre-existing indigo laboratory there in a shambles; all equipment and construction had been either dismantled or damaged. In these circumstances, plans were made to immediately take on lease a small factory at Sirsiah and to assemble the laboratory there. The site was soon inspected by the officials and approved. Necessary buildings were planned and the budget approved. An advance amount was also sanctioned to expedite the process of starting work at Sirsiah. [10]

R S Finlow Comes Aboard For Sirsiah

On April 1, 1904, after the Dalsingserai Laboratory closed down, the indigo expert R S Finlow was retained by an arrangement between the government and BIPA. The government sanctioned an advance out of the indigo grant that they had earlier committed to pay towards Finlow's salary.

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[9] Notification – By the Government of India (No. 953, dated July 26, 1904), No. 22, Serial No. 27; Notification – By the Government of India (No. 954, dated July 26, 1904), No. 23, Serial No. 28, Government of India, Proceedings of the Department of Revenue and Agriculture for 1904, May, 1904, IOR, GOI, Proc. Rev & Agr, P/6826

[10] No. 3337 Agri., Letter from Revenue Secretary, Government of Bengal to Director of the Department of Land Records and Agriculture, dated, August 10 1904, No. 68, File 2-I/20; No. 2154A, Letter from S L Maddox to Revenue Secretary, Government of Bengal, Proceedings of the Revenue Department for the month of August 1904, P/6794. These files are available at the British Library in London under the general rubric of India Office Records. Henceforth, these files have been referred to as IOR, GOB, Rev (Agr.).

As we saw in the previous chapter, Finlow had been working with Bloxam at Dalsingserai. When contacted for reemployment to continue work on indigo, he had refused saying that he was bound to *not* do any research work on indigo until Bloxam had publicly presented the results of his research, the research on which Finlow had previously assisted Bloxam at Dalsingserai.

But the government in their wisdom still decided to retain him. Experts were scarce, especially those with a knowledge of the local conditions in the colony. Besides, getting a new person out from England always involved belabored discussions and several mandatory rounds of communication between the different levels of government in India and England as the search for a new person was conducted. It was not always easy to find a competent person who would also be willing to come to India.

Finlow had other merits. Other than his primary work on indigo he also had some knowledge of jute. The officials reckoned that he could be possibly put to work on the problem of deterioration of jute in India, which had recently become a serious issue. Jute was another important industry in Bengal. Merchants based at Dundee had financial interests in the jute industry of British India, and therefore there were adequate reasons to have an expert address that problem. Besides, as a jute expert, Finlow could always prove useful to those indigo planters that ever considered switching to that commodity. For some time it had been an avowed policy of the government to encourage indigo planters to divest.

The plan to retain Finlow was also affected by the discussions that were underway to turn Sirsiah into a permanent agricultural station under the provincial government. The regional bureaucrats had been slowly but surely veering around to the position that indigo experiments should be conducted in a separate laboratory. Now that the Sirsiah laboratory was up and running, the next step in their plan was to turn it into a permanent station. They were also mindful that the central government had stated it would recall Bergtheil as soon as the Pusa laboratories became functional. The Bengal bureaucrats planned that once Bergtheil moved to Pusa, they could have R S Finlow head the provincial station. [11]

They were so determined to retain Finlow for their Sirsiah Station that they wondered if the normal bureaucratic hierarchy of seeking approval could be bypassed to accommodate him. S L Maddox was concerned that the Secretary of State had recently sanctioned the post of a Deputy Director for the agricultural department. In view of the recent support for a post for the agricultural department he might not be positively inclined to defend another post. Both Maddox and J W Mollison felt that there was already enough work to do on the chemistry and bacteriology of jute in the country. Therefore, it might be worth the time to explore and ask if the Bengal Chamber of Commerce, which was supported to a large extent by jute interests, would be willing to pay his salary. [12]

In the end, however, the agreement of the Secretary of State was sought for R S Finlow's appointment to the agricultural services of the Government of Bengal. He was to be given a permanent position as an expert on both indigo and jute. Pending Bloxam's

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[11] Letter from H LeMesurier, officiating Secretary to the Board of Revnue to Revenue Secreteary, Government of Bengal, dated, November 1, 1904, Nos. 5-6, File, 2-I/2 31, Government of Bengal, Proceedings of the Revenue Department for the month of March 1905, IOR, GOB, Rev (Agr.), P/7032

[12] Letter from H LeMesurier, officiating Secretary to the Board of Revnue to Revenue Secreteary, Government of Bengal, dated, November 1, 1904, Nos. 5-6, File, 2-I/2 31, Government of Bengal, Proceedings of the Revenue Department for the month of March 1905, IOR, GOB, Rev (Agr.), P/7032

presentation of his findings on indigo in England Finlow had been engaged on miscellaneous tasks by the agricultural department in Bengal. Bloxam published his report in March 1905 thus releasing Finlow to work on indigo if he so wished. An understanding was immediately reached that while official support was awaited for his permanent appointment, during the peak season for the manufacture of indigo – July to August - he should assist the other experts working full time on indigo. Once the formal approval came from England Finlow began to divide his time between work on indigo and jute. [13]So the stage was set for the next round of experiments and trials at Sirsiah to be undertaken by Bergtheil in association with Finlow and Briggs.

Developments Leading To The Engagement Of William P Bloxam At Leeds

Bloxam's Relations With William Ramsay And Other Metropolitan Chemists

Bloxam had failed to convince the provincial government to extend his tenure. The bureaucrats had shown neither the inclination to keep the Dalsingserai Laboratory running, nor to move Bloxam to another laboratory. When Bloxam came to know that the proprietors of the Dalsingserai estate had refused to let out their property any longer for indigo experiments and trials, he suggested to the officials that he should be moved to the Indian Museum at Calcutta. Bloxam had contacted the chief scientist working at the laboratory of the museum - one Mr. Burkill, who was willing to accommodate him in the laboratory at Calcutta. Bloxam expressed the view that his re-location at the Indian

[13] Letter from R W Carlyle, Revenue Secretary, Bengal to Revenue Secretary, Government of India, dated, May 22, 1905, letter no. 839T, No. 15, File 2-I/3 8; Letter from the Governor General of India to the Secretary of State in London, dated, July 27 1905, letter no. 270 and Telegram, from Secretary of State in London to Viceroy in Simla, dated, September 13 1905, Nos. 17-18, File 2-I/2 10; Government of Bengal, Proceedings of the Revenue Department for the month of December 1905, IOR, GOB, Rev (Agr.), P/7034

Museum laboratory would actually be ideal as in the city of Calcutta he would have easier access to scientific apparatus. And whenever he needed to collect additional samples of indigo plant he could visit the indigo fields that were not too far from that city and well linked by trains. [14]

But the provincial administrators were unmoved. There was a basic lack of interest among the Bengal bureaucrats for the work that Bloxam did. They were unwilling to invest their meager financial resources in the very specialized chemistry of indigo that Bloxam's work incorporated. It would be fair to say that they were, unsurprisingly, "provincial" in their outlook. They wanted to help a local, regional industry. And they wanted to assign their resources to arrange the work of experts that could bring benefits to the industry in the short-term. They could not afford to support any scientific pursuit that could be characterized as anything otherwise. The administrators were not moved at all by Bloxam's arguments that his work would also bring, as Bloxam described, "scientific reputation."

But even as Bloxam faced the threat of banishment, he turned to another constituency that he had painstakingly cultivated over the years. This constituency was comprised of notable chemists in the metropolis – in England. He turned to them for support. Two of them in particular, William Ramsay and Arthur G Green, appreciated the significance of his current work and ensured, as we shall see below, his continued employment to do research on indigo in England beginning 1905.

[14] Letter from W P Bloxam to the Director, Land Records and Agriculture, Bengal, dated, December 3,1903, Proceedings of the Government of Bengal, Revenue Department for the month of July 1904, IOR, GOB (Rev), P/6793

After returning to England Bloxam spent the next six months or so writing his report on the work done at Dalsingserai. As agreed upon, he submitted a copy of the report to the Government of Bengal. But he also sent across a copy of the report to a prominent chemist in England, William Ramsay at University College, London. He had known Ramsay for some time, having worked in his laboratory previously. In fact, Ramsay had been instrumental in securing appointment for him in the first place in India in 1901. Thus Bloxam was well aware that the metropolitan and imperial bureaucracy respected Ramsay. On this occasion, Bloxam wanted him to read his report on indigo work and comment on it as an expert. He also desired that Ramsay intervene with the India House bureaucracy and impress on them the need to employ him for an additional year so that he could finish his work.

Ramsay was happy to oblige. He was admittedly struck by the brilliant work Bloxam had just completed. As requested, he wrote to India House, attesting the value of Bloxam's work and urging that Bloxam be given an opportunity to continue his work for another year. He expressed confidence that a continuation of his current work would bring fruitful results. [15]

Ramsay made another crucial point. He stated that the metropolis England rather than colonial India was the appropriate location for the critical work that Bloxam was engaged in. First of all Bloxam had obtained pure indigotin, which in itself involved a mastery of the very difficult chemistry of the relevant processes. He had also discovered

[15] Letter from William Ramsay to the Under-Secretary of State for India, India House, dated, November 6, 1904, "Employment by the India Office of Mr W P Bloxam for the purpose of carrying on further researches regarding the methods of production of natural indigo," Government of India, Proceedings of the Department of Revenue and Agriculture for May 1905, No. 25, Serial No. 1, IOR, GOI, Proc. Rev & Agr, P/7069

that the red bodies present in the dye did not contain nitrogen. It was "not unlikely" that this red body was an intermediate compound from which the coloring matter was finally formed in the leaves. Thus Ramsay raised expectations that Bloxam might be close to uncovering the very basis of the formation of color in the plant, an insight that was certain to prove critical. Ramsay also attested that Bloxam was currently trying to devise a correct method to estimate color percentages that would enable putting the knowledge of the field of natural indigo on firm footing. Having demonstrated the usefulness of Bloxam's work in progress, Ramsay also strongly urged that for carrying out such cutting edge chemical research Bloxam should be placed in one of the fine laboratories in England. Such work "could be better carried out in this country, where advice from skilled chemists is easily obtainable, and where the literature on the subject is easily accessible, than in India."

Ramsay's letter to India House had the desired effect. The communication immediately had the bureaucracy there interested. The Secretary of State asked back immediately which way Ramsay thought the government should assist him. They also asked him to name the specific laboratories where Bloxam's work could be carried out. [16]

Ramsay suggested that Bloxam could work at the Inland Revenue Laboratory under the supervision of Dr Thorpe. Bloxam had previously presented a copy of his report to Dr Thorpe too. The latter had thus read the report and Ramsay confirmed that Thorpe also had a positive opinion of Bloxam's work. The Scientific and Technical Department of the Imperial Institute could be the other place that could be considered for locating Bloxam. But if these two places were not available, Bloxam could be gainfully

[16] Letter from A Goldby Under-Secretary of State for India to Sir William Ramsay, No. R&S 2662, dated, November 11, 1904, No. 25, Serial No. 1, Government of India, Proceedings of the Department of Revenue and Agriculture for May 1905, IOR, GOI, Proc. Rev & Agr, P/7069

employed at the Clothworkers Laboratory in the University of Leeds to work under the general supervision of Prof Arthur G Green, a well-known natural dye expert. As an afterthought Ramsay added that Bloxam's location at Leeds would actually be the best option, considering the fit between the specialization of that laboratory and Bloxam's interests.

Those at India House consulted other experts too. They were in touch with Dr Thorpe "unofficially." After hearing from their counterparts in India they decided to engage Bloxam and place him at the University of Leeds.

The Position Of The Metropolitan, Imperial, And Provincial Governments On Bloxam's Work

While corresponding with William Ramsay, Dr Thorpe and other experts, the Secretary of State's office wrote to the government in India asking that a copy of Bloxam's report be supplied to them, as well as to send their opinion on the subject of the continuation of Bloxam's research in England. [17]

The Secretary of State's query galvanized the provincial bureaucracy in Bengal into action. An honorarium of Rupees 3,000 was immediately sanctioned for payment to Bloxam as promised. S L Maddox the head of Bengal's agricultural department as well as J W Mollison, the Inspector General for Agriculture in India, were asked to submit their opinion on the matter of employing Bloxam again.

[17] Letter from Secretary of State to the Government of India, dated, December 23, 1904, No. 193 (Revenue), No. 25, Serial No. 1, Government of India, Proceedings of the Department of Revenue and Agriculture for May 1905, IOR, GOI, Proc. Rev & Agr, P/7069

R W Carlyle, Bengal's Revenue Secretary, represented the perspective of Bengal's bureaucrats. They concurred this time that it would be helpful to have Bloxam undertake further research on indigo. Bengal's bureaucrats could very well feel the pulse of the situation. William Ramsay's letter attesting the potential of Bloxam's completed work and the usefulness of extending his research had a major influence on all. The Secretary of State, too, seemed to be tilting towards it. Notwithstanding that just a few months ago they had disengaged Bloxam from his work in India, they recapitulated to say that the extension of his work in England was a good idea. [18]

The letter from Carlyle also suggested that Bloxam would be better off conducting "analytical work on manufactured indigo" rather than on the "indigo plant." Carlyle argued that since it was not possible for Bloxam to obtain fresh samples from India, he should focus on the samples of manufactured cake. This suggestion appears a bit odd because these officials knew very well that Bloxam had carried samples of both plant leaves and the dye in stages of manufacturing from the *mahai* of 1903. In his previous letters as well as in his last report Bloxam had indicated that he was currently engaged in devising a method for the estimation of color in the leaves and in the dye in order to answer the question as to how much color the leaf could give and how much was actually extracted. Thus his current work encompassed examination of the samples of the leaf *and* the dye.

Were they, then, trying to propose a division of work between Bloxam in England and their own expert Bergtheil in Bengal? That seems to be a possibility. The same letter

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[18] Letter from R W Carlyle, Revenue Secretary, Government of Bengal to Secretary, Revenue and Agricultural Department, Government of India, dated March 27, 1904, Letter no. 1717, No. 28, File 2-I/2 6, Government of Bengal, Proceedings of the Revenue Department for the month of November 1905, IOR, GOB, Rev (Agr.), P/7034

also stated that Bloxam's work must be carried out "in conjunction" with similar work on indigo in India, and expressed hope that the two experts would communicate and keep each other informed of the progress of their respective works. Apparently the Bengal bureaucrats, from their own perspective, were trying to bring an element of organization into the scientific endeavors by proposing such division of work, bring an element of efficiency, and thus maximize benefits from the government money spent on research.

The central government officials forwarded the recommendations of Bengal bureaucrats. They amended the suggestions sent from Bengal only on the matter of the proposed division of work between Bloxam and Bergtheil. They had a slightly different perspective than the regional bureaucrats on the issue. The central government officials considered themselves inadequate to advise on the matter, and instead proposed that expert advice should be sought on how to establish a division of work. They also stated that in their opinion only that work should be supported that would bring "the greatest hope of results of practical value." [19]

India House finally offered Bloxam a job for one year at the University of Leeds that started in August 1905. They only asked that he should coordinate his research efforts with the efforts of Bergtheil in India. They too did not raise the issue about the division of work. [20]

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[19] Letter from the Governor General in Council in India to the Secretary of State in England, dated, May 4 1905, Letter no. 15, Nos. 29-30, File 2-I/2 7, Government of Bengal, Proceedings of the Revenue Department for the month of November 1905, IOR, GOB, Rev (Agr.), P/7034

[20] Letter from A Godley, Under Secretary of State for India to W P Bloxam, dated, July 27, 1905, Letter no. R&S 1911, No. 1, Serial No. 8, File No. 18 of 1905, Government of India, Proceedings of the Department of Revenue and Agriculture for September 1905, IOR, GOI, Proc. Rev & Agr, P/7069

The Experts And The Direction Of Their Experiments, 1905-08

The Turf War: Bloxam Versus Bergtheil, And The Questions Of "Core" And "Periphery"

The issue about the division of work between the experts was, however, not going to die down easily. It erupted in the form of a turf war between the two scientists wherein each accused the other of encroaching on the work assigned to them by the government. This was partly a reflection of the fact that experts' notions of the division of work were dramatically different from those proposed by the Bengal bureaucrats. In other words, the tensions arose from the imperatives of the nature of experimental work that they wanted to undertake.

But equally importantly, the confrontation also arose out of professional ambition to claim success in a critical area of chemical research, to present the results of experiments at professional societies in England, and to publish in the journals in England. This directly leads us to examining the question of the identity of these experts working on indigo. They were all, of course, applied chemists working to improve indigo or examining questions that would eventually assist the process of improving plant indigo's yield and quality. That is what their immediate patron – the government - expected of them. But their identity was not limited to working for the government or industry in British India. In a general way all of them aspired also for a definite, independent academic and professional stature. They published the results of their work in various academic journals and presented their findings at various professional societies like the *Society of Dyers and Colourists*, the *Society of Arts*, and most importantly the *Society of Chemical Industry and the Chemical Society*.

Maintaining visibility among their peers in England was critical. This was especially true of Bloxam who sought the final validity for his work from the metropolitan chemists. Bergtheil, too, moved among his peers in England and was cognizant of the need to keep his credibility with them. This was generally true of all Western-trained experts working in British India who aspired to one day return to their home country and seek employment there. But unlike Bloxam, or at least more than him, Bergtheil also sought validity for his work from his local employers in colonial India – the central government officials, the Bengal bureaucrats, and the indigo planters.

It was Bloxam who first protested to the officials in England in May 1906 that Cyril Bergtheil had failed to communicate to him the results of his experiments in India over the last year. He reminded them that the terms of his appointment had mandated that Bergtheil should keep him informed of his work in India and that he keep Bergtheil posted of the progress of his work in England. There was thus a real danger of duplication of work by the two experts who were both employed by the government. That might possibly result in wastage of public funds. [21]

This firing of the first salvo publicly evoked a similar response from Bergtheil and to a disclosure of communication that had transpired between them previously. Two things become apparent on a reading of the "personal" letters that had passed between the two. First, both scientists had failed in communicating the results of their experiments to each other over the past year. This was largely the result of their intent to keep the results of their experimental work clandestine and their ambition to publish the results in the

[21] "Extract of a letter from Mr Bloxam, dated 5th May 1906," Letter from T W Holderness, Secretay, Revenue and Statistics, India Office to Revenue Secretary, Government of India, dated, May 8, 1906, Letter No. R&S 1132, No. 11, Serial No. 1, File No. 123 of 1906, Government of India, Proceedings of the Department of Revenue and Agriculture for July 1906, IOR, GOI, Proc. Rev & Agr, P/7338

Journal of the Society of Chemical Industry before their colleague. Secondly, the letters also reveal an extreme eagerness shown by Bloxam to reserve analytical chemical works related to color estimation and the nature of the "red bodies" (indirubin) in the dye for himself. These were incidentally the aspects on which he had worked before at Dalsingserai during 1902-03.

Soon after joining the Clothworkers Laboratory Bloxam sent a letter to Bergtheil asking him about the result of his experiments in 1904-05, and the lines of experiments he wished to follow during 1905-06. He promised that he would very soon after consultation with his supervisor send a note on what experiments he was going to conduct at Leeds. Bergtheil would later charge Bloxam that while he had fulfilled the condition about communicating with him "in a literal sense," he had throughout abstained from providing any "information as to the [actual] lines of his work." [22]

In his response, Bergtheil proposed to Bloxam what he thought would be a judicious and practical division of work between them. Considering the physical distance that separated them and the time it would take to correspond, he suggested each of them take up distinct areas of work. They could then share the results from their respective fields to benefit the corresponding side of query. Bergtheil reserved for himself work on the problems relating to the cultivation and manufacturing of indigo. He invited Bloxam to work on finished indigo. He further suggested that he study the improvement of indigo "from the dyer's stand point." In what form did the dyer want the product? Which constituents of the dye were more useful for the users? Any information on these subjects

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[22] Letters that passed between Bergtheil and Bloxam in 1905; and Letter from Cyril Bergtheil to C A Oldham, dated July 5, 1906, Enclosures in Letter from C A Oldham, Director of Agriculture, Bengal to Secretary, Board of Revenue, Lower Provinces, dated, July 11, 1906, letter no. 2755A, No. 19, Serial No. 4, File No. 123 of 1906, Government of India, Proceedings of the Department of Revenue and Agriculture for April 1907, IOR, GOI, Proc. Rev & Agr, P/7613

would be of “greatest value” to their common concern to protect the natural indigo industry. In suggesting this division of labor Bergtheil seems to have expanded on the line earlier proposed by the Bengal bureaucrats. [23]

Bergtheil also claimed a right to work on the processes of color estimation and the nature of “red bodies” in indigo thus denying Bloxam any exclusive right to work on those areas. It was this denial that offended Bloxam the most. Bergtheil agreed that the division left work on finished indigo to Bloxam. But he had to make an exception in this particular case since he had been working on these two areas for some time and disclosed would be soon submitting papers for publishing.

Whatever the pretext that Bloxam and Bergtheil may have used, a core element of the current round of correspondence between them was the effort to secure separate territories for individual research and publishing. Bloxam’s initial letter invited dialogue referring to the terms of his appointment that had obligated him to collaborate with his counterpart in India. Bergtheil’s response discussed the advantages of dividing work between production and consumption imperatives. But, equally importantly, Bloxam’s first letter proposed a “mutual agreement” between them on the “time and place of publication” resulting out of their work. Bergtheil’s letter was even more explicit. He said that as far as the results of “practical value” at Sirsiah were concerned, he was bound to communicate them to BIPA. But for work of “more scientific nature” he was ready to enter into an agreement with Bloxam so that they could publish independently “with no

[23] Letter from Cyril Bergtheil to W P Bloxam, dated September 2, 1905, Enclosure in Letter from C A Oldham, Director of Agriculture, Bengal to Secretary, Board of Revenue, Lower Provinces, dated, July 11, 1906, letter no. 2755A, No. 19, Serial No. 4, File No. 123 of 1906, Government of India, Proceedings of the Department of Revenue and Agriculture for April 1907, IOR, GOI, Proc. Rev & Agr, P/7613

disadvantage to one another." He encouraged Bloxam to respect the arrangement he was proposing.

Bloxam was bitterly offended to learn that Bergtheil was working on red bodies and on perfecting the methods of color estimation. He claimed he was the first to raise doubts on the accuracy of assays to check color percentages as pointed out in his published report on the work done in India. He was similarly the first to fathom the nature of red bodies present in the blue dye. He raised his objections in two ways. First of all, he alleged that only he could claim "*sole ownership*" [his emphasis] of the findings. According to him it was wrong on the part of Bergtheil to pick up an unfinished line of experiments that he had left in India and which he was now following up. His second objection was targeted to move the administrators. Bergtheil, according to him, had intruded into the *purely chemical* [his emphasis] part of the work that had been originally assigned to him. Bergtheil was after all the Imperial Bacteriologist and should therefore confine his work to the areas that best matched his qualifications as a bacteriologist. [24]

He was also alarmed to know that Bergtheil was about to publish papers on color estimation for the natural indigo dye. He hurried early in 1906 to submit his paper at the Yorkshire section of the Society of Chemical Industry in order to get precedence over Bergtheil. The full text of Bloxam's paper appeared in the 15th August issue of the *Journal of the Society of Chemical Industry.* But much to his bewilderment he found out that the same issue also included a paper on the same subject by Cyril Bergtheil and R V

[24] Letter from Bloxam to Bergtheil, dated, October 12, 1905, Enclosure in Letter from C A Oldham, Director of Agriculture, Bengal to Secretary, Board of Revenue, Lower Provinces, dated, July 11, 1906, letter no. 2755A, No. 19, Serial No. 4, File No. 123 of 1906, Government of India, Proceedings of the Department of Revenue and Agriculture for April 1907, IOR, GOI, Proc. Rev & Agr, P/7613

Briggs entitled, “The determination of indigotin in commercial indigo and in indigo-yielding plants.”

Bloxam was indeed very angry with Bergtheil. He was so reproachful that he went on to complain to the officials at India House arguing that Bergtheil had ignored legitimate work on the bacteriological aspects of indigo improvement, which he was primarily expected to undertake. Such dereliction of duty on the part of Bergtheil was going to prove detrimental to the future of the natural indigo industry where much bacteriological work was still required, Bloxam argued. He also contended that Bergtheil’s insistence to work on the chemical aspects of the estimation of indigotin, an area that he had been working on, had led to the “unseemly” situation when an important chemical journal had publications on the same subject by two experts both of whom were employed by the government. Such a duplication of work on the government’s money was wasteful. Bloxam also raised a technical issue that under the current rules results of research done in India with the support of the Government of India could not be published in Europe except by special permission. Bergtheil had not sought such permission to publish. He asked that remedial measures be taken so as to avoid such duplication in future. He also asked that rules be amended to clearly specify which types of scientific work originating in the colonies could be published in Home scientific journals. [25]

Bloxam’s personal indignation apart, a sense was emerging in the metropolis that Bergtheil had failed in collaborating with Bloxam, and therefore that a great opportunity was being lost. A G Perkin, a natural dyes and pigments expert at the University of

[25] Letter from Bloxam to T W Holderness, Secretary, Revenue and Statistics, India House, dated, August 23, 1906, No. 20, Serial No. 5, Government of India, Proceedings of the Department of Revenue and Agriculture for April 1907, IOR, GOI, Proc. Rev & Agr, P/7613

Leeds, was one of those who believed that. Bergtheil was present "on the spot" in India where the cultivation and manufacture of indigo was taking place. Thus he had an intimate knowledge of the actual system of production. On the other hand, Bloxam in England had access to "many more facilities and advantages for working out the scientific side of the question." If anything, Bloxam's insistence on claiming his exclusive right to publish in the journals in the West was also impinging on attempts to reserve to metropolitan scientists the right to publish in the most prestigious journals. At the same time, he offered to Bergtheil that he would be glad to examine specimens that he may want to send home to him. [26]

Perspectives like those of A G Perkin advanced a particular vision of science critically centered on the metropolis. Such visions incorporated a "division of labor" between the scientists and between the natures of scientific pursuits in the metropolis and the colony – at the "core" and in the "periphery." In such a conception the experts placed in the colonies were primarily engaged in the job of data collection. The critical advances in the process of knowledge took place in the metropolis on the basis of data supplied from the colonies.

Substantial literature already exists in the field of colonial science that analyzes the relationship between the metropolitan "core" and the colonial "periphery." Lately scholars have been critical of the core-periphery paradigm, and have criticized it as being "West-centric." They have argued that such conceptions advance a thesis about the lack

[26] Letter from A G Perkin to T W Holderness, Secretary, Revenue and Statistics, India House, dated, December 3, 1906, No. 21, Serial No. 6; Letter from W P Bloxam to Cyril Bergtheil, dated, October 12 1908, Enclosure in Letter from C A Oldham, Director of Agriculture, Bengal to Secretary, Board of Revenue, Lower Provinces, dated, July 11, 1906, letter no. 2755A, No. 19, Serial No. 4, File No. 123 of 1906, Government of India, Proceedings of the Department of Revenue and Agriculture for April 1907, IOR, GOI, Proc. Rev & Agr, P/7613

of contribution of the nonwestern world in the making of "Western" science beyond providing data through field studies. They charge that such arguments foreground developments in the metropolis and minimize the importance of the developments in the colonies. Going against the grain, more recently scholars have highlighted circulation of people, artifacts, and knowledge among the colonies and the metropolis in their attempt to de-center Europe from the current narratives of history of science. New knowledge, it has been argued, also evolved in the colonies through circulation, adaptation, experimentation, and then became part of world's larger repertoire of technical know-how. Therefore, the argument runs, "Science" does not have an exclusively European lineage, but is rather transnational in its origin.

On the specific question of the hegemonic ability of the metropolis to shape the nature of science in the colonies, this study furnishes a split verdict. Within the larger understanding that the indigo experiments in India by Western-trained experts were colonial because they were influenced by local resources and conditions (as discussed in Chapter Three), this study makes further contributions to the study of core-periphery relations. Since political power was centralized in the office of the Secretary of State in England, decisions emanating from that office could have a determining influence on the nature of science on a case-to-case basis. Certain appointments of experts could be sanctioned or disapproved, which directly affected the nature of scientific investigation in India. But, more importantly, the scientists working in the colony gravitated towards their peers in England. They aspired for a certain degree of visibility in the community of metropolitan scientists, which in turn ensured a degree of connection with metropolitan science. It was this type of deference to peers in England that was perhaps more relevant in this regard.

But there were countervailing forces at work that ensured an autonomous line of development for science in the colony. In politics, and in science, the physical distance from the metropolis ensured a certain degree of autonomy *a priori* for the colonial bureaucrats and scientists. Bureaucrats responded to local needs in devising plans for setting up laboratories. *Post facto* they persuaded the metropolis to agree with their decisions. Experts ran the risk of losing their patronage if they did not respond adequately to demands placed on them by the local patrons – both planters and the government. Bloxam's experience at failing to find sponsorship for his work in India is a splendid example. In contrast, Bergtheil worked more in deference to the wishes of his local patrons and thus enjoyed their support until the time when curtains were drawn on all scientific efforts in India.

Indeed, the case of India House trying to force Bergtheil placed in India to "collaborate" with Bloxam in England in deference to the wishes of metropolitan scientists Arthur G Green, A G Perkin and others is insightful, and so is their failure in evoking the response they wanted. As mentioned before, Perkin had sent a letter expressing regret that cooperation had not been ensured from the experts in India. Acting along the same lines, India House wrote to the officials in India pointing out the failure of Bergtheil to collaborate with Bloxam. [27] But such efforts to force a collaborative effort between the two experts did not succeed. The physical distance between the experts and

[27] Letter from J H Seabrooks, Assistant Secretary, Revenue and Statistics Department, India House to Revenue Secretary, Government of India, dated, August 31, 1906, R&S No. 2423, No. 20, Serial No. 5, Government of India, Proceedings of the Department of Revenue and Agriculture for April 1907, IOR, GOI, Proc. Rev & Agr, P/7613

the personal acrimony between Bloxam and Bergtheil were certainly two factors inhibiting cooperation. But the more deep-rooted cause was the fact that the administrators and their experts, Bergtheil in particular, found the results of Bloxam's endeavors irrelevant in practice for the type of work being done in India. As we shall see below in the next section, the laboratory work at Sirsiah in India had evolved in quite a different direction from the line of query being pursued at the University of Leeds in England. The very nature of that laboratory cum agricultural station was more in tune with the demands placed by the local patrons. It was more adapted to the scientists' and patrons' knowledge of local conditions.

Not unexpectedly, then, the bureaucrats from India put up a strong defense of Bergtheil. They regretted that the collaboration between the researchers as initially envisaged by the officials in India and England had not worked out. But perhaps they were in a better position to appreciate why such collaboration had not worked. On the specific issue of encroachment on each other's area of research, too, the officials defended Bergtheil: " Mr. Bergtheil does not appear to be to blame in his action." Such a defense in effect killed any chance of collaboration or understanding being reached between experts either for purposes of future scientific efforts on indigo or towards their individual, professional ambition with regard to academic publications.[28] The "distance" between Bloxam and Bergtheil persisted through the period. This distance was fomented by both personal acrimony and the divergence in their approach to their ongoing work on indigo.

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[28] Letter from E D Maclagan, Revenue Secretary, Government of India to Secretary, Revenue and Statistics, India House, dated, January 17 1907,letter no. 73, No. 23, Serial No. 8, Government of India, Proceedings of the Department of Revenue and Agriculture for April 1907, IOR, GOI, Proc. Rev & Agr, P/7613

The Turn To Agricultural Experiments In India: Cyril Jonas Bergtheil, 1905-08

Reflecting on the status of indigo experiments in August 1905, Bergtheil made two vital observations. Firstly, he spoke of ways in which his perspective on making manufacturing processes more efficient differed from that of his former colleague Christopher Rawson. Rawson had asserted in one of his last reports before departing for England that the efficiency of the manufacturing processes had been improved to the limit. In that report Rawson had claimed that the yield obtained by the scientists was already within ten per cent of the theoretical value. Bergtheil believed that Rawson's fine work on purifying water for use in manufacturing, oxidation of liquor, and after-treatment of recovered indigo had left little scope for further improvement in those areas. But Bergtheil believed that the yield from the stage of steeping could still be improved. Bergtheil argued that Rawson's conclusion about the efficiency of manufacturing was faulty because he had used an "erroneous" method of analysis for checking *indigotin* percentage. This belief encouraged Bergtheil's efforts toward analytical work to perfect the procedures for estimating color percentages. [29]

Secondly, and more importantly, Bergtheil's note indicated his growing belief that the greatest hope for yield improvement now rested in the direction of enhancing the plant's characteristics through better farming practices. He especially wanted selection and hybridization of plants to be in the forefront of all scientific efforts. Speaking of the potential of selection and hybridization specifically, he said:

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[29] Cyril Bergtheil, "An account of the scientific investigations which have been and are being conducted in India," NAL, *Indian Planters' Gazette* (December 23, 1905): 771-72

> As has been frequently pointed out, this is a most important aspect of the work, and perhaps the direction in which the chief hope of permanent assistance to the industry lies. [30]

Bergtheil was the head of the Sirsiah Laboratory and it was he who defined the agenda for scientific explorations there. With the help of his assistants RV Briggs and R S Finlow, Bergtheil basically followed three lines for his work at that station. A few experiments were conducted to streamline the process of steeping. A second group of analytical experiments was conducted to perfect the processes of estimating color percentage, the results of which were presented to the Society of the Chemical Industry in 1906. But the strongest and widest emphasis was put on the agricultural lines of experimentation. The chemical experiments to improve manufacturing were given a second place at Sirsiah. It would be fair to say that spearheaded by the efforts of Bergtheil and his team at Sirsiah this period in India saw a clear turn towards agricultural experiments.

Bergtheil conducted a few chemical experiments on manufacturing at Sirsiah and Pusa in 1905. His experiments were constrained due to his inability to produce absolutely pure cultures of the indigo enzyme, *indimulsin*, and also because of his failure to obtain the glucoside, *indican* in a crystalline form. As pointed out in the previous chapter, Bergtheil failed in obtaining *indican* using the methods proposed by the Dutch chemists Hoogewerff and ter Meulen in1900. At this time, the Dutch scientists, especially Beyerinck, Hazewinkel and van Romburgh, had been very successful in understanding

[30] Cyril Bergtheil, "An account of the scientific investigations…,," NAL, *Indian Planters' Gazette* (December 23, 1905): 772

the character of the indigo enzyme.[31] Incidentally, as we shall see in the next section, Bloxam in England procured samples of both *indican* and *indimulsin* from the Dutch chemists in Holland. The availability of these key specimens was going to provide considerable edge to Bloxam in his similar analytical work.

The majority of Bergtheil's experiments on steeping consisted of varying the temperature of liquor and duration of steeping to assess their effect on the output of the dye. He made a separate set of recommendations for steeping Java and Sumatrana plants. For the Java plant the planters were advised to keep the temperature of water during manufacturing at 90 F and to carry on steeping for ten hours. The Sumatrana plant was to be steeped for seven hours in water at a higher temperature of 104 F. Bergtheil expressed confidence that if the planters maintained the optimal conditions relating to temperature and duration of steeping, they would be able to extract up to 83% of *indigotin* recoverable from leaves. His report also claimed that since 5% of *indigotin* inevitably got soaked in the refuse plant and was apparently not recoverable, and because Rawson's method of oxidation was "as perfect… as can be desired," there did not exist any room for enhancing productivity of either the oxidation or the fermentation stage. Such conviction put a cap on future experiments on manufacturing at Sirsiah. [32]

Bergtheil also devoted some time to conducting experiments on fermentation that were not connected with indigo. He was aware of his position as the Agricultural Bacteriologist and therefore his obligation to contribute to scientific investigations of a

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[31] For Dutch chemists' work on indican and Bergtheil's failure in obtaining indican see A G Perkin and A E Everest, *The Natural Organic Colouring Matters*. (New York: Longmans Green and Company): 482-483

[32] "C Bergtheil's account of scientific work at Sirsiah, 1905-06," NAL, *Indian Planters' Gazette* (December 22, 1906): 730-731

more general nature. Thus he presented the results of some of his experiments on fermentation to agricultural journals in India. [33]

The annual report for 1905-06 mentioned that "several agricultural experiments" had been initiated during the year. The scientists first conducted comparative trials of the Java and Sumatrana varieties to assess their respective potential. Preliminary results of trials at Pusa showed that the Java variety of plant gave 60% higher yield than the Sumatrana variety. Additionally, the quality of dye obtained from the Java plant was found "in most cases" to be better than Sumatrana. After having affirmed the superiority of the Java variety, the experimenters conducted extensive trials to establish the optimum

Table 6.1
Area under Java indigo at the Belsand factory, 1904-1909

Year	Area in *bigha* for the first cutting
1904-05	33.5
1905-06	289
1906-07	666
1907-08	1,191
1908-09	1,559

Source: Adapted from D J Reid, "Ten years' practical experience of Java indigo in Bihar" [34]

[33] C Bergtheil, "The Study of Fermentation as Applied to Agriculture," *The Agricultural Journal of India* (1906) 1, 1: 68-75; C Bergtheil, "The Study of Fermentation as Applied to Agriculture, Part II," *The Agricultural Journal of India* (1906): 1, 3: 230-236

[34] D J Reid, "Ten years' practical experience of Java indigo in Bihar. *Agricultural Journal of India* (1917): xii 1: 19

cultivation practices for the Java plant – analyzing the best farming methods with regard to "spacing," "topping," and "cutting back." The agricultural orientation of experiments at Sirsiah was the direct result of a key development in the agricultural side of indigo manufacturing in Bihar. The period in focus saw a major switch in Bihar away from the native Sumatrana to the imported Java variety of indigo. We have data on the growth in Java acreage from the Belsand factory (see Table 6.1 above). The case of the Belsand factory, one of the largest indigo factories of the times, owned by the influential planter D J Reid, can be safely taken to be representative of the general trend. The initial success with the introduction of the higher yielding Java variety had generated optimism. Many planters were drawn to growing the new variety. But even as the adoption of the Java variety continued, the planters faced new types of problems that came up with the cultivation of Java indigo. The Java variety proved to be a breed difficult to tame over the long-term. Problems related to the germination of the Java seed confronted the planters. Pest attack also continued to adversely affect the cultivation of Java variety in the local environs of Bihar. Under such circumstances the planters demanded that the experts devote their time to confronting problems related to the acclimatization of the new variety of indigo plant.

To handle the problem of "hard" seed coat obtaining in Java indigo, which delayed its germination, Bergtheil and his associates suggested treating seeds with concentrated sulfuric acid, as opposed to scarifying (physical scratching), which was the usual practice so far. In his papers published subsequently Bergtheil explained that the hard seed coat arose from the depositing of extra cellulose, and that scarifying removed a portion of this resistant covering and allowed water to penetrate. Bergtheil instead suggested immersing the seeds in sulfuric acid for some time, washing, and then drying, a combination of steps that was easier and required less labor. He also claimed that after treatment with sulfuric acid the *arrecta* variety's germination rate would go up from 3% to 95%. Dipping seeds into acid for about forty minutes usually sufficed in case of most *arrecta* species plants, although the exact time for every category of *arrecta* seed, originating from different regions, could also be easily determined by means of preliminary experiments on factory premises. The suggestion regarding treatment with sulfuric acid was well received by other scientists working in the field. In his assessment of the work of BIPA's scientists, Eugene Schrottky called acid treatment one of the best innovations ever suggested. According to Schrottky, acid treatment not only facilitated unhindered germination, but also made indigo less prone to the widely prevalent plant disease, called blight.

The scientists at Sirsiah also explored the effect of the addition of nutrients for improving the color-yielding ability of the indigo plant. In their experiments involving manures, the experimenters tried to look, more precisely than their predecessors, for possible effects of the addition of compounds on an increase in the content of *glucoside* in leaves, the color-giving principle. Previously the scientists at Dalsingserai had faced problems in validating the results of their agricultural experiments. The varying nature of soil on the experimental farms on the one hand and the induced artificiality of growth conditions in case of trials within "glass-houses" on the other, had continued to intrigue them. By filling a pit with soil of uniform quality the experimenters at Sirsiah tried to obtain standardized conditions for their trial, while also retaining the advantage of natural weather conditions for plant growth outside the laboratory. Lastly, during the course of the year, Bergtheil laid the groundwork for the planned selection and hybridization experiments at Sirsiah. He entertained high hopes in the efficacy of botanical manipulation to improve the stock of plants grown in Bihar. In anticipation of such experiments he systematically grew indigo plants originating from different regions on a large-scale. [35]

In conformity with the recent demand for agricultural and botanical experiments the scientists at Sirsiah demanded the appointment of a botanist to aid their ongoing efforts in this direction. Bergtheil in his annual report to BIPA strongly urged that a botanist be employed as soon as possible to assist with the plant selection.

BIPA requested the Secretary of State in London through the provincial government that a botanist be sent from England. Apparently some delay occurred in the process of communication among administrators within Bengal, and in Simla and London. Showing impatience with the bureaucratic delay, BIPA went ahead and appointed a botanist, A. Turnbull, without obtaining prior official approval from the government, an act that generated consternation among the bureaucracy. They simply refused to consider Turnbull as a government appointee. But they agreed that the expert's

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[35] "Cyril Bergtheil's account of scientific work at Sirsiah, 1905-06," NAL, *Indian Planters' Gazette* (December 22, 1906): 730-731; Schrottky's letter of February 1907 to the BIPA, NAL, *Indian Planters' Gazette* (March 16, 1907): 299; Cyril Bergtheil and D L Day, "On the Cause of 'Hardness' in the Seeds of Indigofera arrecta,' *Annals of Botany* (1907): 21, 81: 57-60; R S Finlow and C J Bergtheil, "A Method for Producing Immediate Germination of "Hardcoated" Seeds," *Journal of the Asiatic Society of Bengal* (1908): 3, 10: 77

salary could be paid out of the grant given by the government to BIPA for indigo research. Turnbull had already joined Sirsiah station in the summer of 1906. [36]

The Permanganate Tests: The Analytical Issue Between Bergtheil And Bloxam

The experiments conducted at Sirsiah from 1904 also took on a third dimension, one involving analytical work to check the efficiency of the manufacturing process. As we saw, Bloxam had earlier questioned the reliability of the diagnostic tests used in India for the estimation of *indigotin*. His claim that the potassium permanganate test, as applied in India, was faulty and gave misleading results had crucial implications for the future design of experiments. These tests could ascertain the percentage of *indigotin* at various stages during the production cycle. Therefore they could help establish the effectiveness of different stages of production and suggest which stage needed further attention – fermentation, oxidation, or boiling. Bergtheil devoted part of his efforts to preparing grounds for responding to the objections raised against the reliability and validity of the permanganate tests by Bloxam.

Both Bloxam and Bergtheil believed that the *indigotin* test used in India had problems. However, they attacked Rawson's permanganate test on different grounds. In his report of 1904 Bloxam had objected firstly to the fact that the test had not been validated with pure indigo. Further, he attacked the reliability of the test, noting that in his trials with the test he got differing percentage values. As we showed earlier, he explained that Rawson's method comprised of a "progressive" chemical reaction, which

[36] Letter of R W Carlyle, Revenue Secretary, Bengal, dated, December 3, 1906, to Revenue Secretary, Government of India. BSA, GOB, Rev (Agr.), May 1907, File 2I/2 5-6, No. 1

gave conflicting results depending on the length of time for which titration with potassium permanganate was carried out. [37]

Bergtheil did not consider Bloxam's criticisms to be definitive. He did not think that the lack of validation with pure indigo was such a serious limitation. He suggested the relatively less accurate method of validating the permanganate test using results from Kjeldahl's test. Kjeldahl's test also enabled determination of the *indigotin* percentage by measuring the nitrogen content of the dye, although the percentage results from Kjeldahl's test could not be guaranteed to be "very" accurate. That was because its use for determining indigotin percentage was based on the assumption that the dye did not contain any nitrogen-based impurity or the isomer, *indirubin.* In further responding to Bloxam's criticism, Bergtheil noted that the reaction that took place during titration was indeed a progressive one and not a "quantitative" one, but again he did not consider that to be problematic. He turned everyone's attention to the long continuing convention of completing titration quickly in order to avoid additional chemical reactions, which in his opinion worked fine. [38]

In addition to Bergtheil, other chemists associated with the dye trade such as J Grossman and Edmund Knecht also endorsed the effectiveness of the existing titration tests with some modifications. Since 1885 the permanganate test had sufficed as a rough and ready test for those interested in measuring the dye's purity and fixing its value in the market. Manufacturers, drysalters, and buying and selling brokers had readily employed

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[37] W Popplewell Bloxam and H M Leake, with the assistance of R S Finlow, *An Account of the Research Work in Indigo, Carried out at the Dalsingh Serai Research Station From 1903 to March 1904.* (Calcutta: The Bengal Secretariat Book Depot, 1905): 26-28. Henceforth, "Bloxam and Leake"

[38] C Bergtheil and R V Briggs, "The Determination of Indigotin in Commercial Indigo and in Indigo-Yielding Plants," *Journal of the Society of Chemical Industry* (1906) 25: 729-730

the test in their trade. Easy to administer and relatively quick, the test lent itself well to the requirements of the commercial transactions. At a meeting of the Society of Chemical Industry in 1905, Grossman argued that Rawson's method was "best and most convenient," despite the presence of a plethora of other methods. He suggested a modification in the method to facilitate better precipitation of impurities. [39]The same year Edmund Knecht, a lecturer at the Manchester Technical School, proposed a method at the Society of Dyers and Colourists, which also worked on the similar principle of dissolving *indigotin* in sulfuric acid followed by titration. Knecht preferred precipitation of impurities by calcium carbonate and titration by reduction with titanium trichloride. [40] The broad endorsement of the existing methods for estimating indigo, even though they were not extremely accurate, has to be understood in the context of that method's adequacy in meeting the requirements of the trade.

But now the scientists had to decide how the permanganate test measured up to the task of checking the efficiency of the manufacturing process, and on this there was a deadlock between Bergtheil's and Bloxam's perspectives. Bergtheil largely endorsed the accuracy of the permanganate method aside from suggesting one minor modification to Rawson's process. His trials with the permanganate test had convinced him that the addition of barium chloride precipitated some amount of *indigotin* and thus caused the

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[39] J Grossman, "An Improved Method of Indigo Testing," *Journal of the Society of Chemical Industry* (April 1905) 24: 308

[40] Edmund Knecht, "A method for the Volumetric Estimation of Indigo, Some Basic Colours and Eosines," *The Journal of the Society of Dyers and Colourists* (November 1905) 21: 292-295

final percentage figure to be lower than the actual. Therefore he suggested that barium sulfate be used as a precipitant for removing impurities. [41]

Bergtheil also suggested a minor modification to Rawson's *persulphuric acid* method for estimating the dye-yielding potential of indigo leaf. Rawson's method consisted of extracting the glucoside from the leaf by boiling it with water, and then converting a known quantity of the glucoside extract into *indigotin* through the addition of reagents hydrochloric acid and ammonium persulfate. Thereafter the weight of the *indigotin*, calculated with the permanganate method (Rawson's), would give the theoretical value of *indigotin* recoverable from unit weight of indigo plant. Bergtheil compared Rawson's method with his own "fermentation method," which involved conversion of the glucoside in the extract by the action of enzymes separately obtained from indigo leaf. In his trials he repeatedly got a higher weight value for *indigotin* percentage when using the fermentation method as against Rawson's "chemical method." After investigating this anomaly he concluded that the disparate value resulted from the addition of excessive persulfate in Rawson's method. He therefore suggested a modification wherein the amount of persulfuric acid added would be closely monitored.[42]

Bergtheil's endorsement of Rawson's method with minor modifications invited vehement attack from Bloxam subsequently. Bloxam determinedly and persistently challenged the accuracy of permanganate test and the procedure for its administration in

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[41] C Bergtheil and R V Briggs, "The Determination of Indigotin in Commercial Indigo and in Indigo-Yielding Plants," *Journal of the Society of Chemical Industry* (1906) 25: 731-734

[42] Christopher Rawson, *Report of the Cultivation and Manufacture of Indigo*. Bradford: William Byles and Sons, 1899; C Bergtheil and R V Briggs, "The Determination of Indigotin in Commercial Indigo and in Indigo-Yielding Plants," *Journal of the Society of Chemical Industry* (1906) 25: 734-735

papers read before the Society of Chemical Industry in 1906 and 1907. A more elaborate critique of permanganate tests appeared in Bloxam's report of 1908.

Analytical Science In A Metropolis: William Popplewell Bloxam, 1905-08

From 1905 on Bloxam focused on developing a clearer understanding of the various constituents of the amalgamated natural dye. He worked using samples from indigo's manufacturing cycle of 1903 at Dalsingserai that he had brought with him. While working at the Clothworker's Laboratory at Leeds, Bloxam also drew on the expertise of some of the most credible chemists of vegetable dyes, most notably A G Perkin, and his supervisor, A G Green. Additionally, he had access to the relevant literature on the latest research on plant indigo, especially those relating to *indican* and indigo enzyme published by the Dutch chemists. Lastly, Bloxam obtained samples of plant extract, *indican*, and indigo-enzyme from scientists in Netherlands, the facts that bear testimony to his far superior access to scientific information in a metropolitan setting, especially as compared to the lack of access for Bergtheil in India.

In order to determine the efficiency of manufacturing operations used in India, Bloxam decided to devise more accurate tests for measuring the output of *indigotin* at different stages of manufacture. He had earlier condemned the permanganate test used for measuring color percentage as inaccurate and unreliable. Bloxam's critique was especially directed at the strategy of precipitating "some half dozen impurities" in the amalgamated dye with a single precipitant in those tests. He pointed out that in Bergtheil's and Knecht's methods the use of a precipitant failed to remove all impurities. As a result, the oxidizing and reducing agents reacted with additional compounds during titration and gave an inflated estimate for *indigotin.* To circumvent the problem of separating multifarious impurities from the soluble *indigotin* derivative, especially because the precise nature of those impurities was still unknown, Bloxam followed an alternative strategy – of precipitating *indigotin* from the amalgamated dye.

Bloxam's tetra-sulphonate method, first proposed at the meeting of the Society of Chemical Industry in August 1906, promised a higher level of accuracy in indigo testing. The new method involved precipitating crystalline potassium indigotin tetra-sulphate by adding fuming sulfuric acid to crude indigo in the presence of potassium acetate. [43]A solution of the resulting salt was then made to undergo titration with known quantities of permanganate. Bloxam provided a new "factor" for deriving the amount of *indgotin* in the solution – predicting the presence of 0.00222 gm. of *indigotin* for every 1.0 cc. of permanganate solution (1/1,000) consumed. Bloxam had validated this conversion rate with the help of pure *indigotin* that he had earlier produced in laboratory.

In his subsequent experiments Bloxam focused attention on understanding the nature of the "impurities" in natural indigo. He isolated indigo-gluten, indigo-brown, indigo-yellow, the other components of natural indigo besides *indigotin*, and demonstrated that they remained non-reactive when potassium acetate was added to them separately. Thus he underscored that the addition of potassium acetate in the tetra-sulphonate test did not precipitate the impurities and therefore that the precipitant enabled

[43] Bloxam noted that in using potassium acetate as a precipitant he had drawn on the precedent of A G Perkin, who had also used the same precipitant "with success for a similar purpose," Cf., A G Perkin, "Notes on the purification of some Congo and Acid Red Colours," *The Journal of the Society of Chemical Industry* (1903) 22: 14

“quantitative separation” of *indigotin* derivative in his test. As a consequence the tetra-sulphonate test was able to provide highly accurate results. [44]

To settle the efficiency question Bloxam next turned his attention to the test used by scientists in India for measuring the color yielding ability of indigo leaf – the persulphate method, and found it wanting in reliability and accuracy. First proposed by Rawson and subsequently modified by Bergtheil, the persulphate method involved hydrolysis and oxidation of leaf extract by ammonium persulphate and hydrochloric acid. The resulting *indigotin* would then be checked with the percentage test. Bloxam and his associates pointed out that despite its modification by Bergtheil the persulphate test gave inconsistent results in laboratory trials and therefore claimed that the test was unreliable. Bloxam also noticed the formation of brown substances during the reaction and suspected that some *indican* was being lost as indigo-brown. Bloxam next tried to validate the results obtained from the persulphate test. He procured leaf extract from the Dutch chemist Beyerinck, and used indigo-enzyme (obtained using Beyerinck’s method) to convert the leaf’s *indican* into *indigotin*. A comparison of the results conclusively proved that the persulphate test then widely used in India was inaccurate. [45]

In January 1907 Bloxam proposed an alternative “isatin method” for accurately and reliably estimating the *indigotin* yielding ability of indigo leaf. Not able to validate Rawson’s/Bergtheil’s method, Bloxam searched for an alternative route, and settled on a

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[44] Bloxam and Leake, 106-107; W P Bloxam, “The Analysis of Indigo,” *The Journal of the Society of Chemical Industry* (August 15, 1906) 25: 735-744; I Q Richardson, S H Wood, and W P Bloxam, “Analysis of Indigo – Part II,” *The Journal of the Society of Chemical Industry* (January 15, 1907) 26: 4-7

[45] I Q Richardson, S H Wood, and W P Bloxam, “Analysis of Indigo – Part II,” *The Journal of the Society of Chemical Industry* (January 15, 1907) 26: 7-8

rather well known reaction, involving treatment of leaf extract with hydrochloric acid and isatin; the resulting *indirubin* (an isomer of *indigotin*) gave an estimate of the dye content in the leaves of the indigo plant. Bloxam indicated that Baeyer had originally thrown light on this chemical pathway, and that more recently Beyerinck had suggested its potential use for purposes of estimating *indican*. Bloxam wanted to confirm the results obtained from the isatin method with pure *indican*. In association with A G Perkin and by generously drawing on information emerging out of experiments of a similar nature by the Dutch chemists, Bloxam now obtained *indican* in the laboratory. Using pure *indican* he confirmed the results of the isatin method, and confidently declared:

> The isatin method for the analysis of the [indigo] leaf is at present the only trustworthy method. [46]

Bloxam arrived at drastically different conclusions regarding the color bearing ability of indigo plant and the efficiency of the manufacturing process. Putting dried indigo leaves to isatin test he found that the average *indigotin* yielding potential of the indigo plant (including stem and leaves) was much higher than the 0.3% by weight estimate as previously believed by the scientists in India. He also tested more than 70 samples of finished cake of indigo from the 1903-04 season at Dalsingserai, which had been produced from the same indigo leaves using the common method of manufacturing. His "accurate" tetrasulphonate method showed that the percentage of color in the final

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[46] Bloxam and Leake, 107-108; I Q Richardson, S H Wood, and W P Bloxam, "Analysis of Indigo – Part II," *The Journal of the Society of Chemical Industry* (January 15, 1907) 26: 8-9; A G Perkin and W P Bloxam, "Indican Part I," *Journal of the Chemical Society Transactions* (1907) 91: 1715-1728; R Gaunt, F Thomas and W P Bloxam, "Analysis of indigo (Part III) and of the Dried Leaves of Indigofera Arecta and Indigofera Sumatrana," *The Journal of the Society of Chemical Industry* (November 30, 1907) 26: 1178-1179, 1182

dye was 60-62% and not 75% as claimed on the basis of application of Rawson's "inaccurate" permanganate test. The combined results of his tests made him conclude that the efficiency of the currently employed manufacturing processes was far less than the 85% commonly assumed in India. Bloxam would present a full-fledged description and analysis of the "low" efficiency of manufacturing processes in India in his report in 1908.[47]

Eugene Charles Schrottky: A Maverick, 1905-08

The case of Eugene Schrottky, planter and chemist, and his experiments in this period is both unique and presents problems in interpretation. It is difficult to establish his personal and professional credentials due to claims and counter claims about him in the sources. It is especially very difficult to establish his motivations for the conduct of indigo experiments and his claims about positive results that were supported by a handful of planters at different times.

Between 1889 and 1902, Schrottky held shares in the Bengal Indigo Manufacturing Company that was registered in London. The company had manufacturing, trading, and dealership interests in indigo. Schrottky had sold his patents dating from the 1870s and the 1880s related to innovations in the manufacturing of indigo to the aforesaid company in lieu of his shares. The company was finally dissolved in

[47] I Q Richardson, S H Wood, and W P Bloxam, "Analysis of Indigo – Part II," *The Journal of the Society of Chemical Industry* (January 15, 1907) 26: 10; R Gaunt, F Thomas and W P Bloxam, "Analysis of indigo (Part III) and of the Dried Leaves of Indigofera Arecta and Indigofera Sumatrana," *The Journal of the Society of Chemical Industry* (November 30, 1907) 26: 1178-1179, 1182

1902. [48] From 1903 onwards, Schrottky remained quite visible in the indigo world. He had apparently cultivated the friendship of a handful of planters and administrators. Some of the planters let him conduct a limited number of trials to improve manufacturing on their premises.

Schrottky's activities were found so intriguing that they generated a confidential query on him in the metropolis. In 1906 Wynstan R Dunstan, the head of the Scientific and Technical Department at the Imperial Institute in London, wrote to William P Bloxam who was stationed at the time at University of Leeds asking if he could independently confirm Schrottky's credentials. Bloxam in his reply characterized Schrottky as a "perennial charlatan" as far as his contributions to indigo manufacturing were concerned. Disparagingly, Bloxam said of him: "His plan seems year after year to start some new notion for improvement and to induce people to finance him. Wonderful increase in produce is claimed but as far as I hear never substantiated." Bloxam also doubted that he had "any professional qualifications at all." [49]However, Schrottky's patent dating from 1906 listed him as a former student of famous German chemist Justus von Liebig. [50] The patent also claimed that Schrottky had taught botany and chemistry at the Grant Medical College in Bombay (India).

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[48] Papers related to the incorporation of the Bengal Indigo Manufacturing Company, PRO, BT 31/4628/1000052

[49] Private, Letter from W P Bloxam to Prof. Wynstan R Dunstan, dated, October 4 1906, PRO AY 4/2048/100168

[50] Patent, Schrottky's Glucosode Process, English Patent No. 10,506 of 1906 – India Patent No. 364 of 1906, PRO, AY4/2048/100168: 6 In a private communication Prof. Ernst Homburg at the University of Maastricht confirmed that the two lists of students for Justus von Liebig do not include the name of Eugene Charles Schrottky. Although he also stated that the absence from the two lists does not completely rule out the fact that he may have been von Liebig's student in a formal or informal way.

No additional information is available on Schrottky. Although definitely kept at an arm's distance by the government officials and their chemists, Schrottky figures consistently in the trade journals either claiming success with the improvement of manufacturing processes or making other recommendations to bolster the prospects of the natural indigo industry. It is not unlikely that through this period he also retained business interests among the indigo factories in Bihar.

Schrottky continued to conduct a few experiments at the factories of individual planters. Although he claimed to obtain good results in improving yield from isolated trials at a few factories, he failed to obtain those results on a consistent basis. In 1906, Schrottky employed a new process of fermentation – now called the "*glucosode* process," at the Burhurwah factory (Turcouleah Concern) belonging to planter James B S Hill. When conducted under his supervision, the trial returned a very good yield of dye. A comparative trial with the old process gave a much lower yield of 12 seers of indigo dye having 69.2% *indigotin*. Another planter, G.W.C. Moore of Buthnaha Indigo Concern in Bihar also confirmed that he got very high yield using the invented process. He said:

> I have tried Schrottky's Glucosode Process this Moorhun Mahai in a very exhaustive manner. It has given me from 15 to 17 seers of Indigo per hundred maunds of green plant. The usual Process yielded 10-11 seers. [51]

[51] GWC Moore's letter, dated August 5, 1906 in Schrottky's patent application, Public Record Office, AY4/2048/100168: 6

Table 6.2
Yield claimed from the *glucosode* process against 12 *seers* (69.2%) by ordinary process

Date of the trial	Total weight of indigo plant processed (in *maunds*)	Output of dye for every 100 *maund* of plant (in *seers*)	Percentage purity of dye
July 28, 1906	1,306	17.70	70.9%
July 29, 1906	1,504	16.75	73.8%

Source: English Patent, 10,506 of 1906, PRO, AY4/2048/100168, p. 6

Schrottky went on to receive patents for his *glucosode* process separately in India and Britain in 1906, a process that involved adding a reagent *glucosode* to the fermenting liquor.

However, the new fermentation process received a lukewarm response from other planters. In July 1906, Schrottky wrote to the secretary of BIPA and offered to conduct a trial of *glucosode* process at their Sirsiah laboratory. The directors of BIPA did not show any interest. Cyril Bergtheil, BIPA's scientist did not consider Schrottky's innovation worthy of an extended trial. In his annual report to BIPA, Bergtheil belittled the innovation in question. He summarily dismissed the usefulness of the innovation stating that the planters who had tried the process had not found it to be having a positive impact on the yield. Schrottky countered Bergtheil's elucidation of the *glucosode* process in the report, arguing that the *glucosode* process did not simply amount to addition of an alkali to the steeping vat, as explained by Bergtheil. He belabored the point, citing chemists at Lincoln's Inn (London), that chemical *glucosode* contained several compounds in addition to the alkali such as methylated ketonic acid, salts of sodium, and other secondary products, and that a combination of several compounds in *glucosode* contributed to enhancing the efficiency of the fermentation of indigo. He criticized Bergtheil for “making a public statement calculated to most seriously harm the prospects of a new and useful invention.” [52]

Schrottky conducted more extensive trials at Turcouleah in 1907, one of the largest indigo growing concerns of Bihar, to establish the credentials of his innovation. At Turcouleah’s head factory, Schrottky put the *morhun* crop aggregating 62,478 *maunds* of the plant through his patented process and obtained a yield of 17 _ seers per 100 *maund* of the plant. The yield at this factory in the previous *morhun* season had been 9 3/4 *seers*. Since the indigo output was known to vary sharply among the factories and over different seasons, Schrottky employed several “controls” to confirm that the increase in yield at Turcouleah had resulted from the employment of the *glucosode* process. He subjected the subsequent *khoontee* crop at Turcouleah to the ordinary process and got a yield of 9 3/4 *seers*. At two neighboring Turcouleah factories, Muckwah and Ghyree, where soil and water supply as well as weather conditions were similar, the ordinary process for *morhun* crop returned 11 5/8 and 10 14/15 *seers*. The gain in yield recorded at the head factory for *morhun* came to 76%. The same year Schrottky carried advertisements in the trade journal *Indian Planters’ Gazette* inviting planters to buy the patented process from him. The advertisement guaranteed an increase in yield of at least

[52] “Eugene Schrottky’s letter to Behar Planters’ Association Limited of February 1907,” NAL, *Indian Planters’ Gazette* (March 16, 1907): 299-300

50%, also stating that the indigo produced by the process had tested 76% *indigotin* on the Calcutta market, and sold at Rs. 185 per *maund* on February 2, 1907. [53]

In the days following the trial at the Turcouleah head factory, Schrottky exuded confidence that a practical new scheme existed to ward off the competition of synthetic indigo. Early in 1907, he wrote:

> With Java-Natal indigo and the Glucosode process we can produce indigo so cheaply that the (natural indigo) Industry will be able to undersell the synthetic product. [54]

Notwithstanding Schrottky's claims, the majority of planters did not adopt his fermentative method. In a subsequent letter Schrottky himself referred to the fact that the planters using his method got "a very low class" indigo, although their total yield went up. He then returned to his laboratory, conducting experiments to remove the "defect" in the *glucosode* process that had caused deterioration in the quality of the dye produced. Schrottky also introduced alterations in the composition of *glucosode*.

It is not difficult to understand the reasons for the lack of a positive response to Schrottky's experiments. The results obtained by the German chemist were not yet definitive. Most trials in which Schrottky claimed success were the ones conducted under his direct supervision. The trials also gave inconsistent results depending upon whether *morhun* or *khoontie* crop was processed, the site of the trial, and local weather conditions. Besides, as one of the planters rhetorically argued, the key to success lay not in getting

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[53] Letter from Schrottky, dated, June 3, 1908 in Indian Planters' Gazette (June 6, 1908): 782; see Schrottky's advertisement, *Indian Planters' Gazette* (March 16, 1907): 296

[54] Eugene Schrottky's letter to Behar Planters' Association Limited of February 1907, *Indian Planters' Gazette* (March 16, 1907): 301

exceptional figures of yield every once in a while, but getting them consistently. This early response from a planter, appearing in the *Planters' Gazette* of March 1904, criticized Schrottky because by his own admission his process seemed to work "on occasions or in very favourable years." He drew Schrottky's attention to the fact that the output from plant indigo was known to be highly erratic, and additionally that other planters too had obtained comparable figures on odd days. But the real challenge was to make high yields a permanent feature of the production system on indigo tracts in Bihar; in other words, to get a sound understanding of the processes that enabled high yields. Thus, it was no surprise that the planters continued to be skeptical of Schrottky's claims and never adopted his "innovation." Schrottky's letter, dated as late as October 1, 1909, admitted that the merits of his manufacturing methods were still being "greatly questioned" by the planters. [55]

Without abandoning his chemical experiments, Schrottky also continued with his other mission of popularizing the cultivation of the Java-Natal variety. He believed that the introduction of the Java-Natal variety held promise for the future of the region's indigo industry even if the newer manufacturing methods were not employed.

Schrottky achieved relatively more success in his attempts to spread the cultivation of the Java variety at indigo factories, although less so in Bihar than in the neighboring United Provinces, a province to the immediate west of Bihar. On Schrottky's personal initiative the Java variety was introduced at two factories in United Provinces - Surriyat and Belwar. Schrottky also won the favor of Sir John Prescott Hewitt, the

[55] "To the Editor, Pioneer," by Interested, NAL, *Indian Planters' Gazette* (March 12, 1904)

Lieutenant Governor of that province, who took personal interest in enabling Schrottky's trials and experiments at the local Gazia Indigo factory.[56]

In the end, Schrottky did little more than earn the reputation of a maverick in India. On the basis of his isolated experiments he continued to make claims about high yields coming from his processes. Neither the majority of planters nor the other scientists could replicate his results. Whatever his motivation for conducting these trials and his claims, neither the planters nor the scientists could ever bring themselves to take Schrottky seriously.

Bloxam's Report Of 1908

Bloxam's report of 1908 authoritatively declared that a huge loss of color was taking place during the process of manufacture of dye in India. Bloxam had set out to provide a quantitative method for estimation of color-giving body in the leaf and the color present in the dye manufactured in India. He was quite successful in doing this. His methods allowed him to provide very precise figures for the percentages. His study indicated that the amount of color-giving glucoside in the indigo leaf was 0.6% by weight and not 0.3% as believed earlier. This doubling of the estimate for obtainable color in the leaf had major implications for the new efficiency he was proposing. He also pointed out

[56] Schrottky's communication from Gorakhpur in the United Provinces, published in the *Indian Planters' Gazette* (September 25, 1909): 482-483; Schrottky's letter, dated October 1, 1909 to the editor, *Indian Planters' Gazette* (October 9, 1909): 554; Eugene Schrottky, "The Natural Indigo Industry: A New Era of Prosperity in Sight," *Indian Planters' Gazette* (August 13, 1910): 289; Eugene Schrottky, "The Natural Indigo Industry," *Indian Planters' Gazette* (August 27, 1910): 377-378

that the indigo cakes that he had examined had a color percentage of 60.3 – 61.9%. [57] In qualitative terms what these numbers implied was that the efficiency of the present processes of manufacturing was quite low. Bloxam's claims regarding "low" efficiency had momentous messages for the scientists, planters, and government in colonial India. To the scientists working in India the report suggested the prospects of improving the extraction processes. To the planters and the colonial government the report announced that it was still possible to save the natural indigo industry:

The Debates In England And India Leading Up To 1908

Dramatically varied reception greeted the report of 1908. Even before the publication of the final report in 1908, the presentations of Bloxam and Bergtheil at the Society of Chemical Industry in 1906 had stirred considerable controversy. All concerned – the metropolitan chemists and the India House bureaucrats in England, the experts and bureaucrats in India, discussed the two different scientific viewpoints in their own ways and developed separate conclusions.

Without delay India House turned to A G Perkin, the metropolitan chemist who had supervised Bloxam's work, to get his opinion on the controversy between the two experts. The bureaucrats wanted him to interpret for them the difference in the account between the two experts, provide his evaluation of the two standpoints, and also enlighten them as to which set of tests the commercial classes were leaning towards. A G Perkin was a much-respected expert working in the field of natural dyes. Besides, not only had

[57] William P Bloxam, *Report to the Government of India Containing an Account of the Research Work on Indigo Performed in the University of Leeds, 1905-1907.* (London: His Majesty's Secretary of State, 1908): 107

he supervised the experiments of Bloxam and the writing of his report, but he had also witnessed the presentations of Bloxam and Bergtheil as well as the follow up discussion among those present at the Society of the Chemical Industry. Thus he had first hand information on what had transpired at the meeting of the professional organization. The officials noted that Bergtheil had claimed in his report to the agricultural department in Bengal that it was his method that was being adopted by the analysts in Calcutta and London in preference to Bloxam's. They trusted Perkin to tell them about the views of the chemists and the leading analysts in the country. [58]

Perkin assured them that leading chemists in the country including those present at the meeting on November 4, 1907 when the two experts had engaged in a dialogue, had overwhelmingly expressed themselves in favor of the superiority of tests presented by Bloxam and his associates. The objections of Bergtheil to the tetrasulphonate and isatin methods had been published in the *Journal of the Society of Chemical Industry*, which in turn had been repudiated by Bloxam in the same journal very recently. On the other hand, he argued that the Bergtheil-Briggs method for color estimation was demonstrated to him on two or three occasions and he did not think that it was more accurate than the previous version – the permanganate test. He shared the view that Bergtheil's test was faulty and certainly gave inflated estimates. [59]

[58] Letter from T W Holderness, Secretary, Revenue and Statistics, India House to A G Perkin, dated, November 12 1907, R&S No. 3295, No. 58, File No. 27 of 1907, Government of India, Proceedings of the Department of Revenue and Agriculture for the month of January 1908, IOR, GOI, Proc. Rev & Agr, P/7896

[59] Letter from A G Perkin to T W Holderness, dated November 15 1907, Government of India, Proceedings of the Department of Revenue and Agriculture for the month of January 1908, IOR, GOI, Proc. Rev & Agr, P/7896

In the same letter Perkin also doubted that Bergtheil's claim that analysts in England favored his method could be true. He did not have information about what was happening in Calcutta. But he was far more knowledgeable about the situation in England. He knew of just a couple of experts/consultants that still remained in the business of administering estimation tests. That was because the scale of indigo imports had dwindled in England. Also, most dyers now employed their own in-house chemists to obtain analytical estimates. He did not think that the surviving few chemists and colorists were using the method proposed by Bergtheil. While he agreed that Bergtheil's criticism had slowed down the acceptance of Bloxam's methods, there was no doubt that Bloxam's processes were becoming widespread. Even A. G. Green used the same method for teaching purposes at the University of Leeds and students of the dyeing department did not face any problem in getting accurate results with his procedure. In this context, he also mentioned that it had been anticipated that given the senior position occupied by Bergtheil, his opposition might have an impact on the users of indigo. To counter that influence the approval of many eminent chemists had been sought by Bloxam for his tests. Many British chemists like J Norman Collie, Alfred C Chapman, W H Perkin, and Arthur G Green had been invited to attest the accuracy of the tetrasulphonate tests and append personal notes of support to his report. [60] The isatin method on the other hand was based on a well-known and widely acknowledged quantitative method and according to him the criticisms by Bergtheil against that test simply did not stand.

The response in India to the presentation of Bloxam's and Bergtheil's results at the Society of the Chemical Industry and the reported difference of opinion between them

[60] Bloxam, *An Account* .., Appendix, 113-116

was quite different. For some of them at least, the response to Bloxam's findings ranged from being indifferent to outright cavalier and dismissive. A categorical support for the nature of work being done by Bergtheil even precluded any consideration of the specifics of the questions being debated at the Society of the Chemical Industry.

When the central government passed along the relevant papers by the two experts to the regional government and to the Inspector General of Agriculture, they responded with indifference. There just did not seem enough concern to examine the scientific questions. J W Mollison represented the sentiments at the local level by stating that work like Bloxam's did not have any relevance for the agricultural needs of Bengal. He said with a sense of definitiveness, "From a practical point of view no great importance needs to be attached to Mr Bloxam's indigo research work in England. He may have worked out problems in the laboratory which are of interest to pure scientists, but I am strongly of the opinion that for the time being, and probably for all time, his results (so far as I know them) will be of no value to the ordinary growers of indigo in India." [61]Mollison's comments turned out to be true and paradigmatic of the sentiments in Bengal. Local bureaucrats never showed any interest in the findings of Bloxam, even as they continued to support Bergtheil's work. A detailed discussion of the nature of the agricultural station at Sirsiah that Bergtheil headed between 1909 and 1912, and the fundamental reason for the support given by the planters to Bergtheil will appear in the next chapter.

The Bureaucratic And Policy Response In England

[61] Letter from J W Mollison to Revenue Secretary, Government of India, dated October 2 1907, letter no. C 672, No. 6, Serial No. 15, Proceedings of the Department of Revenue and Agriculture for the month of October 1907, IOR, GOI, Proc. Rev & Agr, P/7614

Participating in a follow-up discussion at the Society of the Chemical Industry another metropolitan chemist Professor Raphael Meldola, a long time advocate of British India's natural indigo industry, had prophetically summed up the relevance of Bloxam's findings. Meldola pointed out that from all appearances Bloxam's isatin test seemed to be an accurate test. But he added, "the end of the matter was not reached when the most perfect of analytical processes had been devised." It was the "bounden duty" of the planters and the government to get to the bottom of the matter while investigating at which point, and by how much, potential color was being lost. But even more than that, they had to determine if it was possible to plug the holes in the manufacturing processes and recover the extra *indican* whose existence the new test had predicted. It was one thing to analytically prove in the laboratory that the indigo plant could yield more color, and quite another to actually recover that extra color on a manufacturing scale by using available capital and technology. [62]

India House bureaucrats seem to embraced Meldola's argument that analytical work on indigo in England had reached its apogee. Therefore they refused to extend Bloxam's further work despite his passionate appeal to them. In the end Bloxam was quite bitter that even important work like that just completed by him at Leeds had been unable to get him an extension of his job with the national government in England. [63]

Indeed Meldola and his prescriptions became a critical part of the relevant bureaucratic structure for decision-making with regard to the administration of the Indian colony. On February 20, 1909 Raphael Meldola repeated his opinion, speaking in front of

[62] "Discussion," *The Journal of the Society of Chemical Industry* (November 30, 1907) 26: 1182-83

[63] Bloxam's obituary notice by A G Perkin, "William Popplewell Bloxam," *Journal of the Chemical Society* (1914) 105: 1195-1200

the Indian Government Advisory Committee of the Royal Society. While he proposed that experimental work on indigo should be continued and that it clearly seemed that the natural indigo industry had a glimmer of hope, he did not seem to favor the continuation of more analytical work. "What is now wanted is field work carried out in India both from the chemical and biological point of view," he recommended. In their wisdom the metropolitan bureaucrats decided to go with that advice. [64]

The Response Of The Central Government In India

Only the central government in India conjured up the resources to investigate the implications of Bloxam's report as opposed to the nonchalant attitude of the Bengal government. Their response was cautious. In order to have the report critically evaluated the government set up a committee comprising of three agricultural experts – J Mollison, Inspector-General of Agriculture in India, B Coventry, Director of the Agricultural Research Institute at Pusa, and J Hector Barnes, Agricultural Chemist in the province of Punjab. [65]

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[64] "Memorandum by Professor R Meldola, FRS, upon the Present Position of the Indigo Question – To the Indian Government Advisory Committee of the Royal Society," Proceedings of the Indian Government Advisory Committee of the Royal Society for 1909, CMB/59. These records are located at the archives of the Royal Society, London. The same report incidentally also appears as an Appendix in Selections from dispatches addressed to the several governments of India by the Secretary of State in Council, 52nd Series, Part 1, 1st January – 30th June 1909, V/6/361. These records are available at the British Library in London, grouped under the category of India Office Records. Henceforth, referred to as IOR, Dispatches. For the role of institutions like the committee at the Royal Society in England and the Board of Scientific Advice in India, see Roy MacLeod, "Scientific Advice for British India: Imperial Perceptions and Administrative Goals, 1898-1923," *Modern Asian Studies* (1975) IX 3: 343-384

[65] Letter of Revenue Secretary, Government of India, R W Carlyle, dated February 3, 1909 to Revenue Secretary, BSA, GOB, Rev (Agr.), File 2-1/2 1-73/4, Board's File, 114 of 1909: 3

The terms of reference of the committee reveal the concerns and priorities of the central administrators. The officials explicitly asked the committee to submit an early report on "three questions."

1) what portions of Bergtheil's work at Sirsiah were affected by the results of Bloxam's investigations?

2) how far was Bloxam's characterization of Indian manufacturing processes being inefficient justified, so far as it was possible to form an opinion on the basis of materials available and without undertaking independent research involving delay?

3) what was the prospect of work currently being done at Sirsiah?

As revealed by the brief of the committee, the administrators did not intend to analyze in detail the scientific import of Bloxam's chemical experiments, or settle the controversy raised by Bloxam's statements about the efficiency of manufacturing. As the title of the report suggested, the government basically wanted to assess the impact of Bloxam's findings on its own research program at Sirsiah. Which part of the current research remained unaffected by Bloxam's assertions and could be judiciously carried forward? Which parts of experiments had become contentious in the wake of Bloxam's claims, and therefore of doubtful efficacy?

Submitted shortly afterwards, the committee's most significant recommendation related to the positive appraisal of Bergtehil's experiments then being conducted at Sirsiah. The members concurred that only a long-winded investigation by a separate body would resolve the controversy regarding the efficiency of manufacturing operations. The members of the committee admitted that they did not have the qualification to carry out an experimental investigation of that nature. Many planters had in person testified to the benefits offered by the ongoing investigation at Sirsiah, which implied that those efforts be continued. Accordingly the committee's report favorably spoke of the contributions made by the scientists at Sirsiah, especially with regard to improving the method of steeping, acclimatizing the Java variety, and adopting sound farming practices. Federal administrators at the center endorsed the positive evaluation of work at Sirsiah. [66]

On the question of settling the controversy generated by Bloxam's arguments about the efficiency of manufacturing, the administrators at the center accepted the submission of the committee that only a different committee with different credentials could examine such issues. In a rejoinder to the report they also added that if the planters did not agree with Bloxam's assertion about the low efficiency of the manufacturing processes, *it* [was] *for the planters to decide* (original emphasis) if they should set up an independent committee to settle that question. A later report by the Director of Agriculture in Bengal makes a reference to the fact that the planters' body, BIPA, had "taken proper steps" to have the specific question relating to the efficiency of current processes of manufacturing investigated. But that is the last one hears of this in the records. It is quite probable that the issue was never scientifically settled. Nobody had the qualifications to settle a question as specialized as thus other than Bloxam and his associates in England. [67]

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[66] J Mollison, B Coventry, J Hector Barnes, "Report of the committee held at in October 1908 to consider the research work carried out at Leeds University by Mr. Bloxam, as set forth in his report to the Government of India, and how far it affects the investigations being carried out at Sirsiah in India," Letter of Revenue Secretary, Government of India, R W Carlyle, dated February 3, 1909 to Revenue Secretary, BSA, GOB, Rev (Agr.), December 1908, File, 11 – A/12 24-25 of 1908, No. 2

[67] Letter from F W Duke, Revenue Secretary, Government of Bengal to Secretary, Revenue and Agriculture, Government of India, dated April 17 1909, letter no. 61 TR, No. 37, Serial No. 7, File No. 18 of 1909, BSA, GOB, Rev (Agr.)

Meanwhile, undeterred and uninfluenced by Bloxam's critiques, indigo experiments in India from 1909 came to bear a primarily agricultural orientation. The context in which such decisions emerged will be the focus of discussion in Chapter Seven.

Concluding Remarks: Why Bloxam's Report Was Not Acted Upon?

Bloxam was deeply distressed by the lack of interest in his report by administrators and planters in India; he was saddened. Bloxam suffered a paralytic attack two years later, and died in 1913. Even the wider community of chemists working on dyes in Britain was amazed at the indifference in India to Bloxam's evidently accurate experiments. [68]

Several factors ensured the irrelevance of Bloxam's key findings. From all appearances Bloxam's tests seemed to be accurate. But as Meldola pointed out the end of the matter was still not reached when the most perfect of analytical processes had been devised. It was left for the planters to get to the bottom of the matter while investigating at which point, and to what extent, potential color was being lost. Also, the business community had to determine if it was possible to plug the holes in the manufacturing processes and recover the extra *indican* whose existence the new tests had predicted. It was one thing to prove analytically in the laboratory that the indigo plant could yield more color, and quite another to actually recover that extra color on a manufacturing scale by using available capital and technology. That never happened.

[68] Bloxam's obituary notice by A G Perkin, "William Popplewell Bloxam," *Journal of the Chemical Society* (1914) 105: 1195-1200

Secondly, Bloxam was also trying to turn back the clock for the scientific community based in colonial India. Scientists in India had moved on to biological lines of investigation since 1905. High yield of the new Java variety of plant provided them hope for results from such experiments. Now Bloxam was imploring the Indian scientists to return to chemical experiments without suggesting a concrete way of recovering the extra *indican*. None of the scientists in India had the skill and training to carry forward Bloxam's line of query to its logical conclusion. Under such circumstances it is no surprise that Bloxam's findings appeared irrelevant to the scientists and bureaucrats in India.

Thirdly, the government too stopped short of putting its weight behind the research possibilities opened up by Bloxam's findings. The administrators were hearing conflicting voices. Imperial Bacteriologist Cyril Bergtheil contested the findings of Bloxam. Additionally, the administrators found a majority of planters solidly united in demanding agricultural experiments in the field rather than chemical experiments in laboratories. The bureaucrats decided to go with the reasoning of the planters whose welfare was the rationale for government's funding of indigo experiments. A year after the publication of Bloxam's report, R W Carlyle, Government of India's Revenue Secretary, stated that the planters were still "inclined to place reliance chiefly on the improvement of seed and of methods of cultivation," thus justifying the focus on agricultural experiments. [69]Perhaps it would be fair to say that the colonial context – the

[69] Letter of Revenue Secretary, Government of India, R W Carlyle, dated February 3, 1909 to Revenue Secretary, Government of Bengal, Agriculture, File 2-1/2 1-7 _, Board's File, 114 of 1909: 3

local conditions and the preferences of scientists and bureaucrats there - effectively resisted the implementation of scientific advice emerging out of the metropolitan context.

CHAPTER 7

BERGTHEIL, BENGAL BUREAUCRATS, AND THE AGRICULTURAL EXPERIMENTS, 1908-13

Introduction

The scientific efforts to improve the yield of indigo in India from 1908 to 1913 largely involved the pursuit of agricultural experiments. Cyril Bergtheil supervised the conduct of these experiments and trials at the Sirsiah Laboratory/Station. Only a few chemical experiments of an analytical nature were conducted, and these were essentially intended to close the controversy over the efficiency of the manufacturing processes. Bloxam's report of 1908 had emphasized that efforts be re-focused on to the manufacturing stage (rather than on the crop in the field) because those currently in use were quite inefficient and left much of the dye behind in the leaf. His claims were backed by a group of metropolitan chemists who attested that the analytical work performed by Bloxam at Leeds and presented at the Society of Chemical Industry was credible. By contrast, from the perspective of the patrons of experiments in Bengal – the provincial bureaucrats and the planters -- the controversy provoked by Bloxam's report was soon settled. They believed in the interpretation provided by the Imperial Bacteriologist, Cyril J Bergtheil, one that implied that Bloxam's assertions were based on "misapplications" of experimental procedures. They continue to allow Bergtheil to define the agenda of scientific work in India. Bergtheil moved on to conduct agricultural and biological trials because he believed these to be the best course for improving the yield of the natural dye.

This was a period marked by minimal metropolitan interest in the prospects of India's natural indigo industry. English chemical manufacturers and some sections of the public raised questions like: Should the German manufacturers of synthetic dyes be allowed to dominate the British markets? What role would the indigenous manufacturers play in meeting national needs? Chemical industry entrepreneur Ivan Levinstein even demanded that the "imperial" natural indigo industry based in colonial India be encouraged through trade protection policies to prevent the dominance of English markets by the German synthetic manufacturers. These pleas were ignored. Others called for the reform of patent laws, arguing that the current set of regulations gave undue advantage to the foreign dye manufacturers. However the patent reforms of 1908 made little real difference. Prompted by the new regulations, one manufacturer, the MLB (Meister, Lucius & Bruning) set up its base to produce synthetic indigo in Britain. Production at MLB's unit in England kept rising till it supplied 50 percent of total British consumption of synthetic indigo by 1913. [1]

Meanwhile, political economy in the province of Bengal took center stage. These years witnessed the outbreak of peasant agitation on the indigo tracts in Champaran, the largest producer of indigo among the four districts (see Table 7.1 below). Citing non-remunerative purchase prices the native growers refused to plant indigo for the European planters. The growing agitation brought a new sense of urgency among colonial administrators with regard to developments within the indigo industry. On the one hand, they counseled the planters to keep wages and purchase prices remunerative. On the other hand, they wholeheartedly supported the conduct of scientific experiments with the hope of turning the indigo industry into a profitable venture for the planters.

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[1] Peter Reed, 'The British Chemical Industry and the Indigo Trade', British Journal of History of Science, 25 (1992): 115

Table 7.1

Indigo Acreage in Four North Bihar Districts in India, 1894-1934 (in hectares)

Year	Champaran	Saran	Muzaffarpur	Darbhanga	Total
1894-1895	21,853	20,638	55,441	37,837	135,769
1899-1900	38,849	18,413	24,280	20,598	102,140
1904-1905	33,993	7,284	14,366	13,314	68,957
1909-1910	14,568	3,925	8,134	4,735	31,362
1914-1915	3,277	930	3,035	2,630	9,872

Source: Jacques Pouchepadass, *Champaran and Gandhi: Planters, Peasants and Gandhian Politics.* New Delhi, 1999, Table A (unpaginated)

Finally, towards the close of the period in question, a curtain was drawn on the planters' initiative to use laboratory science for improving the yield and quality of the natural dye. Planters' profits plummeted to a dismal level. By taking into account the cost of factors of production (land, wages, financial capital) on the one side and the falling prices for indigo and returns from divesting into profitable crops on the other side of the equation, historian Jacques Pouchepadass has calculated that the average profitability on planters' invested capital decreased from 25-35% in the 19th century to 3-3.5% in the pre-War years. [2] Political agitation brought additional costs for court litigations and also raised concerns about the physical safety of European planters against attacks from locals. All these factors resulted in a very high rate of turnover as European planters deserted their business in great numbers. In the context of such adversity the planters stopped the scientific work of Cyril Bergtheil in 1912 and in early 1913 requested that the

[2] Jacques Pouchepadass, *Champaran and Gandhi: Planters, Peasants and Gandhian Politics* (Delhi: Oxford University Press, 1999): 103-105

Sirsiah Station be permanently closed down. The government transferred the indigo experiments and trials in progress to Pusa.

The Outbreak Of Indigo Disturbances In Bihar, 1906-1908

The indigo disturbances during the period provided the backdrop against which the provincial government adopted a new set of policies towards the planters and the plantation industry. One measure taken by the government to deal with these disturbances was to regulate the plantation industry.

Jacques Pouchepadass has provided a comprehensive account of indigo revolts during the period being considered in this chapter - 1908-13. [3] Pouchepadass has pointed out that the indigo revolts during the first decade of the 20th century were related to the fall in the market price of natural indigo. The planters took several steps to offset the low prices in the market. And the measures taken by the planters in managing contractual obligations with the agriculturists and in divesting were perceived by the popular masses as "excesses" and by the rural oligarchy as an encroachment on their financial interests.

The widespread agitation reflected the crisis that had beset the industry, and further aggravated it. Towards the end of 1906 the first agitation broke out on the Sathi plantation (Champaran). Despite police repression and the arrest of leaders the movement showed no signs of dying out. By the end of 1907 and early 1908 the agitation had gathered full momentum.

A major cause of discontent was the fact that the native growers were being forced by the planters to pay additional charges called *abwab*. The obligation to pay *abwab* had a long history in the region. The term referred to numerous types of exactions

[3] Jacques Pouchepadass, *Champaran and Gandhi*: Chapter 6, "Towards Struggle"

demanded from the subordinates in a feudal agrarian set up. The superior classes freely enjoyed this privilege. As a matter of fact the payment of this charge was not recognized under the rule of law. But in the countryside it was not uncommon that long-standing conventions rather than Pax Britannica would determine rural relations.

On this occasion the planters were demanding the payment of *abwab* based on their authority as the local landlords and contractors. Most planters had purchased *zamindari* rights from the superior landed classes. The possession of these coercion rights enabled them to exercise a better control over the indigo growers. At the same time the planters had signed indigo contracts with the growers that were recognized by the rule of law. Seventy per cent of land in Champaran was under the *asamiwar* system of cultivation in which the peasants cultivated indigo on their own land and supplied the produce to the planter. A clause of the *asamiwar* system was *tin-kathiya* that allowed the lease-holding planter to demand that the growers put 3/20th (that is three *katthas* per *bigha*) of their land holdings under indigo. The latest complication arose because the planters were now showing a preference for divesting - growing food crops instead of indigo, for one. Food crops fetched them a better price in the local markets and helped offset the loss on indigo. The planters now insisted that the growers put 3/20th of their land under food crop or pay compensation if they did not. Natives considered such a demand to be irregular because their contract originally obliged them to grow indigo. Therefore they turned to the courts requesting that the "illegal" *abwab* payments be stopped.

Friction also rose over the planters' drive to engage in sugar manufacturing, which brought them into competition with the rural oligarchy. The planters were relatively more resourceful. They began to offer higher prices to the producers of sugarcane in the countryside and thus challenged the position of native sugar interests. [4] Rich peasants, merchants, and bankers – all natives – had so far dominated the niche of sugar manufacturing. These aggrieved upper classes saw the arrival of European businessmen as a threat and therefore joined with the contract indigo farmers in opposing the planters. [5]

The agitation in Champaran increasingly invited the attention of the nationalist elements at a time of a growing national movement against the colonial rule. The court cases brought the indigo growers in contact with lawyers in locations as far as the divisional city of Patna. And in the first decade of the 20th century the spread of nationalist ideology was most prominent among the legal professionals in urban Bihar. The nationalists in turn were motivated to intervene in the conflict to exploit a local grievance to push their agenda of broadening the anti-colonial, nationalist platform. Thus there were linkages emerging between the local indigo growers and the nationalist middle classes. These emerging connections threatened to enlarge the scope of the indigo disturbances. [6]

The administrators could not afford to let the situation drift out of control. They faced a dilemma. They had all along known that the *abwab* was an illegal payment and a vice perpetuated on the plantations. But the administrators had never made any efforts to check them. The colonial officials regarded turning a blind eye to this legal infraction to

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[4] Letter of the manager of Parsa factory in Champaran, dated, October 8, 1908, in Proceedings of the Government of Bengal, Political (Police), No. 16, April 1909

[5] Jacques Pouchepadass, *Champaran and Gandhi*: 150-160

[6] Jacques Pouchepadass, *Champaran and Gandhi*: 160-166

be a small cost in favor of pushing the colonial enterprise of indigo manufacturing. But the spreading political unrest and violence on the indigo tracts forced a re-evaluation of the official perspective on the peasant movement.

A confidential enquiry was ordered by the government to get an assessment of the prevailing tensions on indigo tracts. W R Gourlay, the Director of the Department of Agriculture, conducted this enquiry. Gourlay's report submitted in April 1909 stated in no uncertain terms that the purchase price given to indigo growers by the planters was not remunerative. It recommended that the prices be enhanced by 12.5%. Gourlay also made a set of recommendations to streamline the working of the contract system. The departmental report suggested that the government should initiate necessary measures to limit the term of indigo contracts to a maximum of nine years, reduce the obligation to grow indigo from 3/20th to 2/20th (that is from three to two *katthas* per *bigha*) of the peasant's holding, and forbid the efforts to force peasants to switch from indigo to food crops, sugarcane etc.

The analysis in Gourlay's report reflects the emergence of new considerations in the official standpoint towards the indigo industry. The colonial bureaucrats were wary of political costs emerging out of the planters' transfer of their financial losses to the indigo growers. They expressed these reservations by openly talking about their opposition to "coercion," something that they had not done before in Bihar. The Lieutenant Governor of Bengal thus commented on Gourlay's report: "India has none too many industries, and no one wishes to destroy or discourage any that she has; indigo as little as any. But the indigo industry must stand on a commercial footing and be dependent in no degree whatsoever on compulsion or even pressure. I am ready to help the planters in every legitimate way. But if indigo cannot subsist without coercion, indigo must perish." [7]

Bergtheil At Sirsiah, 1908

Backed by the Bengal government's unflinching support, Bergtheil's work continued uninterrupted during the year. He conducted some "dye tests" in order to compare the dyeing potential of natural and synthetic indigo and a few trials to streamline the manufacturing operations. But the majority of his experiments were of an agricultural nature aimed at increasing the percentage of *indican* in the leaves. [8]

Bergtheil's experiments on dyeing potential were more in the nature of "demonstration experiments." Did natural indigo give more color than an equal weight of synthetic indigo? Was the higher price of the natural product in the market justifiable? A lot was at stake in these questions. An affirmation would demonstrate the superiority of the natural product. These experiments were not fundamentally directed towards the improvement of yield. Bergtheil conducted them at the behest of the planters. They were targeted to persuade the consumers.

But the tests proved inconclusive. Bergtheil was specifically called upon to test the statement made by some dyers in Britain that the natural dye was capable of imparting more color than the synthetic. He prepared separate vats with equal amount of natural and synthetic dye. Equal loads of fabric were then dyed for similar lengths of

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[7] Gourlay's Report and Lieutenant Governor's comments are cited in Jacques Pouchepadass, *Champaran and Gandhi*: 154-155

[8] "An Account of the Scientific Work on Indigo During the Year 1908-09," Appendix IV, Agriculture, October 1910, File, 7-R/15 1-3, Board's Agriculture File 150 of 1910, BSA, GOB, Rev (Agr.). The report describes Bergtheil's work done up to January 1909.

time. The results were identical as far as the shades were concerned. But the garment in the two instances consumed equal amount of dye, whether natural or synthetic. This seemed to go against the original claim according to which a lesser amount of natural should have been consumed. Bergtheil admitted that if the difference in the amount of dye consumed was miniscule his apparatus might not have detected it. Therefore on the basis of his trials he was not in a position to confirm or deny that natural indigo had a superior coloring power. At the same time he stressed that the question was worth further study. A marginal difference, if it existed, could result in cost savings for large concerns that used large amounts of dye.

The trials connected with manufacturing were focused on the processes of loading the vats, filtration of the run off liquid, and grinding of the indigo cake into powder. Bergtheil first experimented with the Java plant. He categorized the plants into superior (40% leaf content and 0.8% *indican* content) and inferior quality (35% leaf content and 0.7% *indican* content). On the basis of his trials (see results as tabulated

Table7. 2
Variation in efficiency of manufacturing due to different loading of vats

	Load per 1,000 cubic feet		
	80 *maunds*	100 *maunds*	120 *maunds*
Efficiency of superior plant	89.2	80.2	75.3
Efficiency of inferior plant	70.8	81	67.8

Source: An Account of the Scientific Work on Indigo During the Year 1908-09, BSA [9]

[9] Appendix IV, Agriculture, October 1910, File, 7-R/15 1-3, Board's Agriculture File 150 of 1910, p., ix, BSA, GOB, Rev (Agr.)

above)he recommended that good quality Java plants should be lightly loaded at 80 *maunds* for every 1,000 cu. feet space in the vats and inferior quality plants at 100 *maunds* for every 1,000 cu. feet of vat space. The weight in the tank should never exceed 120 *maunds*. He faced problems in acquiring samples of the Sumatrana plant in a sufficient quantity. But he was able to conduct a limited number of trials with Sumatrana. On their basis he felt reasonably confident to recommend that similar weight ratios for loading should be followed for the Sumatrana as for Java variety.

Bergtheil's efforts on the filtration of run-off liquid from the fermentation tank and on making indigo powder were not successful. The mechanical process of filtering being tried out at Sirsiah posed problems. Cloths of looser texture did not hold back the dye in a sufficient quantity. But when a cloth of close weave was tried the process of filtration was too slow to be practical for implementation on an industrial scale. To prevent this wastage Bergtheil suggested intervention in the oxidation tank. He recommended that Rawson's patented "ammonia gas process" of oxidation be used by the planters as it offered two advantages. In the first place it enabled better oxidation. At the same time it also facilitated a better settling of color to the bottom of the oxidation tank leaving very little dye suspended in the vat.

The powder-making machine procured the previous year did not perform as expected. It did manage to turn out flakes that could be easily ground. But the flow and speed of producing flakes was too slow. Therefore another machine was ordered from a firm in Edinburgh for a trial.

The vast majority of Bergtheil's experiments were along agricultural lines. In his annual report for the year he had said:

> The future of experimental work on indigo lies almost entirely in agricultural directions, in attempts to improve the indigo plant by selecting and breeding, to stimulate the production of indigo [indican] in it by manurial treatment, or to discover new plants capable of yielding more indigo [color] than anything we yet have. [10]

In 1908 Bergtheil mostly focused on enhancing the content of *indican* in the indigo leaves. Improved knowledge of *indican* and the wider circulation of that information must have facilitated his work in this direction. He had clearly shown an increased familiarity with the subject. He used the word *indican* for the first time in his scientific papers in 1907, as opposed to "the glucoside" or "the coloring principle" as before. He also explicitly referenced the work of the Dutch scientist, Beyerinck, on *indican* and indigo enzyme, revealing his familiarity with the relevant technical literature.

Bergtheil primarily tried the route of adding metallic salts, mostly sulfates, to plants and measured their effect on the increase of *indican* in the leaves. He prepared pot cultures to complete these experiments. He found that the addition of copper salts caused maximum increase followed by magnesium, iron, and nickel in that order (see results in Table 7.3 below).

[10] Cyril Bergtheil, "An Account of the Scientific work on Indigo during the year 1908-09," Appendix IV, Agriculture, October 1910, File, 7-R/15 1-3, Board's Agriculture File 150 of 1910, p., viii, BSA, GOB, Rev (Agr.)

Table 7.2
Effect of salts on the production of *indican*

Metallic salt	Average *indican* in the leaves from two cuttings (in grams)
Copper sulfate	.794
Magnesium sulfate	.432
Ferrous sulfate	.348
Nickel sulfate	.233

Source: An Account of the Scientific Work on Indigo During the Year 1908-09, BSA [11]

The importance of these trials lay in the forming of Bergtheil's initial conjectures. He found out that if the copper salt was added to the soil prematurely in the pre-planting stage it had an adverse effect on germination. But when added at a later point of growth of the plant it positively affected the production of color. In his mind there was no doubt that the addition of salts was causing differences in the level of the color-bearing principle in leaf. That is why the first cutting that transpired soon after the addition of salts gave a higher weight of *indican* than the second cutting. These early results made him hypothesize that the copper salts led to vigor of growth and early development of high *indican* content. Magnesium salts, on the other hand, caused good leaf development with a moderately high and steady *indican* content in leaves. He was encouraged by the results with magnesium because the soil in Bihar was rich in magnesium salts and thus little additional treatment was needed to augment the magnesium content of soil, in case the final results confirmed what he had learnt. He also explained that the relatively low

[11] Cyril Bergtheil, "An Account of the Scientific work on Indigo during the year 1908-09," Appendix IV, Agriculture, October 1910, File, 7-R/15 1-3, Board's Agriculture File 150 of 1910, p., x, BSA, GOB, Rev (Agr.)

yield in his pot-cultured plants was due to the especial and regimented conditions of experimental analysis. This was intended to deflect criticism of overall poor yield in his trials, because Java plants as ordinarily grown by the planters were known to give an *indican* content of 0.7-0.8%. Although his trials were in a preliminary stage he felt quite confident that this line of inquiry would be fruitful.

Bergtheil highlighted the importance of "selection" experiments of a biological nature. He had become a firm believer in the potential of such procedures of supervised isolation of plants with the best phenotypes and genotypes and their propagation through controlled breeding. He was especially inspired by the example of the beet sugar industry in the West of India where such principles had been successfully utilized to improve yield.

In the case of indigo there were still many open questions. Not even a simple process of selection had been ever implemented on an industry wide scale. Would such methods bring results in the case of indigo? The ability to produce *indican* was "a chemical property" as against "physical" properties that were widely known to be inheritable. Could this ability be inherited? He begged for the appointment of a botanist who was in touch with new knowledge on the principles of heredity to resolve these questions:

> The field here is an enormous one, calling for years of patient work from both a chemist and a biologist schooled in the most recent views on heredity.[12]

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[12] Cyril Bergtheil, "An Account of the Scientific work on Indigo during the year 1908-09," Appendix IV, Agriculture, October 1910, File, 7-R/15 1-3, Board's Agriculture File 150 of 1910, p., xi, BSA, GOB, Rev (Agr.)

The Decision To Continue Bergtheil's Experiments At Sirsiah

Even as Bergtheil continued his trials at Sirsiah the continuation of his work became an issue of debate between the central and provincial officials. In 1908 it was the provincial government in Bengal that showed an exceptional commitment to continue the indigo experiments. The laboratory complex at Sirsiah had achieved a certain legitimacy that the provincial officials were better positioned to appreciate. They witnessed at first hand how the local community of planters appreciated the work in progress at Sirsiah under Bergtheil. And thus they became forceful campaigners for the continuation of ongoing work there.

In contrast, the officials at the center were lukewarm to the question of indigo experiments. They first expressed concern that the absence of Bergtheil from Pusa was disrupting the imperial plans of supporting agricultural research and education in the colony. Subsequently the publication of Bloxam's report in 1908 also threw a spanner in the works. Now Bloxam's claim that the current line of experiments at Sirsiah was not the appropriate one, and Bergtheil refusal to accept his criticism, gave mixed signals. In such a situation the commitment of central government officials to support the indigo experiments at the Sirsiah Laboratory became fragile.

The Argument Of The Provincial Government In Favor Of The Sirsiah Station And Bergtheil

Back in 1904 the central government had approved a proposal originating from Bengal to allow Bergtheil to work at Sirsiah for a term of two years. Subsequently the provincial government had obtained another year's extension to Bergtheil's deputation. The Bengal bureaucrats requested a third time that Bergtheil's term is extended for another two years until 1 April 1909. But this time the central bureaucrats turned down their request, and instead demanded that Cyril Bergtheil, who was after all the Imperial Bacteriologist, return to join his primary appointment at Pusa from 1st April 1908. [13]

The next few months proved to be eventful. The Lieutenant Governor and his team in Bengal were a little surprised by the response from the center. They made frenetic efforts to retain Bergtheil at Sirsiah. They realized that the transfer of Bergtheil would inevitably cause a rupture in the experiments at Sirsiah, something that they did not want. They first contacted the Inspector General of Agriculture in Pusa, J. Mollison, and sought his intervention on the matter with the Revenue Department officials at the center.

Mollison was happy to oblige. He was a supporter of the agricultural paradigm the way Bergtheil had defined it. He was also known to hold a positive opinion of Bergtheil's expertise. In more recent times he had expressed appreciation of the current work at Sirsiah. He interceded on behalf of the Bengal officials. On his initiative the officials were able to get a reprieve for a few months beyond April.

Meanwhile Bloxam's report of 1908 further hardened attitudes at the center on the question of sparing Bergtheil. By introducing doubts about the appropriateness of the direction of experiments in Bengal the report invited a fresh review of the experimental work at Sirsiah. The central government set up a committee to study the implications of

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[13] Letter from J Wilson, Revenue Secretary, Government of India to Revenue Secretary, Government of Bengal, letter no. 1114, dated, July 1 1907, No. 27, Serial No. 2, Government of India, Proceedings of the Department of Revenue and Agriculture for June 1907, IOR, GOI, Proc. Rev & Agr, P/7613

Bloxam's report and the report of that body further de-legitimized in their eyes the experiments at Sirsiah. Now the officials were not sure if they wanted to compromise their own agenda of agricultural research and education at the imperial center in Pusa for the sake of indigo experiments at Sirsiah.

The Bengal bureaucrats were convinced, however, that Bergtheil's work at Sirsiah was important. They decided to write another letter to the center arguing how important it was to keep Sirsiah running and to retain the scientist there. This second time they prepared a belabored defense of their position. They made two kinds of arguments. One, they cited the good work accomplished by Bergtheil at that station in the past, described what work was still incomplete and in progress, and how the prospects of results coming out of that work looked good. Two, they argued that Bergtheil was the most suitable expert by training and experience to undertake the required research on indigo. They also tried to establish Bergtheil's individual credibility in the light of counter claims from chemist Bloxam in England about the efficacy of experiments being supervised by the former in India.

Rhetorically making a point, they argued that it would be a "mistake" to dilute in any way the long-standing commitment that they had so far shown to indigo experiments. The government had started subsidizing the experiments in 1900 because saving an important industry of colonial India was considered a task worthy of their attention. Support for the indigo industry was also considered tactically advantageous since the European planters in India were significant political allies. The laboratory experiments to date had proven fruitful, and there was "great hope" that continued efforts would further improve the yield of the dye. At the same time, the need for "political advantage" accruing from support to the planting community had not diminished in any way. Therefore they advised that the government must not now withdraw its support of the work. [14]

On manufacturing, they noted how Christopher Rawson had earlier contributed to perfecting the oxidation stage. Following him Bergtheil had made useful contributions toward improving the yield from the fermentation stage. It was now believed that those two core processes in manufacturing were working at an optimal level of efficiency. But the "subsidiary processes" in manufacturing still needed more attention. They pointed out that there was scope to devise procedures to recover color from the run off liquid. Savings could also be made through recovery of color during the stages of boiling and drying that came before indigo pulp was pressed into cake. More efforts were similarly required in the direction of turning indigo cake into a powder of uniform texture. The planters and their experts were increasingly considering the production of indigo in the form of a dry powder. It was now believed that supplying indigo in the form of a powder would improve user processes at the consumers' end and enhance its market value.

But the central focus of future experiments was going to be the plant in the field. The Bengal officials pointed to the need for agricultural and biological experiments especially through a focus on "field selection." The final goal was to get plants of "pure type" that would give more leaf per unit area, that would have more *indican* in the leaf, and that would be disease resistant. Experiments with manures were continuing in parallel supervised by Bergtheil to get such plants. But the best hope lay through

[14] Letter from F W Duke, Revenue Secretary, Government of Bengal to Revenue and Agriculture Secretary, Government of India, dated, June 17 1908, letter no. 1182T.-R, Government of India, Proceedings of the Department of Revenue and Agriculture for October 1908, IOR, GOI, Proc. Rev & Agr, P/7896

biological selection. The center at Dasna was already working on the selection of the Sumatrana variety of indigo plant, but those efforts were in a very early stage. Three small centers had been recently inaugurated for the selection of the Java variety. The high yield prospect, the Java variety, had proven to be a breed difficult to tame in the local environs of Bihar. Pests were routinely attacking this foreign variety and year after year crops were being destroyed. It was thought that a disease resistant Java variety could be obtained through the process of isolating and propagating plants with better phenotypes.

The administrators in Bengal also underscored the importance of Sirsiah for addressing the day-to-day problems of a sundry nature faced by the planters in Bihar. Sirsiah was a very useful "advisory center" for the planters. The experts at Sirsiah routinely conducted scores of analyses with samples of dye, water, leaf etc that the planters brought to them and provided expert advice on agricultural practices. The need for such a center was especially critical when the planters were adopting a new variety of indigo plant – the Java variety. The officials gave examples of how in the absence of appropriate knowledge the planters had made mistakes in the culture of Java seeds. Many of them ended up with seeds that failed to germinate and thus had their entire season's crop destroyed. There were many similar problems faced by the planters on their plantations requiring expert advice.

Bergtheil, with his training in chemistry, bacteriology, and agricultural sciences, seemed to be the most suitable person to carry out the proposed work. The task at hand required the skills of a botanist and a laboratory chemist because monitoring the economic value of the plant depended on estimating leaf percentage in the field and *indigotin* content in the laboratory. Bergtheil alone was best positioned to do both. All that he would need, it was thought, was a botanist of relatively little experience to assist him. Besides, Bergtheil also had "great personal qualifications." He had lived with the planters; he fully identified with the interests of the planting community, and had won their complete confidence.

The administrators in Bengal proposed a plan for reorganizing the scientific infrastructure of the province of Bengal that would accommodate the interests of the indigo industry as well as meet the needs of the region's agriculture. The planters' organization, BIPA, wanted to continue indigo experiments under Bergtheil. But due to financial constraints they were only in a position to offer him temporary employment. And in the absence of more permanent prospects in India Bergtheil was likely to leave. The bureaucrats did not want the regional industry to lose the services of a person whose assistance they considered was critical for that industry. Therefore they were willing to be accommodative in a proactive way.

They submitted the blue print of a plan that involved turning Sirsiah into the government's own agricultural center focusing on the needs of north Bihar, for five years to begin with, and appointing Cyril Bergtheil as its head. The province of Bengal was too large to be administered by the single Deputy Director of Agriculture stationed at Pusa. Pusa had anyway not focused on many of the staples of north Bihar such as sugarcane and tobacco. The second agricultural station that the administrators planned at Sirsiah with Bergtheil as the additional deputy director could serve well the agricultural needs of the region. The Bengal Government also disclosed that they intended to lend the services of Bergtheil to the planters to undertake indigo research as long as their annual grant to the indigo industry was operational. Such a blue print for reorganization had been prepared in consultation with the Inspector General of Agriculture, J Mollison. The favorable attitude of this important official must have been an important factor encouraging the Bengal bureaucrats to come up with such a plan for proposing to the center.

In their letter the Bengal bureaucrats also went out of their way to express their trust in the ability of Bergtheil as well as the experiments he wished to pursue. Obviously they were trying to dispel the doubts that Bloxam's report had sown into the minds of the officials at the center. They were quite willing to engage the central bureaucrats in a debate, and try to persuade them about the appropriateness of Bergtheil's experiments in Bengal.

The bureaucrats stated that their faith in Bergtheil was "unshaken." Bloxam had argued that the tests currently in use overestimated the content of the color in the dye by 5-6%. He had also claimed that the use of his novel *isatin* method of testing proved that the content of recoverable color in the leaf was 50% more than what was believed in India. All these meant that there was much more color to be extracted from the leaf. The Bengal bureaucrats brushed aside these claims. They instead highlighted the fact that Bergtheil had pointed to problems in the procedures adopted by Bloxam, which were at the root of his "erroneous" conclusions. Bloxam's third claim was that indigo plants had higher average leaf content than was generally assumed in India while calculating efficiency. The bureaucrats once again argued that the opinion of Bergtheil who was a "man on the spot" and who had made "hundreds, even thousands" of determinations about leaf content had to be more trustworthy. On the face of it, the Bengal authorities should have welcomed Bloxam's assertion that Bergtheil was underestimating yield.

Such inference only pointed to scope for increasing yield through agricultural and chemical means. But instead they were dismissive of Bloxam. Such was the level of their distrust in Bloxam from his previous stint that the Bengal bureaucrats simply brushed aside his claims.

The Bengal officials also highlighted the fact that the favorable assessment of Bloxam's work by the chemists at the Society of Chemical Industry in England pertained only to one of his three conjectures. Much had been made of the support for Bloxam's experiments by the renowned chemists in England. In that context, the officials noted that the discussion at the Society of Chemical Industry had revolved only around the reliability and validity of Bloxam's tetrasulphonate method of dye testing, and that the relevance of that discussion was marginal to his claims on overall efficiency. On the basis of the new terasulphonate method Bloxam had contended that older methods of testing overstated the color content in the final product by 5-6%. If one were to believe in those figures then it only implied that the margin for improvement was wider by that percentage. That was a small margin compared to Bloxam's overall claim that the manufacturing processes could be made 60% more efficient. Practically no discussion had taken place among the chemists at the Society of Chemical Industry over the accuracy of the *isatin* method or over the issue of the average leaf content of indigo plants. Adopting this line of reasoning the bureaucrats in Bengal tried to minimize the impact of opinions expressed by the metropolitan chemists in England.

The officials argued that it was only "natural" that in the context of existing difference of opinion among experts they should believe in Bergtheil's account. Due to their previous experience with the two experts they considered Bergtheil to be more worthy of their trust. In his scientific endeavors Bergtheil was always guided by the pursuit of "practical issues." In the past he had delivered results that were found to be "useful." In contrast, Bloxam's experiments, though based on valid procedures, only led to claims of theoretical interest and not to ready application. Way back in 1903 Bloxam had asserted that the manufacturing processes in India had an efficiency of only 12 %. Now he was claiming that the processes had a slightly higher efficiency than the 12% mark he had earlier proposed. But he could never suggest a way of extracting the extra color that he hypothesized was present in the leaves. Thus the planters and administrators in Bihar generally perceived Bloxam's objections as "destructive criticism." In that context, even as the experts in India and England debated the technical issues at stake, the administrators in Bengal readily accepted Bergtheil's judgment over what types of experiments were likely to bear results.

It needs to be underscored here that although Bloxam was making claims that a huge improvement in yield was theoretically possible, he was simply brushed aside in Bengal at this time. The Bengal bureaucrats had decided to support their in-house expert Bergtheil, come what might. They supported the idea of agricultural improvement over potential manufacturing improvements. As we shall see in the next chapter, such a dogmatic attitude was later given up. After 1913 the Bengal bureaucrats were again willing to consider the possibilities of improving manufacturing through the application of chemical knowledge. This was not merely vacillation. It reflected a very basic problem in colonial India – that no one could identify the "best point" of attack for improving indigo with any degree of conviction or certainty.

The Different Perspective Of The Imperial Government

The officials at the center were not moved. They insisted that Cyril Bergtheil must quit his work on indigo at Sirsiah and take up his appointment as Imperial Bacteriologist at Pusa.

Their stance clearly revealed a new attitude at the center that now laid less stress on the importance of indigo relative to general public obligations towards research and development of colonial agriculture. First and foremost they referred to the procedural issue that Bergtheil's appointment at Sisrsiah in 1904 was of "a purely temporary nature." That year Bergtheil had accepted the appointment of Imperial Bacteriologist made to him by the Secretary of State. But on Governor Andrew Fraser's request he had been allowed to work out definite experimental issues related to indigo in Bengal. The understanding reached at that time was that Bergtheil would revert to his position at Pusa as soon as the laboratory and other infrastructure there were ready. For this reason alone they affirmed their right to recall Bergtheil to Pusa. [15]

But significantly, they also questioned the usefulness of experiments in progress at Sirsiah and the contribution that Bergtheil could possibly make. They referred to Bloxam's report and the report of the committee that they had set up to evaluate the implications of Bloxam's findings. Admittedly they skirted the discussion of contradictory technical explanations put forth by Bergtheil and by Bloxam and other metropolitan chemists. Instead they based their argument on another set of factors. The committee set up at the center had pointed out that the planters had not brought their

[15] Letter from R W Carlyle, Revenue Secretary, Government of India to Revenue Secretary, Government of Bengal, dated February 3, 1909, letter no. 152, No. 20, Serial No. 2, Government of India, Proceedings of the Department of Revenue and Agriculture for February 1909, IOR, GOI, Proc. Rev & Agr, P/8174

manufacturing operations even to the level of efficiency that Rawson's and Bergtheil's experiments had shown to be possible. The planters were more inclined to try and improve the stock of seeds and the cultivation practices. They argued that Bergtheil, a bacteriologist by training, was not suited to work out and improve agricultural practices in the field. In making such an argument they differed from the suggestion put forth earlier by the Bengal bureaucrats. The latter had contended that agricultural bacteriologist Bergtheil was ideally suited to split work between the laboratory and the field. They considered his practical experience of six years with indigo planting and manufacturing in Bihar rather than his formal training to claim that he was the most suitable expert.

The contention of the center was that a bacteriologist was more appropriately required at Pusa. Research and education work had been going on at Pusa in every branch of agricultural sciences except in bacteriology, the field for which Bergtheil had been originally appointed. The Imperial Mycologist, for instance, had to put aside some experiments in the absence of the bacteriologist with whom he needed to collaborate. The federal government had also received representation from a provincial government to start instructions in bacteriology for native apprentices as soon as possible. The government had so far been distracted from its original plans at Pusa in order to protect the interests of the planting community. But enough had already been done, they argued. The federal officials *now* believed that it was time they considered the "general interest" as against the interests of one industry and one community.

The Counter-Proposal And Decision

The final decision to continue the experiments at Sirsiah under Bergtheil came at the end of a third round of negotiations during which the planters in Bihar very forcefully articulated their demand. The chain of events started after the decision of the central government was received in Bengal. The planters met in an extraordinary session to discuss the implications of losing Bergtheil. They unanimously proposed that the work at Sirsiah should be continued. They requested the Director of Agriculture in Bengal to intercede on their behalf and to ask the central officials one more time to allow Bergtheil to stay at Sirsiah. They also offered to pay a major part of Bergtheil's salary and laboratory expenses if their request was granted.

Bergtheil also exuded confidence on his part. He offered to step down from his lucrative post of Imperial Bacteriologist to accept the position of indigo specialist at Sirsiah if the planters could assure his employment for a reasonable period of time. He believed in the indigo work that he was pursuing, and was confident that he could deliver positive results.

The Revenue Secretary of Bengal again wrote to his superiors at the center pointing out that new conditions had emerged and asking if they would re-consider their earlier judgment. The planters had shown an utmost interest in favor of the continuation of Bergtheil's experiments, and Bergtheil himself had conveyed his availability for the indigo work. The federal officials were requested to decide firstly whether they would be ready in principle to let Bergtheil resign and stay at Pusa. They were also asked if they would waive their right to let Bergtheil resign without the six months' prior notice as was required by the terms of his contract. [16]

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[16] Letter from F W Duke, Revenue Secretary, Government of Bengal to Revenue and Agriculture Secretary, Government of India, dated, April 17 1909, letter no. 61TR, No. 37, Serial No. 7, File

On their part the Bengal bureaucrats contended that the new direction of work on biological lines at Sirsiah was indeed worthy of all the support the government could provide. They had studied the annual scientific report for Sirsiah for 1908-09, which outlined that the station would focus on identifying and selecting plants with the appropriate physiology, on studying conditions that augmented the production of *indican* in the leaves, and on controlling pollination to ensure that the *indican*-producing faculty was inherited. In their opinion this was a very legitimate agenda for the improvement of indigo.

They also seconded the plans for experiments at Sirsiah led by Bergtheil assisted by a new botanist. In saying so they stuck to the earlier line that due to his long experience with indigo experiments in India Bergtheil was the most suitable expert to lead the scientific endeavors. The officials also supported the plan to bring a new botanist to the station. They agreed with the rationale that a botanist, one with an expertise in plant breeding and plant physiology, would make a good team with Bergtheil.

This time they put forth a fresh assessment of Bloxam's experimental results while defending the preferred route of biological experiments. In their earlier letter they had been more or less dismissive of Bloxam's point of view in favor of Bergtheil's. But this time they remarked that the planters had set up an independent committee to settle the "debatable" issue of efficiency. The report of the same committee was expected to resolve the question whether the manufacturing processes could be further improved. If those experts concluded that Bloxam's objections were valid, then focus would be reverted towards the processes in the vat. But until proven otherwise by that committee,

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No. 18 of 1909, Government of India, Proceedings of the Department of Revenue and Agriculture for June 1909, IOR, GOI, Proc. Rev & Agr, P/8174 they argued, it was appropriate to focus efforts on augmenting the color bearing ability of the plant.

They also underlined the fact that neither Bloxam's report nor the other expert committee's report in the possession of the central government had discounted the prospects of improving yield through biological experiments. Bloxam had certainly suggested that primary attention revert to the manufacturing processes. In his opinion the chemical pathway held maximum promise rather than anything else. But he also suggested in his report that a secondary line of biological and agricultural experiments should be maintained. The other report available with the central government had also mentioned how the planters were persuaded about the potential of agricultural experiments.

The center finally showed willingness to spare Bergtheil for Sirsiah as long as they could insure that his absence from Pusa would not hamper research and educational work there. The first issue that they considered was the length of time for which Bergtheil's services were required at Sirsiah. They were told that the biological experiments in the province were being planned on a long-term basis. Results from breeding and selection trials would only emerge gradually. The Inspector General had also advised the Bengal officials that experiments should be planned for a period of five years. Accordingly the government in Bengal had committed their support to Sirsiah for five years, and made provisions in their budget for financial support to indigo experiments for the same length of time.

Under the circumstances the central officials began to lean towards allowing Bergtheil to resign his position. The fact that the Bengal government had committed support to indigo experiments for the next five years spoke for itself. They had shown exceptional support, and deserved encouragement. The repeated extensions of Bergtheil's absences had been more in the nature of temporary measures. Now that the Bengal government had a long-term plan in place it was considered more prudent to relieve him and let him be re-employed by the provincial government.

A letter was also dispatched to Mollison, at Pusa. He was asked to comment on the effect that Bergtheil's resignation without prior notice of six months was likely to cause. He was also asked to state the measures he contemplated to fill the void created by Bergtheil's resignation. [17]

Mollison did not think that the absence of Bergtheil at Pusa would pose insurmountable problems. The station already had a mycologist, Dr Butler. Mollison was confident that even without Bergtheil the current mycologist would be able to perform the functions expected of the bacteriologist in the short-term. The boundary between the fields of agricultural mycology and agricultural bacteriology was a blurred one. In fact he preferred to merge the two departments. He also suggested the name of a person currently employed by the Mysore State for filling the position to be vacated by Bergtheil. [18]

The path was finally cleared for the retention of Bergtheil at Sirsiah. The Revenue and Agriculture Secretary dispatched a telegram stating that the central government did not have any objection to Bergtheil resigning his position. They also waived the clause in

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[17] Letter from Secretary, Revenue and Agriculture, Government of India to the Inspector General of Agriculture, dated May 15, 1909, letter no. 543, No. 40, Serial No. 10, Government of India, Proceedings of the Department of Revenue and Agriculture for June 1909, IOR, GOI, Proc. Rev & Agr, P/8174

[18] Letter from the Inspector General of Agriculture to Secretary, Revenue and Agriculture, Government of India, dated May 18, 1909, letter no. 1939, No. 41, Serial No. 11, Government of India, Proceedings of the Department of Revenue and Agriculture for June 1909, IOR, GOI, Proc. Rev & Agr, P/8174

the contract that required Bergtheil to give six months' notice before resigning. [19] The Bengal government sanctioned a grant of Rupees 32,500 per annum for the next five years to Sirsiah. The government also received a commitment from BIPA that they would contribute Rs. 10,000 per annum for funding the experiments at Sirsiah. [20]

"Reforms" And Scientific Experiments

The Government Implements Wage Reforms, 1910

The government persuaded the planters to implement a set of measures in 1910. Most importantly, they made the planters raise the purchase price for indigo to Rupees 13 and 8 *annas* per *bigha.* There was an additional relief built into this price. The planters previously drew land rent from the growers separately in their capacity as landlords. The new price was supposed to be a net price after deducting the rent. It was also stipulated that in the case of destruction of the indigo crop due to circumstances beyond the control of the peasant the latter would not incur any type of financial liability. Lastly, new rules were created reducing the obligation of the peasants to grow indigo only on two *katthas*

[19] Telegram from Secretary, Revenue and Agriculture, Government of India to Revenue Secretary, Government of Bengal, dated May 26, 1909, No. 42, Serial No. 12, Government of India, Proceedings of the Department of Revenue and Agriculture for June 1909, IOR, GOI, Proc. Rev & Agr, P/8174

[20] For sanction of 32,500 to the BIPA, see "Order – By the Government of Bengal, Revenue Department," Agriculture, October 1909, File 2-I/3 1-7 _, Board's file 114 of 1909, No. 10, BSA, GOB, Rev (Agr.); for reference to BIPA's acceptance regarding payment of 10,000 per annum, see the letter of Director of Agriculture, Bengal, W R Gourlay's to Revenue Secretary, Bengal, dated March 31, 1909, Agriculture, October 1909, File 2-I/3 1-7 _, Board's file, 114 of 1909, No. 5, BSA, GOB, Rev (Agr.)

out of every *bigha* of land they possessed, a recommendation that had been endorsed by Gourlay's report. [21]

The measures of 1910 only brought a temporary relief from the agitations. The new norms failed to create an administrative structure that would preclude the possibility of the planters transferring their net loss in the market on to the native growers. The continuing drop in the price of indigo prompted the planters to adopt other financial measures that were equally unpopular. Two obvious routes to enhance obligations due from the growers were foreclosed. The indigo prices could not be touched. Secondly, a demand for the "illegal" *abwab* was also not possible in the days following the submission of Gourlay's recommendations. The planters therefore tried to exact other types of payments that were more easily defensible in the court of law. Depending on whether they held the plantation in perpetual lease (*mukarrari*) or on contract (*thika*), they offered to change the obligation of growing indigo into *sharahbeshi*, an enhanced rent payment, or *tawan*, a payment that brought freedom from growing indigo. Many growers accepted the offer to pay *shrahbeshi* and *tawan* as they were so desperate to get out of the contractual obligation to grow indigo. But most growers fell into financial distress as a consequence. The annual increase in rent was usually of the order of 50-60% and could even be as high as 100%. The *tawan* payments could vary between Rupees 40-60 per *bigha*. As year after year the burden of rent and *tawan* installments continued to be felt the wave of discontent continued among the indigo growers. [22]

Bergtheil's Experiments, 1909-10

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[21] Government of Bengal, Proceedings of the Department of Revenue (Land Revenue) for the month of June 1910, Nos. 31-47, BSA, GOB, Rev (Agr.)
[22] Jacques Pouchepadass, *Champaran and Gandhi*: 158-160

Work was suspended at Sirsiah in early 1909. A decision was awaited over Bergtheil's future assignment. Was he going to continue work at Sirsiah? Would the Bengal government's proposal to retain him at Sirsiah be finally approved at the center? Funds for the experiments at Sirsiah were also not disbursed since funding of experiments at Sirsiah was tied up with the decision on Bergtheil. As the bureaucrats at various levels debated those issues, work was temporarily stalled at Sirsiah. Bergtheil also moved to the Agricultural Research Institute at Pusa. Indigo improvement work was finally resumed at Sirsiah from July 1 1909. [23]

The year's scientific work did not begin well for Bergtheil. Two of the measures involving treatment with reagents and cultures proved unsuccessful. He first followed on leads from the trial with metallic salts in the previous year. Plants treated with copper sulfate had shown a maximum output of *indican*. Therefore he decided to use the same compound as a plant stimulant. Experimental plants were treated with copper sulfate. But the results were discouraging. While the plants treated with copper sulfate showed a content of .478%, those in the control plot showed an *indican* content of .483%. The difference was marginal and it was assumed that the reagent had failed in stimulating the production of color in the plant. [24] This line of experimentation was then given up and never pursued again.

More elaborate trials were made with an inoculation for leguminous plants called nitro-bacterine. This was a culture of nodule organisms. In his 1906-07 report Bergtheil had referred to a similar culture that reportedly brought positive results to leguminous

[23] *Report of the Indigo Research Station, Sirsiah, For the Year 1909-1910*. (Calcutta: Bihar Planters' Association, 1910), p., 1

[24] *Report of the Indigo Research Station, Sirsiah, For the Year 1909-1910*. (Calcutta: Bihar Planters' Association, 1910), p., 4

plants in the United States. A Professor Bottmley of King's College in London had recently prepared nitro-bacterine as a special culture for use on the indigo plant. Many planters during the current manufacturing season had applied nitro-bacterine on an experimental basis. At Sirsiah, two adjacent plots of 1/3 acre each containing regular Java crop were marked off. One was treated with nitro-bacterine while the other was kept as

Table 7.3

Effect of Nitro-Bacterine on indigo plants

	Weight of plant in *maunds* and *seer*	Average leaf percentage	Average *indican* percentage	Total *indigotin* from the plot (in *seers*)
Treated	44 – 6	33.6	.506	3
Untreated	38 – 30	35.7	.532	2.94

Source: ***Report of the Indigo Research Station, Sirsiah, For the Year 1909-1910***

a control. When the plants rose to a height of about 3 inches the culture was watered on them. The growth of plants was closely monitored. The output was subjected to a careful physical and chemical analysis.

The results were discouraging (see Table 7.3 above). A heavier cutting of plant was obtained from the plots that were treated with the culture. Bergtheil suspected that some of this extra growth might have resulted from the better quality of soil in that plot. But there was no doubt that the treated plants showed a better growth overall. However the increased vigor of growth was accompanied by a loss in the quantity of leaf. The leaves also had a relatively lower percentage of *indican*. In the end the total *indigotin* obtained from the two plots was almost identical. This was a second disappointment for Bergtheil.

A great deal of effort was invested into producing indigo in the form of powder. The new machine imported from England was installed at the Barah factory. It was a drying machine. The *mal* or finished indigo coming out of the washer and boiler was fed into it, which was dried into the form of a powder. Two preliminary trials were made in September and November.

The operations for producing indigo powder ran into mechanical problems as well as those related to increased cost of production. The best rate for the production ever obtained was about 25lbs of indigo powder per hour. If the speed of drying was increased the output tended to be coarse, which required grinding. The process of grinding would make the total cost prohibitive. Bergtheil was disappointed: "The hope with which I originally started these experiments … does not seem capable of realisation except either by considerably complicating the process of production or by making it extremely slow, in either case increasing its cost to an impracticable extent." [25] Nonetheless he proposed that the machine be retained at Barah and trials be made again under the supervision of a skilled engineer in the next season to improve speed and volume.

There were other critical issues that also needed to be thought through. Would it be more advisable to grind the indigo cake instead? The latter option offered definite advantages in some cases. For instance, it made sense to grind the cakes that were of

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[25] *Report of the Indigo Research Station, Sirsiah, For the Year 1909-1910*. (Calcutta: Bihar Planters' Association, 1910), p., 2

inferior quality and fetched a low price when sold in that form. In their case value addition by turning into powder would be substantial and would easily recover the extra effort invested in crushing. But there did not exist facilities in India for crushing large-sized indigo cakes. Bergtheil proposed instead that the feasibility of making powder from cake be examined in England and if found successful, it be tried out in India during the next manufacturing season.

Bergtheil also addressed the issue of making a "uniform paste." The European consumers had a clear preference for a uniform paste of indigo rather than indigo powder. He proposed "bulking" of indigo consignments of different qualities in locations where the processing of the product for consumers could be undertaken. He referred to certain consultations that had taken place between some home firms and BIPA about the viability of producing indigo paste in India and selling it to industrial consumers in England. [26]

Eugene Schrottky

As before, Eugene Schrottky continued to undertake a range of scientific and commercial initiatives on indigo. He worked independently of BIPA and its experts at the premises of individual planters. Just like Bergtheil he too lost faith in the utility of conducting any more chemical experiments in the laboratory. He also thought that the extractive processes were already working at an optimal level of efficiency. About the possibility of extracting more color by improving the manufacturing processes, he wrote

[26] The making of indigo paste was certainly an important issue. However, only feeble attempts were made to produce indigo paste during this period and not much came out of such efforts. A more concerted effort was made later during the War when metropolitan interest was revived in Indian indigo due to stoppage in the supply of synthetic indigo from Germany.

in October 1909, “I have reached bottom now, and have come very near to what I know the indigo plant can yield.” [27]

Schrottky turned his attention to an agricultural question. There was a growing concern all around over the deterioration in output from the Java variety of indigo plant. Some planters thought that the local soil and climate conditions in Bihar were not amenable so that seed grown locally in Bihar gave a low yield. They wanted someone to culture Java seeds outside Bihar in a location where the conditions would be more favorable. In 1910, Schrottky undertook the culture of Java seeds at Surriyat, Belwar, and Gazia indigo factories in the neighboring United Provinces. Java seeds at the Belwar factory were totally destroyed by frost. He realized that the frosty conditions in January and February, considered normal for that time of year in the region, would continue to pose problems in the years to come. He then explored the option of growing seeds in the Godavari district in south India, which had traditionally supplied seeds to yet another important indigo growing province of India – Madras. Schrottky’s proposal for shifting the seed factory to South India met with the approval of many planters. [28]

Schrottky also encouraged planters to undertake the production of indigo paste. He claimed that the planters would have to sell the natural dye in a paste form to win back those dyers and printers that had already switched to synthetic indigo. He referred to his interview with some of the industrial consumers in Britain in this regard.

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[27] *Indian Planters' Gazette*, October 9, 1909. The holdings of this newspaper are present at the National Agricultural Library, Beltsville, U.S.A.

[28] Eugene Schrottky, “The Natural Indigo Industry,” *Indian Planters' Gazette*, August 27, 1910, p., 378; Schrottky’s letter, addressed to the planters in Bengal and Bihar, ”Indigofera Arrecta,” dated February 1911, *Indian Planters' Gazette*, March 4, 1911, p., 304; Letter to the Editor by “An Old Biharite,” dated, April 5, 1911, *Indian Planters' Gazette*, 597

> They [British dyers and printers] acknowledged that natural dyes had some advantages and declared themselves ready to return to it, if they could get it in a paste and as cheap as the synthetic dye. [29]

He undertook trials to make indigo paste at numerous factories on small scale. But he did not report any major success in this regard.

The Collaboration Between Bergtheil And Botanist,F R Parnell At Sirsiah

A new botanist, F R Parnell, joined the Sirsiah Station in October 1909. Experiments related to plant physiology and plant breeding had been declared to be the mainstay of research efforts at Sirsiah. Bergtheil had been contributing to this effort as a chemist. But the purely biological line of query had not taken off. Bergtheil himself and the planters had long demanded a botanist for Sirsiah, and the government obliged.

With the arrival of Parnell a new range of experiments was inaugurated at Sirsiah. Parnell applied his knowledge of botany to investigate the basis of formation of *indican*. He utilized “sand cultures” to monitor the plant’s metabolism. He studied the processes leading to the deposition of the glucoside in the leaves.

Bergtheil used a chemist’s approach for a similar line of inquiry. He tried to find the links between chemical substances stored in the seed, those produced at the different stages of the plant’s development, and *indican*. His experiments were directed at establishing whether it was possible to manipulate the plant’s growth or add nutrients to augment the final deposition of *indican*.

[29] Eugene Schrottky, “The Natural Indigo Industry,” *Indian Planters’ Gazette*, August 27, 1910: 378

The selection of the Java plant had not proceeded well. In the previous season Bergtheil had sown seeds obtained from high-yielding plants at Pusa. He returned to Pusa to inspect the plot. The leaves produced an overall high figure for color content. But the plants did not exhibit any type of uniformity morphologically or in terms of percentage of *indican*. Their qualities also failed to correspond with their parent plants' characteristics. No strong inference could be drawn from this round of trials. It was not certain if the high yield characteristic had been inherited or was the result of environmental factors.

Parnell supervised the second round of selection trials. He soon noticed an anomaly that explained how the previous selection trials had been compromised. Indigo plants normally cross-fertilized. In Bergtheil's specimens of the previous year no special precaution had been taken to ensure self-fertilization. Thus no purity from the plant to the seeds had been maintained. To rectify this problem Parnell isolated the high yield plants and ensured self-fertilization. He collected a sample of such seeds for planting in the next season.

The efforts on the selection of the Sumatrana variety had been continuing at Sirsiah for some time. Different sub-varieties of the plant had been identified and plotted separately. But now doubt was cast on all previous efforts in the face of new knowledge about cross-fertilization. Just as in the case of Java, the Sumatrana specimens would also have been cross-pollinated disrupting the line of inheritance from the parent plant to the progeny. Accordingly it was planned to re-start the selection trials for the Sumatrana plant.

The Incidence Of Wilt, 1911-13

It is difficult to re-construct the specifics of Bergtheil's and Parnell's experiments for the last two years. The annual report of the Sirsiah Station for 1912-13 has not survived in its complete form in any of the likely locations. Only some excerpts from the report have survived as citations in the annual reports of the Agricultural Research Station at Pusa. A few references also occur in the government papers from which the general nature of efforts made at Sirsiah may be inferred.

It can be safely stated that the nature of experiments at Sirsiah remained predominantly agricultural. [30] One part of these efforts was directed at the botanical selection of Java indigo. Towards those efforts Parnell made a detailed study of the nature of pollination and fertilization of the Java plant. Botanical study revealed that the morphological structure of indigo flowers inhibited self-fertilization. The particular placement of anthers and stigma was geared to facilitate cross-fertilization with the help of insect visitors. Two common Indian bees, *Apis florae* and *Halictus gutturosus* were identified as the vectors. These discoveries were valuable in themselves. Later the experts at Pusa followed up on this work by Parnell. [31]

The second annual report of the agricultural department of Bihar and Orissa mentions that the selection trials of Bergtheil and Parnell at Sirsiah were compromised due to a ferocious flood and later due to the spread of the disease-like condition in the

[30] Cyril Bergtheil's autobiography also implies that a search for higher-yielding varieties continued. Cyril Berkeley, *My Autobiography*, privately published and undated, p., 10. A copy of the autobiography survives with the scientist's granddaughter Prof. Mary N Arai at the University of Calgary in Canada.

[31] Albert Howard and Gabrielle L C Howard, *Third Report on the Improvement of Indigo in Bihar*, Bulletin No. 67 (Calcutta: Agricultural Research Institute, , 1916): 23-24

indigo plant called *wilt.* [32] In particular it blames the incidence of *wilt* for having "largely diverted the attention of the experts" from their selection experiments.

Table 7.4
Decrease in the yield of Java crop due to wilt at Belsund Factory

Year	Number of cuttings	Yield per *bigha* in *seers* and *chattak*
1904-05	2	16 s. 5 _ cht
1905-06	1	9 s. 7 _ cht
1906-07	3	23 s. 2 cht
1907-08	3	23 s. 7 _ cht
1908-09	2	6 s.
1909-10	2	13 s. 8 cht
1910-11	2	10 s. 2 cht
1911-12	2	6 s. 15 cht
1912-13	1	3 s. 1 cht
1913-14	2	9 s. 9 cht

Source: D J Reid, "Ten years' practical experience of Java indigo in Bihar" [33]

[32] Second Annual Report of the Agricultural Department, Bihar and Orissa, 1913, p., 5, Government of Bihar and Orissa, Revenue Department, Agriculture Branch, File no. 1A/189 of 1913, Nos. 29-32. The province of Bihar and Orissa was carved out of the larger Bengal in 1911. The Agriculture Department files of the new province are preserved at the Bihar State Archives in Patna (India). Henceforth these files are referred to as GBO, Rev. (Agr.)
[33] D J Reid, "Ten years' practical experience of Java indigo in Bihar," Agricultural Journal of India XII 1 (1917): 19

The first incidence of *wilt* in Bihar was reported in 1908. It increased in ferocity at the turn of the decade. In every season beginning 1911 much of Java crop in Bihar was infested with *wilt.* The external symptoms of *wilt* included a slowing down of growth and leaf fall. The leaves that remained turned in color from ordinary bright green to yellowish-green. The trouble began after the first cut. The new set of leaves on the plant never matured to be ready for a second cutting. In the absence of the second and third cutting the total yield from the indigo fields dropped. The figures of yield available for a very large factory in Muzaffarpur (see Table 7.4 above) are representative in indicating the decline in yield precipitated by *wilt*.

Still worse, *wilt* created a severe shortage in the supply of Java seeds in Bihar. Under the diseased condition the plant died after the first cutting. Thus it never reached the last stage of growth during which the plant would ordinarily bear seeds. After repeated failures of Java indigo over the years the planters in Bihar faced a situation of shortage of Java seeds.

Albert Howard, the Imperial Economic Botanist, and Gabrille L C Howard have stated in their report of early 1914 that *wilt* was the primary cause for the closure of the Sirsiah Station.[34] Despite their best efforts the experts at Sirsiah failed to induce the Java plant to form seed on their experimental plots. The failure to beget seeds stalled their selection experiments that were based on the principle of propagating healthy and well-suited plants.

The tone of the annual report of the agricultural department of Bihar and Orissa referring to the work at Sirsiah is also indicative of the general hopelessness with regard

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[34] Albert Howard and Gabrielle L C Howard, *First Report on the Improvement of Indigo in Bihar*, Bulletin No. 51 (Calcutta: Agricultural Research Institute, , 1915): 2, India Office Records, V/25/500/121

to the experiments being run currently at Sirsiah: "These … experiments have not produced any practical results." In the context of such despondency the planters terminated their contract with Bergtheil prematurely and paid him a lump sum to compensate for his early termination. Wanting to seek fortune in the business of orchards in Canada, Bergtheil left India in early 1913. F R Parnell obtained the post of Agricultural Chemist to the Government of Madras in southern India. The BIPA was not interested any further in the experiments at Sirsiah. On their request the Sirsiah Station was closed down from March 31, 1913. [35]

Thereafter the government concentrated all research on indigo at the Botanical Section of the Agricultural Research Institute at Pusa. The focus of research on *wilt* had anyway shifted to the Imperial Agricultural Department at Pusa. The last report from Sirsiah mentions the fact that after "a fruitless examination" the scientists at Sirsiah had sought the aid of Pusa experts. The same report also mentions the involvement of the entomologist, mycologist, bacteriologist, and the economic botanist in the study of *wilt.* Thus the government thought it wise to maintain the continuity in such investigations at Pusa. [36]

Epilogue

A review of the scientific efforts during the period 1908-13 shows a clear dominance of the agricultural paradigm. The planters had expressed preference for such

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[35] Second Annual Report of the Agricultural Department, Bihar and Orissa, 1913, p., 5, Government of Bihar and Orissa, Revenue Department, Agriculture Branch, File no. 1A/189 of 1913, Nos. 29-32

[36] Cyril Berkeley, *My Autobiography*, pp, 11-13; Second Annual Report of the Agricultural Department, Bihar and Orissa, 1913, p., 5, BSA, Government of Bihar and Orissa, Revenue Department, Agriculture Branch, File no. 1A/189 of 1913, Nos. 29-32

experiments. The Java variety of indigo that was introduced into India from Southeast Asia and from the Natal province in South Africa proved to be a breed difficult to domesticate. Problems related to pest attack adversely affected the cultivation of the Java variety in the local environs of Bihar. In this situation the planters asked their experts to focus on devising and perfecting appropriate agricultural practices for the Java variety.

Bacteriologist Bergtheil also favored agricultural investigations to understand and control the indigo plant's physiology and metabolism. He had a domineering presence in Bengal. His voice carried weight with both officials and the planters in the province. As the "imperial" bacteriologist he occupied an elevated stature. He also enjoyed a privileged access to the Inspector General of Agriculture in India, J W Mollison, who was stationed in the province at Pusa. The latter was always willing to go all the way to back up Bergtheil and his experiments. Besides, Bergtheil also enjoyed exceptional credibility with the planting community. As "a man on the spot" he was always available to offer advice. He had earned the reputation among the planters of being "a practical agriculturist," rather than being " an academic laboratory chemist." Therefore the planters accepted his sense of judgment over the advocacy of the agricultural line.

Ultimately it was the provincial government's resolve that determined the "turn" to agricultural experiments. The funds for the Sirsiah Station came out of the Bengal Government's budget. As the primary sponsor the provincial government had a final say on the nature of experiments to be conducted at that station. After the publication of Bloxam's report in 1908 the central government was leaning towards the chemical approach. They were more influenced by the impulses coming from the metropolis. But the provincial government took a firm stand on the issue. They stood by the opinion of their own expert at Sirsiah – Cyril J Bergtheil. They also backed the views of the planters in Bihar, the protection of whose interests was the principal reason for the subsidy on indigo experiments. It was their opinion that prevailed, securing the shift to agricultural experiments.

Was the chemical path, then, irrevocably doomed? Not quite. Bloxam in England pursued his chemistry-based line of query for quite some time. Between 1909 and 1910, he published additional papers on *indican*, indigo-brown, and *indirubin*. In 1909, most notably, Bloxam presented his findings on the chemical nature of *indican*. To replicate the chemical processes of manufacturing in the laboratory, Bloxam studied the effects of the indigo-enzyme, *indimulsin* on the glucoside *indican*. The resulting solution of indoxyl was found to be characteristically unstable and underwent change to other substances including indigo-brown and *indirubin*. Although he identified the instability of indoxyl to be the major cause of low yield in manufacturing, Bloxam was still not in a position to suggest concrete measures to prevent wasteful secondary reactions from taking place. Predictably, in his subsequent experiments he focused on understanding the nature of *indirubin* and indigo-brown. [34]

But Bloxam was a lone warrior. His efforts were driven by personal motivation. He did not get any institutional support in the context of a diminished interest in indigo in the metropolis. He appealed to the India Office in London for an extension of his research contract. Bloxam was confident that he could build on his research to suggest measures that would hold the key to the survival of the natural indigo industry. However, the India

[34] Frederick Thomas, W P Bloxam, and A G Perkin, "XCIL – Indican. Part III," *Journal of the Chemical Society, Transactions* 95 (1909): 824-847; W P Bloxam and A G Perkin, "CXXXV – Indirubin. Part 1," *Journal of the Chemical Society, Transactions* 97 (1910): 1460-1475

Office did not renew their contract with him. Soon after Bloxam suffered a paralytic stroke from which he never recovered, and he died on December 26, 1913. Writing the obituary for Bloxam, A G Perkin mentioned that it was a matter of keen disappointment to Bloxam that his results were so little appreciated in India. [35]

But the chemical approach came back in India. As the next chapter will show, during the period from 1914-22 the agricultural and chemical sciences were put on an equal footing one more time. Many of these efforts were made at the Agricultural Research Institute at Pusa in India. An Indigo Research Committee was also formed in London, which took the ultimate responsibility to coordinate efforts made to improve the plant-derived indigo during the War. The doyen of British chemistry, Henry E Armstrong, was the overall head of this committee.

CHAPTER 8

[35] A G Perkin, Obituary, "William Popplewell Bloxam," *Journal of the Chemical Society, Transactions*, 105 (1914): 1195-1200

WORLD WAR: THE RE-ORGANIZATION OF THE INDIGO EXPERIMENTS, 1914-1919

Introduction

The singular most striking feature of this period was that the metropolis gained the upper hand in the formulation of plans and programs for the indigo industry of colonial India. Prior to 1913 the provincial government in Bengal defined the agenda of experiments. The closure of Sirsiah brought that era to an end. The imperial department of agriculture in Pusa absorbed the remaining agricultural experiments at Sirsiah. This signified the decline in importance of the provincial research station. Beginning in 1913 a number of new initiatives were taken in England. A new phase was thus inaugurated in which the actors, institutions, and the framework of policy-making in England began overwhelmingly to determine the nature of indigo experiments in India.

The outbreak of the War in July 1914 brought a new sense of urgency in the metropolis. The Indian cake indigo became a much-desired commodity as the supplies of the synthetic substitute were disrupted by the War and the stocks in England dried up. As English dyers clamored for more blue dye India House in London was quite willing to examine any suggestion that seemed to offer a possibility to revive the dilapidated natural indigo industry of colonial India.

Two important conferences called in 1915 defined the agenda of the subsequent experiments in India and England. Prodded by the administrators in London the colonial government called the Delhi Conference on February 22, 1915 to meet with the planters' representatives, the administrators from all the Indian provinces manufacturing indigo, and a few select scientists. The Secretary of State in England also called a conference in

London on September 20, 1915 at which he met with selected scientists, planters, *and dyers*. The deliberations at the two conferences shaped the nature of initiatives in the following years.

With supply interrupted, consumers in England now came to play a direct role. Except for the niche market where natural indigo had prevailed, the majority of English dyers and printers had already switched to synthetic indigo by the outbreak of World War I in 1914. Now the consumers faced a difficult dilemma. Synthetic indigo was unavailable while the old techniques of dyeing with cake indigo had fallen into disuse. Consumers preferred to use natural indigo if it was presented to them in the form of a standardized paste rather than as cake, i.e.the same way as the synthetic was offered to them. They approached the imperial administration hoping to use the office to persuade the indigo producers in colonial India to switch to paste production. Following the intervention of the Dyers Guild, the largest organization of dyers in England, and on the personal initiative of its President, Rowland E Oldroyd, in late 1915 the Secretary of State invited the planters to put natural indigo onto the market in the form preferred by the consumers. More assistance from India House followed in this regard. With its active intervention an Indigo Paste Committee was formed in England. Its main aim was to find economical ways to turn indigo cake into user-friendly indigo paste. Despite its best efforts the project did not succeed and a viable method of making indigo paste was not found.

Meanwhile English entrepreneurs manufactured synthetic indigo for the first time in England in 1917. The Levinstein family managed to produce the first supplies of English synthetic indigo from the sequestered MLB factory that they had taken over.

Later Swiss and even French sources of supply were revived. At the end of the war the technique of making synthetic indigo made its way from Germany to England. With the synthetic substitute available at home the British government lost all interest in colonial India's natural indigo at the end of the War in 1919.

The Continuing Experiments Of The Agricultural Research Institute At Pusa, 1913-15

The indigo experiments in India between 1913 and 1915 were conducted by scientists at the Botanical Section of the Agricultural Research Institute (ARI) at Pusa. The person in charge of the experiments was the Imperial Economic Botanist Albert Howard. Howard was a biological botanist by training who had come from England to join the ARI at Pusa in May 1905, the year when the institute was inaugurated. The very next year he was promoted to the rank of Imperial Economic Botanist.

The attribution of indigo work to Albert Howard was a deliberate decision. Since 1911 the experts at Pusa had been trying to resolve the mysterious disease wilt. A consensus had emerged that the "disease-like" condition was connected with the waterlogged conditions and with cultivating practices rather than with infection by any outside vector. The Imperial Entomologist confirmed that wilt was not connected in any way to the common pest *Psylla* or to any other insect. Similarly the mycologist had subjected samples of the diseased plants to tests and did not detect the presence of any fungus. C H Hutchinson, the imperial bacteriologist had similarly discounted the presence of any bacteria in the affected plant through his examinations. The introduction of a plant with wilt into a group of healthy plants did not automatically cause the spread of the unhealthy condition. This at least discounted the possibility of wilt being a contagious and infectious disease. As more evidence accumultaed the conjecture that wilt was due to waterlogged conditions or cultivation practices seemed more probable.

Aside from the goal of conquering wilt the other important ambition in 1913 was to improve the stock of indigo plants through a process of biological selection. The economic botanist seemed the man best suited to achieve both ends. [1]

The Season Of 1913-14

Albert Howard's trials in the first year were directed towards growing Java seeds and reducing the incidence of wilt in the Java crop. Some preparatory work was also done towards the selection of the Java variety. Wilt had become so widespread in Bihar that there was an acute scarcity of seeds to plant the next crop (of Java). In such a situation the priority was to culture the seeds and secure their supply to the plantations. But parallel efforts were also made to devise ways to eliminate wilt and improve the stock of higher-yielding varieties through biological selection. [2]

Howard built on the small-scale trials from the previous season (1912-13) and the preliminary inferences he had drawn from them. He planted the new crop at Pusa and the adjoining Dholi estate based on the premise that the Java plant could not tolerate rainy conditions for more than two months. Normally indigo was sown in Bihar before the beginning of summer. Bihar received the bulk of its rains between mid June and mid September. To avoid maximum incidence of rainfall during the period of growth the

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[1] Albert Howard and Gabrielle L C Howard, *First Report on the Improvement of Indigo in Bihar*, Bulletin No. 51 (Calcutta: Agricultural Research Institute, Pusa, 1915): 3-4, India Office Records, V/25/500/121

[2] Albert Howard and Gabrielle L C Howard, *First Report on the Improvement of Indigo in Bihar*, Bulletin No. 51 (Calcutta: Agricultural Research Institute, Pusa, 1915): 1-27, India Office Records, V/25/500/121

seedlings were planted in August. They were also put on highlands to ensure that subterranean water from other areas did not accumulate underneath the fields.

The seedlings were sown in lines two feet apart. The intention was to facilitate proper pollination of flowers through the activity of insects. The common practice followed in Bihar todate had been to broadcast the seeds or to sow them by drills in lines close together, which did not provide adequate space for branching. Howard believed that such a practice inhibited pollination. It also made weeding of the ground between the plants a near impossible task.

In a major departure from the past no cuttings were made when the experimental plants reached maturity. The plants escaped wilt and came to flower in October/November. Affirming the appropriateness of the methods followed a good harvest of seeds was gathered in February/March. Normally in Bihar a second and possibly a third cutting followed the first cutting. Thereafter the plant was allowed to flower to produce the seeds. Thus the same plant that gave a harvest of leaves also produced seeds. Howard recommended that the plants for seeds should be different from those that were grown for leaves. He said, "The practice of growing seed from an old worn out plant cannot be too strongly condemned." [3]

Howard also provided a critique of the way the Java crop was ordinarily harvested for leaves in Bihar. Normally the first cutting was made in the month of July. Howard claimed that the way the plant was "completely" cut down harmed its subsequent growth. Harvested this way the plant had to grow all of its shoots at the peak of the rainy season

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[3] Albert Howard and Gabrielle L C Howard, *First Report on the Improvement of Indigo in Bihar*, Bulletin No. 51 (Calcutta: Agricultural Research Institute, Pusa, 1915): 5, India Office Records, V/25/500/121

when its roots were in a very moist soil. A total cutting down of leaves also disturbed the transpiration currents from the roots. The transportation of food and water was disrupted. As a result either the new leaves were unhealthy or the plant died completely.

The experts at Pusa suggested "pruning" leaves instead of cutting them. Half the crop that was sown in the previous year was pruned in the month of July, and its behavior was compared with the other half that was cut down completely. The pruned plants were also left with a branch to carry on an uninterrupted growth. The results (see Table 8.1 below) confirmed what Howard had hypothesized. The first cutting in the pruned plant obviously returned a lower yield. But the plant escaped wilt-like degeneration and went on to give a second cutting. The shortfall of the first cutting was more than made up during the second cutting. The total yield was appreciably

Table 8.1
Comparative yield of leaves from pruned and cut down plants

	"Pruned" plants	**"Cut down" plants**
First cutting	15 maunds, 11 sers	22 maunds, 39 sers
Second cutting	23 maunds, 37 sers	6 maunds, 19 sers
Total	39 maunds, 8 sers	29 maunds, 18 sers

Source: ***First Report on the Improvement of Indigo in Bihar,*** **ARI**

more from the pruned plants. Howard also suggested removal of the crop after two cuttings. The yield from the third cutting would not be much. The plant would have already exhausted itself and would neither be good for harvest or for seeds. It would make more sense to replace indigo with a *rabi* crop in the field.

The efforts toward biological selection began with a review of Parnell's previous works. Parnell had earlier noted that the indigo plant was ordinarily cross-pollinated with the help of bees that visited the plant during the flowering season. Experiments made with the Java plant confirmed Parnell's observations. A large number of healthy plants were put under frames before the flowers had appeared on them. Then they were covered with a net. In all cases where the plants had been covered up no pods were formed. The plants from the same batch grown under ordinary circumstances bred seeds in abundance. These results re-confirmed that Java indigo did not normally self-fertilize. The plants under ordinary circumstances would never breed true and thus progeny would not bear the same characteristic as the parent plant from which seeds had been collected. Therefore it was clear that the application of the ordinary single plant selection method would not work in this case.

The Season Of 1914-15

The scope of the agricultural trials in the following year was widened to include an emphasis on the Sumatrana indigo in addition to Java indigo. Through a focus on the functioning of the root nodules a new set of recommendations were made regarding appropriate cultivation practices for Java and Sumatrana crops. [4]

The nodules (which contained the bacteria *rhizobium*) in the root system needed an appropriate supply of food and air in the soil for their proper functioning. The "nodule factory" was responsible for the general health of the plant as well as for the accumulation of *indican* in the leaves. When grown in soil rich in nitrates the indigo plant absorbed the nutrients through the root hairs. It was characteristic in such cases for the plant to show a good amount of leaves. But those leaves had a low *indican* content. On the other hand, when the soil was poor in nitrates, its nodules worked at a brisk pace in order to fix the atmospheric nitrogen. In such cases the leaves showed a high level of accumulation of *indican* in their leaves. This explanation accounted for the fact that the indigo grown on relatively poor lands (*zilla*) gave a high color content in the leaves.

Howard emphasized proper drainage of the soil to ensure an adequate supply of oxygen so that the bacteria could work well in the nodules. In his view, persistently waterlogged conditions of the soil inhibited the functioning of nodules and was the primary reason for the onset of wilt. When the air spaces of soil were filled with water for a prolonged time the nodules stopped functioning and the formation of *indican* too stopped. The plant then fell back on its reserve of *indican* thus exhausting the amount of color in the leaves. Any prolongation of this unfavorable soil condition caused the decay and death of the entire plant. A "Pusa method of drainage" was devised to prevent subterranean water from the adjoining areas accumulating beneath the plants.

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[4] Albert Howard and Gabrielle L C Howard, *Second Report on the Improvement of Indigo in Bihar*, Bulletin No. 54 (Calcutta: Agricultural Research Institute, Pusa, 1915): 1-18. India Office Records, V/25/500/121

Howard also took strong exception to the current cultivation practices in Bihar. With respect to Java indigo in particular, he said, "The present practices in Bihar in growing Java indigo are about the worst that could be devised." [5] Separate methods of tilling and preparing of soil were recommended for the Java and Sumatrana variety of indigo with emphasis on the need for the proper aeration of the sub soil.

The Java crop was sown in October under the cover of another *rabi* crop. As soon as the cover crop was reaped, Howard suggested deep harrowing of the soil with lever harrows. The topsoil should not be allowed to bake and get infested with weeds. Any crust (*papri*) that might form after the rains must also be broken. Such crusts blocked air supply to the roots. He also recommended leaving 2-3 inches of loose soil at the top to conserve moisture.

The Sumatrana crop presented a dilemma. Since it was sown at the beginning of the summer the soil had to be compacted to bring the moisture near enough to the top through capillary action. Compacting at the same time compromised the availability of air spaces in the soil. Some young shoots withered as a result. As soon as the plant was large enough, Howard recommended harrowing. Since the root system of Sumatrana was more delicate as well as nearer the surface than Java, he suggested using the "spring-tine cultivator" instead of the lever harrow. He recommended harrowing again after the first cut.

Two indirect methods of improving the indigo industry were also being perfected at Pusa. The first of these was the singling out of Pusa 4, a particular breed of wheat, as a

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[5] Albert Howard and Gabrielle L C Howard, *Second Report on the Improvement of Indigo in Bihar*, Bulletin No. 54 (Calcutta: Agricultural Research Institute, Pusa, 1915): 6. India Office Records, V/25/500/121

“cover crop” for the indigo plant. The cover crop was a quick grower and developed strong shoots in loose soil that was prepared for indigo. At the same time it did not have a lot of foliage that would cut off light and air to the primary plant. For that reason many of the high yielding wheat varieties were ruled out as they all had thick foliage. Thus Pusa 4 seemed to suit all the requirements expected of a cover crop very well. It also had a market in the nearby mills. Thus the breed was tried at Pusa and Dholi with the indigo crop. Its trial proved successful.

The other indirect method being tried out at Pusa was to improve the value of *seet* – the refuse from indigo manufacturing. *Seet* from indigo manufacturing was popularly known to be a good manure for the tobacco crop. Thus planters sold it to the tobacco growers in the neighborhood adding to their profits. In order to improve the utility of *seet* as manure, the effect of adding tile (*thikara*) to the refuse was explored. The intention was to provide an aerating power to the land in addition to improving its fertility. If the trials proved successful the value of *seet* would go up.

The Season Of 1915-16

By the beginning of the 1915 season the experts at Pusa could take satisfaction from some of their achievements. The problems in the supply of Java seeds had been positively solved. The report published from Pusa in 1915 said, “The experiments carried out at Pusa and Dholi in 1913 and 1914 have been uniformly successful…The production of seed now offers no difficulty and yields of 8 to 10 maunds per acre can be obtained." [6] Later yields of 23.5 *sers* were also obtained.

The efforts on biological selection, however, remained a challenge. Even after continuous efforts in this direction since 1913 the project did not seem any nearer to completion. Much of the trials at Pusa in the year 1915 were directed towards the biological selection of the Java and Sumatrana plants. [7]

Howard also pointed to a paradoxical situation wherein the plants with low *indican* had gotten "selected" on the Bihar plantations. A correlation existed between plants that grew slower and a high content of *indican* in the leaves. Similarly the plants that grew fast and luxuriantly upfront had a lower content of color in their leaves. But most planters now tended to favor the quick growing "cart-fillers." The longer the plant stayed in the field the greater were the chances that floods, pests, or even wilt could harm it. The considerations in favor of having an early harvest outweighed all others. Therefore the experts at Pusa also tried to select the "early types," the plants that came quickest to maturity.

The evidence was adding up that indigo plants were "natural" cross-fertilizers and that any induced self-fertilization would be counter-productive. Java plants raised from self-fertilized seeds showed a marked falling off in both size of the plant and in general growth even in a single generation. If individual plants with high *indican* content were

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[6] Albert Howard and Gabrielle L C Howard, *Second Report on the Improvement of Indigo in Bihar*, Bulletin No. 54 (Calcutta: Agricultural Research Institute, Pusa, 1915): 9. India Office Records, V/25/500/121

[7] Albert Howard and Gabrielle L C Howard, *Third Report on the Improvement of Indigo in Bihar*, Bulletin No. 67 (Calcutta: Agricultural Research Institute, Pusa, 1916): 22-31. India Office Records, V/25/500/122

artificially self-fertilized, they were likely to turn sterile. Thus there was no point in avoiding cross-fertilization.

Under the circumstances it was going to be preferable "to control crossing rather than to attempt to prevent it." [8] But the selection of the favored "early types" was not going to be easy. It was the "least satisfactory" of all methods of selection. It had to be "continuous" over a period of time and over several cropping seasons to be effective. The principle followed was to isolate the stock of successful plants and make them grow together. After the next crop matured the odd ones were weeded out and another round of healthier varieties were planted. The experts were pessimistic from the very beginning. The report from Pusa for the year said, "The improvement of the Java crop by selection will not be easy." Two methods were tried out – the "selection of mixed early types" and the "selection of single early type." In the first method seeds of good plants from a season's crop were selected for propagation. These breeds were then grown together in a separate location. In the second method all seeds of a single "successful" breed were collected and planted together. Howard pointed out that the indigo planters themselves could implement these types of selection on their farms.

The work on the selection of the Sumatrana variety proved to be even more tortuous. Characteristically the Sumatrana variety bred fewer seeds than the Java variety and that made any procedures of propagation an intrinsically difficult one. The methods of selection were virtually the same. There were three regional varieties of Sumatrana – the Madras type, the Northwest type, and the Cawnpore type. The Madras type, though having more color than the other two, was a deep rooted, late growing variety. It was not

[8] Albert Howard and Gabrielle L C Howard, *Third Report on the Improvement of Indigo in Bihar*, Bulletin No. 67 (Calcutta: Agricultural Research Institute, Pusa, 1916): 25. India Office Records, V/25/500/122

suited to the local conditions in Bihar. The Northwest variety too was inappropriate. Therefore all selection trials had to be limited to the Cawnpore variety.

There was an additional consideration. Small farmers in the region around Delhi, a location that was several hundred miles away from Bihar, grew the Cawnpore variety of indigo plant. From all available indications it seemed that it would not be economically viable to grow the seeds locally in Bihar. Therefore, assuming that the selection of this variety was successful, it would still be very difficult to motivate the growers to implement selection and control such procedures if they were initiated.

Parallel Developments In The Metropolis, 1913-15

Sir Lewis John Enroll Hay And A G Perkin In England

In the summer of 1913 Sir Lewis John Enroll Hay of Edinburgh in England was the tireless campaigner pushing for the initiation of scientific measures on natural indigo. A baronet and an indigo planter, he had retired to England after spending much of his active life in Bihar. His close relatives still remained in the indigo business in India, a fact that explains his interest in matters related to indigo.

He proved quite successful in initiating a new range of debates. There were reasons for his credibility. For several years he had been engaged with indigo plantations and could thus claim to have first hand information about the indigo industry. His opinion was valued when he provided details about the nature of reactions underlying the manufacture of indigo. Knighted and a distinguished person in British society, he used his privileged access to important figures including the Secretary of State for India to project his viewpoint.

Lewis Hay did not have an advanced scientific training. He attended Fettes College in Edinburgh, but did not receive any higher university education. However, he was an experienced planter and an astute observer. When in India he had diligently recorded the changes in color taking place in the indigo liquor as it passed through the various stage of manufacturing. On their basis he prepared "color charts" and formed a preliminary hypothesis about the nature of chemical reactions in the manufacturing vats.

He passed along his color charts to a number of key persons. Utilizing the good offices of the Secretary of State at India House he first sent his chart to J. Mackenna, the new Agricultural Adviser to the Government of India and to the General Secretary of the Bihar Indigo Planters' Association in India. Through this chart he argued that it was possible to vastly improve yield from manufacturing. The communication only elicited a placid response from Mackenna in India. The Agricultural Adviser pointed out that he had not been able to get the opinion of Cyril Bergtheil on the charts. The Sirsiah Station had been closed down and Bergtheil was anyway preparing to leave India. The BIPA Secretary on the other hand was reported to have expressed disagreement with the claims made in Hay's chart. In agreement with the views of Bergtheil the BIPA Secretary argued that only 12-15% of the dye was getting wasted during the manufacturing cycle. Such a loss was generally "unavoidable." The Secretary also pointed out that there were ways to plug the residual wastage but that it was "not worth the cost." [9]

Other than the officials in India Lewis Hay also contacted a number of chemists in England to win support for his assertions. The most prominent chemist that he contacted

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[9] Letter from J MacKenna, Officiating Agricultural Adviser to the Government of India to Secretary, Revenue and Agriculture, dated, May 19, 1913, letter no. C-169, Serial no. 2, No. 56, File No. 142 of 1913, Government of India, Proceedings of the Department of Revenue and Agriculture for September 1913, IOR, GOI, Proc. Rev & Agr, P/9215

at this stage was A G Perkin. Perkin was a very respected British chemist at Leeds University and a well-known natural dye expert. He was perhaps most suited to comment on Hay's observations. His affirmation was bound to carry weight generally.

Perkin sent a reply to Lewis Hay affirming that there was a margin for improvement.[10] He put the losses at about 30 per cent, which was far below the 38 per cent proposed by Bloxam in his report of 1908. Perkin referenced his previous experiments conducted with Bloxam to clarify that the primary cause of loss of color was the unstable nature of *indoxyl* – an intermediate compound formed in the fermentation tank. Instead of being oxidized into *indigotin* parts of this compound automatically disintegrated into *isatin.* Other reactions also took place leading to the transformation of some of *indoxyl* into *indoxylic acid* that in turn got converted into what was commonly called brown substance. In laboratory trials it was possible to prevent some of this conversion of *indoxyl* by the addition of a small amount of sulfuric acid to the fermenting mixture.

There was no doubt that the most wasteful conversions took place during the stage of fermentation. Perkin therefore suggested that the possibility of bypassing fermentation altogether should be further explored. There was an alternative "hot water process" that required treating leaves with hot water and then hydrolyzing *indican* in the extract with a small quantity of acid. This alternative for fermentation had been known for some time. Rawson had actually considered it for a while. But finally he did not adopt

[10] Letter from A G Perkin to Lewis J E Hay, dated, May 14, 1913, enclosed in letter from Francis C Drake, Secretary, Revenue and Statistics, India Office to Secretary, Revenue and Agriculture, Government of India, dated June 6, 1913, letter no. R&S 1891, Serial No. 3, No. 57, Government of India, Proceedings of the Department of Revenue and Agriculture for September 1913, IOR, GOI, Proc. Rev & Agr, P/9215

it due to the high costs involved in heating. Perkin wondered if the use of natural sources of energy or the creation of efficient plants to prevent loss of heat would make the hot water process workable in Bihar.

Hay also forwarded a small amount of residue from *seet* water (the run off liquid that along with *seet* or the steeped plant was the byproduct of the manufacturing processes) to Perkin for experimental analysis. Hay wanted him to confirm what he suspected - the presence of products of *indican* decay in the waste water. The presence of such compounds in large amounts would prove his thesis that a huge proportion of the color element was getting wastefully converted during manufacturing and, therefore, that the manufacturing processes needed streamlining.

Perkin noted that while there were indications that the sample supplied to him contained elements from *indican* decay it was perhaps too early to make definitive claims in this regard. His preliminary examination of the residue revealed the presence of indigo brown-like substances in the residue. But one could not assume that indigo brown and similar substances in the sample from waste water came out of the disintegration of *indican* in the leaves. Firstly it was known that the amount of *indican* in the leaves varied according to the season of the year. Thus the leaf itself must contain compounds released from the conversion of *indican.* He also noted that during manufacturing the leaves were brought into contact with water and acids. These reagents would also have acted on the substances present in the leaves to form other substances. Therefore the mere presence of substances like indigo brown, indigo glutten, and indigo yellow in the waste, if confirmed, would not directly lead to the hypothesis that they were all byproducts of the decay of *indican.*

Perkin also noted that the sample sent to him was without specifications. It was not clear from what amount of *seet* water the residue had been deposited. Neither did he know how much indigo leaves had been used in the cycle from which the *seet* had been obtained. In the absence of such data it was difficult to work out the ratio of wasteful versus useful conversion even if one were to assume that all "waste" in the *seet* came out of *indican.*

Lewis Hay interpreted Perkin's communication as supporting his view that there was a margin for improving the production process of indigo. He forwarded Perkin's letter to India House hoping to persuade them that more scientific efforts were required to improve manufacturing. The fermentation stage required maximum attention. Hay stated that the exact scope for improvement was still an open question. He believed that the processes could be made a lot more efficient than the 30% that Perkin had proposed. He was still in the process of consulting additional chemists on the issue of margin for improvement. [11]

Indeed Hay confronted Perkin pointing out the probable 'secondary' routes for the decay of *indoxyl.* He belabored the point that under actual conditions of manufacture there were other chemical reactions taking place that might not take place under laboratory conditions. And therefore Perkin might not be immediately aware of them. One particular loss was taking place through the production of *indi-humin.* Indigo manufacturing in Bihar invariably took place under hot and humid conditions. The vats were infested with various kinds of bacteria. It was well known that some parts of *indican*

[11] Letter of Lewis J E Hay to the Under Secretary, Revenue and Statistics, India House, dated May 29, 1913, enclosed in letter from Francis C Drake, Secretary, Revenue and Statistics, India Office to Secretary, Revenue and Agriculture, Government of India, dated June 6, 1913, letter no. R&S 1891, Serial No. 3, No. 57, Government of India, Proceedings of the Department of Revenue and Agriculture for September 1913, IOR, GOI, Proc. Rev & Agr, P/9215

underwent early breakdown into *indoxyl* and *dextrose*. He conjectured that the latter was acted upon in turn by lactic and then butyric bacteria. The final products in this case were carbonic acid and hydrogen, the emission of both of which was earlier detected by Christopher Rawson. The last two reagents also reacted with *indole,* one of the substances formed by the breakdown of *indoxyl* to produce *indi-humin.* He pointed out that chemist Schunk had documented the production of *indi-humin* as a byproduct of the chemical reactions underlying indigo manufacturing in the mid-nineteenth century. [12]

The primary goal pursued by Hay was to turn everyone's attention to *seet* – the liquor and the refuse plant usually discarded after the manufacturing cycle was over. The planters in India were then resisting the suggestion of any further trials on manufacturing. Their experts had convinced them that there was no possibility of improving manufacturing. Hay's strategy was to demonstrate the presence of certain elements in the *seet* and thus prove that the planters' convictions were misplaced. If that could be done, the planters would be once again open to the idea of new experiments. He said, "I am anxious that this question of the brown residue of the waste liquor should be thoroughly investigated by skilled analysts as soon as possible." [13]He considered early results from the experimental analysis by Perkin to be encouraging. He was trying to obtain more *seet* from India in order to facilitate further analytical examination in England.

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[12] Letter from Lewis Hay to A G Perkin, dated May 23, 1913, enclosed in letter from Francis C Drake, Secretary, Revenue and Statistics, India Office to Secretary, Revenue and Agriculture, Government of India, dated June 6, 1913, letter no. R&S 1891, Serial No. 3, No. 57, Government of India, Proceedings of the Department of Revenue and Agriculture for September 1913, IOR, GOI, Proc. Rev & Agr, P/9215

[13] Letter from Lewis Hay to A G Perkin, dated May 23, 1913, enclosed in letter from Francis C Drake, Secretary, Revenue and Statistics, India Office to Secretary, Revenue and Agriculture, Government of India, dated June 6, 1913, letter no. R&S 1891, Serial No. 3, No. 57, Government of India, Proceedings of the Department of Revenue and Agriculture for September 1913, IOR, GOI, Proc. Rev & Agr, P/9215

In 1913 Lewis Hay, backed by supporting assertions from Perkin, was demanding something not very dissimilar from what Bloxam had demanded in 1908. Bloxam's report of 1908 had argued that color was being lost in the process of manufacturing and therefore that the scientists in the Indian laboratories should turn their attention to what was happening in the manufacturing vats. In substance Hay was also demanding the same. He wanted the India Office to use its influence to convince the central and the provincial governments to re-start chemical experiments in India.

The communications from Hay along with Perkin's papers were promptly forwarded to India. [14] J Mackenna, the Agricultural Adviser in India also took timely action. The issue of reviving chemical experiments had cropped up repeatedly in India in recent times. Eugene Schrottky in India had also asked for the involvement of chemists in the task of making indigo paste. Mackenna decided to elicit the opinion of the planting community on the issue whether the chemical experiments should be resumed. He called a meeting with the representatives of the planters at Pusa. [15]

The planters were provided with all the relevant information including the communication from Hay and the letters from Perkin. Mackenna clarified the implications of Perkin's intervention on the question of efficiency. He also provided those present with an overview of the continuing biological experiments on indigo by the

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[14] Letter from Francis C Drake, Secretary, Revenue and Statistics, India Office to Secretary, Revenue and Agriculture, Government of India, dated June 6, 1913, letter no. R&S 1891, Serial No. 3, No. 57, Government of India, Proceedings of the Department of Revenue and Agriculture for September 1913, IOR, GOI, Proc. Rev & Agr, P/9215

[15] Letter from F Noyce, Under Secretary, Revenue and Agriculture, Government of India to Secretary, Revenue and Statistics, India House, dated September 4, 1913, letter no. 1104, Serial No. 4, No. 58, Government of India, Proceedings of the Department of Revenue and Agriculture for September 1913, IOR, GOI, Proc. Rev & Agr, P/9215

Imperial Economic Botanist at Pusa. Two questions were put to the planters. Were they completely satisfied with the biological work being carried out at Pusa without the involvement of the chemists? In the context of Prof. Perkin's opinion that the efficiency of the manufacturing processes could be improved by another 30% did they think that the resumption of chemical experiments would be of any value?

The planters were clearly in favor of the continuation of biological selection trials. They emphasized that an increase in the *indican* content of the leaves must be made the basis for plant selection. To determine and select the plants with high *indican* content they suggested that a chemist should be employed to assist the current botanist Albert Howard. Thus they more or less persisted with the model of collaboration between a biologist and a chemist that they had been emphasizing since 1908. They believed that if Howard's trials could help increase the color of the leaves by about twenty-five per cent there was a good chance of overcoming price competition from the synthetic substitute. But they were clearly against the idea of initiating any experiments to improve yield from manufacturing. They reportedly said that such efforts were "unnecessary and practically useless in the present [depressed] state of the industry."

The discouraging response from the planters did not preclude the next round of communications from the officials at India House. They again forwarded a letter from Lewis Hay in which the ex-planter expressed regret over the negative response from India. He reiterated that the experts in India had inadvertently made an "omission." They had tested the *seet* for *indigotin* and found only small traces of it. On that basis they formed an opinion that a very small amount of color was being lost. They committed an error in not testing the liquor for substances wastefully converted from *indican.* He argued that a different picture of the efficiency of manufacturing processes would emerge on taking into account the presence of these other substances in the waste that had also been formed out of *indican*. [16]

Perkin was currently occupied analyzing the exact composition of the indigo residue. Hay was quite confident that the completion of Perkin's experiments would put a seal on the debate over efficiency. There seemed little doubt in his mind that the results of that investigation would conclusively establish the need for improving the manufacturing processes.

This time Hay, Perkin, and India House succeeded in eliciting interest in India on the subject. The perseverance shown in the metropolis was beginning to pay off. A relatively more encouraging reply came from India. The central government officials expressed interest in Perkin's experiments on the nature of substances in *seet*. They requested that they be acquainted with the outcome of the researcher's investigations in England. [17]

War And A New Sense Of Enthusiasm Over The Future Of Natural Indigo

[16] Letter of Lewis Hay to India House, dated October 22, 1913, enclosed in letter from Francis C Drake, Secretary, Revenue and Statistics, India Office to Secretary, Revenue and Agriculture, Government of India, dated October 30, 1913, letter no. R&S 3943, Serial No. 5, No. 43, Government of India, Proceedings of the Department of Revenue and Agriculture for September 1913, IOR, GOI, Proc. Rev & Agr, P/9215

[17] Letter from Under Secretary, Revenue and Agriculture, Government of India to Secretary, Revenue and Statistics, India House, dated December 31, 1913, letter no. 1647, Serial No. 6, No. 44, Government of India, dated October 30, 1913, letter no. R&S 3943, Serial No. 5, No. 43, Government of India, Proceedings of the Department of Revenue and Agriculture for September 1913, IOR, GOI, Proc. Rev & Agr, P/9215

The outbreak of World War I in July 1914 excited those in England with an interest in the future of the natural indigo industry. They sensed a new opportunity, as disruption in the supplies of synthetic indigo of German origin created an artificial scarcity for the blue dye in England. Consumer demand for the natural product was restored in the metropolis.

In a letter to his brother-in-law, also a planter in India, dated August 19, 1914 Lewis Hay said, "Our 'Hour' has arrived… *Now,* I think is the appointed hour and we should strike quickly and *hard."* [18] He also wrote another letter to the India Office asking for immediate help to the indigo industry in two respects. First he suggested that India Office facilitate the procurement of Java seeds from Zululand in South Africa where the plant grew wild. It was believed by many that the spread of wilt disease on the indigo plantations was the outcome of the Java plant becoming progressively weaker on account of cultivation through generations. Albert Howard was addressing the problem of wilt in India. He was engaged in the biological selection of plant at Pusa through which he hoped to obtain a disease resistant stock. But such procedures would inevitably take a long time to bring results. Previously uncultivated and wild strains found naturally-growing in Zululand would not suffer from any such disadvantage. Hay further suggested that Sir David Prain, the director of the Botanical Garden at Kew be consulted on the issue. He also suggested that Martin J Sutton of the transit company Sutton and Sons of

[18] Letter from Lewis Hay to planter L W Macdonald at Hathwa, Saran in Bihar, dated August 19, 1914, enclosed in letter from E J Turner, Assistant Secretary, Revenue and Statistics, India House to Secretary, Revenue and Agriculture, Government of India, dated September 4, 1914, letter no. R&S 3465, Serial No. 6, No. 33, Government of India, Proceedings of the Department of Revenue and Agriculture for March 1915, IOR, GOI, Proc. Rev & Agr, P/9726

Reading, and Major Gage, the Superintendent of the Botanical Gardens in Calcutta, be asked how to safely transport seeds to India. [19]

Hay also wanted the assistance of the Home Government in the training of the dyers in England in the use of natural indigo. For a good number of dyers, dyeing with natural indigo had become a thing of the past. They had long switched to synthetic indigo and used chemical vats. The hydrosulphite and woad vats for dyeing with natural indigo had fallen out of use generally. The new generation of dyers was also oblivious of the skills required for dyeing with the natural product. Therefore Hay wanted the government to assist with the re-training of the dyers with the aim of popularizing the use of natural indigo among them.

Perkin was also enthusiastic about the possibilities that the War had opened up for natural indigo. Referring to the conflict and its implications for the natural indigo industry, he said, "It is an ill wind which blows nobody any good,…[but] in this case the war should be of great benefit to the indigo planter, and give him opportunity and breathing space to set his house in order." [20] He was of the opinion that it would be difficult to immediately produce synthetic indigo in Britain. Even if efforts were initiated it would be another two to three years before such attempts would succeed. After the War the Germans would also take a while before they would be able to supply synthetic

[19] Hay's letter to India Office, dated August 20, 1914, enclosed in letter from E J Turner, Assistant Secretary, Revenue and Statistics, India House to Secretary, Revenue and Agriculture, Government of India, dated September 4, 1914, letter no. R&S 3465, Serial No. 6, No. 33, Government of India, Proceedings of the Department of Revenue and Agriculture for March 1915, IOR, GOI, Proc. Rev & Agr, P/9726

[20] Letter from A G Perkin to Lewis Hay, dated September 20, 1914, enclosed in letter from E J Turner, Assistant Secretary, Revenue and Statistics, India House to Secretary, Revenue and Agriculture, Government of India, dated September 4, 1914, letter no. R&S 3465, Serial No. 6, No. 33, Government of India, Proceedings of the Department of Revenue and Agriculture for March 1915, IOR, GOI, Proc. Rev & Agr, P/9726

indigo again at pre-War prices. Therefore now was the time. In Leeds the indigo from Bengal was fetching ten shillings for every pound. The profits from these enhanced prices should enable the planters to put their product on an even keel.

Perkin was also pushing for the chemical route for the improvement of yield. He wrote to Lewis Hay, "Apart from the agricultural side, I am certain that if your industry is to be saved it must be by purely chemical means." Earlier communications from Perkin [21] reveal that his work on the *seet* water and residue was getting impeded due to the delay in procuring appropriate samples. Also, the paths that he was traversing in his investigations were totally new. The only publication on the nature of indigo-brown was the paper that he had co-authored with W P Bloxam several years before. There was nothing published on glutten. Indigo glutten was different from the more familiar vegetable glutten in many respects. It was also a mixture rather than a pure substance and that brought additional challenges to investigators. But despite the difficult nature of the problem he was optimistic about the final outcome. He had found a large amount of indigo-brown and indigo-glutten in the residue. He suspected that the substances in the residue had been formed during the fermentation of the leaf extract, and was hopeful that with more effort such wasteful conversions could be stopped.

On receiving the communication from Hay and Perkin the administrators at the India Office acted with a heightened sense of purpose. The context in the metropolis had changed. There was a revival of interest in Indian natural indigo due to disruption in the

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[21] Letter from A G Perkin to Lewis Hay, dated August 19, 1914, enclosed in letter from E J Turner, Assistant Secretary, Revenue and Statistics, India House to Secretary, Revenue and Agriculture, Government of India, dated September 4, 1914, letter no. R&S 3465, Serial No. 6, No. 33, Government of India, Proceedings of the Department of Revenue and Agriculture for March 1915, IOR, GOI, Proc. Rev & Agr, P/9726

supplies of the German synthetic substitute. Sir Lewis Hay and A G Perkin were only advocates. It was up to the officials to act on their suggestions or to dismiss them. But in 1914 the suggestions of these two eminent individuals were followed up and acted upon with resolve.

The director of the Botanical Garden at Kew, David Prain, was approached and asked for his advice on the issue of procurement of Java seeds from South Africa. Prain supported the idea that a "fresh" strain of wildly growing Java indigo from Zululand might help tide over the problem of weak and disease-prone strains in India. The Java seeds had been originally procured in India either from Southeast Asia or from Natal. In both these places indigo had been sown for several years by the agriculturists and some kind of conscious or sub-conscious selection of stocks may have taken place there. In that sense a "pure" strain had never been tried in India. The wildly growing Java indigo in Zululand could be a legitimate source for the supply of a strain that had not been acclimatized previously in any farming environment. There was a chance that such a strain might prove to be stronger. [22]

The general mood at India Office was supportive. The officials were more willing at this time to examine suggestions on a case-to-case basis and extend whatever support they could. On receiving the response from Prain they contacted Hay again and asked him to formulate a concrete scheme about Zululand seeds. The government would then see what help it could render. But most importantly, the officials at India House

[22] Letter from E J Turner at India House to David Prain, Director, Botanical Garden, Kew, dated September 1, 1914; Reply of David Prain to E J Turner, dated September 2, 1914, enclosed in letter from E J Turner, Assistant Secretary, Revenue and Statistics, India House to Secretary, Revenue and Agriculture, Government of India, dated September 4, 1914, letter no. R&S 3465, Serial No. 6, No. 33, Government of India, Proceedings of the Department of Revenue and Agriculture for March 1915, IOR, GOI, Proc. Rev & Agr, P/9726

forwarded the communications by Hay and Perkin regarding the manufacturing experiments to the Indian authorities "for consideration."

William Beddome Bridgett In London

Another interlocutor in the re-emerging debate on natural indigo in Britain was William B Bridgett. Bridgett clearly had a vested interest in promoting natural indigo. He was a very important importer and distributor of the plant-derived dye in Britain. He owned the East India Indigo Company located in London whose transactions were of a considerable size. Having been in the business of importing indigo for more than thirty years Bridgett had seen the ups and downs in the fortunes of the natural dye. Obviously he was not pleased that the industry had fallen onto bad times. With the outbreak of the War and the disruption in the supply of synthetic indigo he sensed his chance.

"There is practically no stock [of natural indigo] available," Bridgett wrote to the Viceroy in India in early September. A bit dramatically, of course, he sent to the Viceroy a copy of the monthly statement of his firm. The demand for natural indigo had soared. Within weeks of the declaration of the War all indigo had been already sold. Whatever remained with him was already committed to the buyers and was awaiting delivery. Cables were being received in London from overseas locations requesting supplies. But the stocks of natural indigo in London warehouses had dried up just as in Bridgett's. He wanted to apprise the Viceroy of the new trade opportunity presented to natural indigo in the markets of the West. The Viceroy's office in India promptly acknowledged the receipt of Bridgett's letter and other information. A copy of the letter with enclosures was then forwarded to the Secretary of the Commerce and Industry Department of the Government of India. [23]

Bridgett appealed to the need for patriotic support for the natural indigo industry of India. The English consumers had made a mistake in the past by preferring cheaper synthetic indigo and thus promoting a German product at the cost of natural indigo that came from within the Empire. Now the same Germans were at war with their country. The Indians continued to be loyal having sent their troops to fight side by side with the English soldiers against the Germans. Therefore the government should do everything possible to resuscitate an imperial product. Such demands for support to an "imperial" industry were not absolutely new. But in the context of the War such rhetoric assumed added meaning and appealed to popular sensibilities.

In a follow-up letter addressed jointly to the Viceroy in India and the Secretary of State for India in England Bridgett stated that natural indigo was a more powerful dye than its synthetic substitute. But, Bridgett argued, inappropriate norms of selling had brought ruin for natural indigo. The two dyes routinely sold in the market on the basis of percentage of indigo. BASF Rein was sold in 20% concentration of indigo. On the other hand, the permanganate test/titration test was used to check the percentage of indigo in the natural dye and its value was fixed according to what percentage of indigo was found in it. Bridgett pointed out that natural indigo was comprised of indigo, and then additionally, indigo-red, indigo-brown, and indigo glutten. Apart from indigo the other constituents in the natural dye also provided color in the vat. Any practical dyer would

[23] Letter from W B Bridgett to the Viceroy, dated September 11, 1914, letter no. 2968, Serial No. 12, No. 39; Acknowledgement of the letter by the office of the Viceroy, dated October 12, 1914, letter no. 11222-32, Government of India, Proceedings of the Department of Revenue and Agriculture for March 1915, IOR, GOI, Proc. Rev & Agr, P/9726

attest to that. This was an aspect that was often missed by chemists who had rendered support to the theory that only indigo provided color and that the value of the dye should be fixed on the basis of indigo percentage. Thus a true comparison of the dyeing power of the two dyes could only be made with the help of "color tests" that measured their respective *coloring potential* rather than *indigo percentage*. [24]

Once again, in appealing to the need for color tests Bridgett was making an argument that many planters had often made in the past. A few public trials had also been conducted both in India and England previously. But such trials had failed in convincing those concerned with the trade that the natural dye had more potency. Nevertheless, Bridgett's arguments were still favorably entertained at a time like this. When he offered to organize public trials in England to show the higher dyeing power of natural indigo the India Office in London encouraged him. A personal note from Secretary of State Sir Thomas W Holderness was communicated to him: it suggested that he should try to arrange for as much publicity as possible for his vat trials. [25]

The office of the Secretary of State encouraged Bridgett to submit a "memorial" to different government departments seeking their commitment to promote the use of natural indigo in Britain. Bridgett accordingly took the lead in organizing a joint appeal on behalf of the supporters of natural indigo. It asked the British consumers and government offices like the War Office, Board of Trade, Admiralty, and Post Office to

[24] "Confidential," Letter from Bridgett to the Viceroy and the Secretary of State, dated September 9, 1914, letter no. 3028, Serial No. 13, No. 40, Government of India, Proceedings of the Department of Revenue and Agriculture for March 1915, IOR, GOI, Proc. Rev & Agr, P/9726
[25] Letter from Francis C Drake, Secretary, Revenue and Statistics Department, India House to Bridgett, dated September 24, 1914, letter no. R&S 3735, Government of India, Proceedings of the Department of Revenue and Agriculture for March 1915, IOR, GOI, Proc. Rev & Agr, P/9726

support the indigo industry in India. [26] The India Office also warmly received a deputation led by Bridgett on September 18, 1914 that submitted a memorandum listing the ways through which the government should help the natural indigo industry. The office of Secretary of State sent a telegram to the Government of India informing them of the contents of the memorandum. Later all the documents were forwarded to India. [27]

The Crystallization Of A New Plan For The Indigo Experiments

The Delhi Conference

The Government of India finalized plans to call a conference to discuss all suggestions related to improving the health of the indigo industry. The conference was being called, admittedly, to discuss suggestions "received from various quarters." But there is little doubt that the persistent pressure from the officials at India House provided the primary impetus for calling this conference.

The conference was to be held in Delhi on February 22, 1915. The Indian Government wanted input from all concerned in order to form a clear view on the question of indigo improvement. It needed all the information it could get so that it could decide whether the government should invest further in that direction. And if the task of indigo improvement emerged as a legitimate agenda from the deliberations of the

[26] Letter from Bridgett to the Secretary of State, dated October 27, 1914, Government of India, Proceedings of the Department of Revenue and Agriculture for March 1915, IOR, GOI, Proc. Rev & Agr, P/9726

[27] Letter from E J Turner, Secretary, Revenue and Statistics, India Office to Secretary, Revenue and Agriculture, Government of India, dated November 13, 1914, letter no. 4471, Serial No. 16, No. 43, File No. 67 of 1914, Government of India, Proceedings of the Department of Revenue and Agriculture for March 1915, IOR, GOI, Proc. Rev & Agr, P/9726

participants, the government needed to know to what extent and in what manner it should assist such programs.

The authorities solicited the participation of all concerned. A letter was dispatched to the Secretary of the Bihar Planters' Association asking the planters to send their representative. Separate letters of invitation were also sent to the revenue secretaries of Bihar and Orissa, Madras, Punjab, and the United Provinces asking if they would be interested in sending their representatives. The effort to involve the other states represents a certain turn at the level of policy. The ground realities of indigo manufacturing had changed. Bihar and Orissa, which was formed out of the larger state of Bengal in 1911, no longer enjoyed a clear dominance in terms of its share of the total indigo exported from India. The relative share of both the Punjab and the United Provinces had gone up although it was still far below the output in Bihar. Madras had always been a supplier of an inferior quality of indigo called *kurpah.* But the relative importance of Madras as an indigo-manufacturing state had risen in the context of a decline in the production of indigo in Bihar. The central officials now wanted the opinion of administrators from all four provinces where indigo was manufactured. [28]

In the end the conference was widely attended. The officials of the agricultural department in the provinces and at the center had a sizeable presence. A few administrators of the commerce department also turned up. Among others were the office holders and a few members of the Bihar Planters' Association, the representative of the

[28] Letter from L J Kershaw, Secretary, Revenue and Agriculture, Government of India to General Secretary, Bihar Planters' Association, dated January 18, 1915, letter no. 224-C, Serial No. 10, No. 37, Government of India, Proceedings of the Department of Revenue and Agriculture for March 1915, IOR, GOI, Proc. Rev & Agr, P/9726; Letter from L J Kershaw to Secretaries of the provinces of Madras, Punjab, United Provinces and Bihar and Orissa, dated January 18, 1915, letter nos. 228-229, Serial No. 11, No. 38, Government of India, Proceedings of the Department of Revenue and Agriculture for March 1915, IOR, GOI, Proc. Rev & Agr, P/9726

indigo trading company Moran and Co., and F Marsden, a dyeing expert from the Madras province.

The participants first of all discussed whether natural indigo had a future in terms of surviving the competition from synthetic indigo at present and after the War. Would it make sense for the planters to simply divest at this stage? A consensus emerged that the indigo industry *had* a prospect. D J Reid, Chairman of the Bihar Planters' Association asserted that taking the average yield at 16 *sers* per acre a profit of Rs. 100 for the acre could be obtained. That was a more generous level of profit than that possible by growing country crops on a large scale in Bihar, generally considered a fine business prospect by many. All those present at the meeting apparently agreed with this assessment. [29]

Moving on to discuss the scientific steps required to strengthen the industry, all participants generally expressed satisfaction with the pace of results on the agricultural front. The problem of the scarcity of Java seeds had been solved. The work of Albert Howard at Pusa came in for special praise. Planters suggested that the work earlier completed at Sirsiah on botanical selection to improve the amount of color in the leaves should be followed up. Howard assured them that such steps would indeed be taken soon. The immediate concern was to introduce early maturing varieties in Bihar. Bihar was currently facing the problem of severely reduced output. The main cause of the shortfall in production was bad weather and attacks by pests. The longer the plant stayed in the field the greater was the risk of losing it. In the short-term therefore the introduction of early maturing varieties in place of the present stock appeared to be the right strategy.

[29] "Memorandum of Proceedings of the Indigo Conference held at Delhi on 22nd February 1915," No. 44, Serial No. 17, Government of India, Proceedings of the Department of Revenue and Agriculture for April 1915, IOR, GOI, Proc. Rev & Agr, P/9726

On manufacturing, the conference strongly recommended hiring a chemist to supplement current research work. The Agricultural Adviser to the Government of India, Bernard Coventry, was a prominent participant who took the initiative to articulate this demand. For the past two years Albert Howard and Gabrielle Howard at Pusa had been engaged with botanical and physiological work including a culture of the seed. Such work was urgent as the plant was threatened with extinction due to the onset of wilt. The chemical work had to be restarted in parallel with research on the agricultural side. In support of his viewpoint Coventry quoted Henry E Armstrong, Professor of Chemistry at Central Technical College, City and Guilds of London Institute, that "chemical problems of utmost importance are awaiting solution." Armstrong had recently visited the plantations in India. He had talked to many planters, advising them on the ways and means to resurrect the natural indigo industry so that the natural dye could compete with the synthetic on its own merits after the end of the War.

A new role was being envisaged for the chemist who the participants to this important conference proposed to hire. The new chemist was *not* to engage primarily in the improvement of yield from manufacturing. His central duty was going to be the purification and standardizing of natural indigo. Obviously he would deal with the manufacturing processes. Any effort to have the final product in a consistent form required a manipulation of the chemical processes underlying manufacturing. But his main aim would be to standardize the output. "The main object was not to increase indigotin recovery but to change the process of manufacture so as to standardize it," the participants agreed.

Though it is not possible to verify directly, there are indications that Henry Armstrong's views persuaded the officials and indigo interests in India that standardization was crucial. [30] There were others too at the conference who drew attention to the need for a standardized commodity from the dyer's perspective. F Marsden, the dyeing expert from Madras in south India told everyone that the preference for synthetic indigo shown by the Indian dyers was due to one reason – "the ease with which it could be handled." The dyeing methods had been revolutionized since the introduction of the synthetic indigo. Earlier natural indigo cakes had to be soaked and ground to uniformity before the vats could be prepared. This often required enormous time, effort, as well as skilled hands. Then came synthetic indigo that was available in the form of a paste. It offered to the users a major convenience over the natural, as it was readily usable. The paste could be immediately used and did not require any preparation time.

Indeed a candid admission of the factors that seemed to have attracted the buyers to synthetic indigo distinguishes the actors in 1915 from those in any time period previous to this. E C H Cresswell from Moran and Company of Calcutta, the leading indigo exporter from India, stated that there was a certain segment of market for indigo cake that was likely to persist. He was concerned to the contrary that the push towards making natural indigo available to the consumers in a paste form might disturb the already existing niche market for cake indigo. [31]

[30] In the conference called by the Secretary of State in September 1915 in London, Henry Armstrong was the most important advocate of the idea of "bulking and standardizing."

[31] The majority of participants, however, were of the view that through a successful conversion into indigo paste the majority of consumers that had been lost to synthetic indigo should be targeted.

The clearest articulation of the factors that had differentiated the market into two segments – the major part that used synthetic indigo and a minor part that used natural indigo – came from Bernard Coventry. He confronted the claims made by a few that natural indigo was a better dye. He began by clarifying the fact that at that time 90% of the market used synthetic indigo and only the remaining10% natural indigo. He chided many for being "blind" to this fact. What was now needed was to try and understand the basis for this overwhelming preference for synthetic indigo. He said, "Now, it is maintained by some of our friends that natural indigo is superior to the synthetic; that the indigotin of the synthetic is not true indigotin; and that the artificial product has been taken up by the dyeing trade not on account of its superior intrinsic merits but to the bribery and intrigue of the Germans. I hope to show this to be an utter delusion." [32]

Coventry provided an analysis of the nature of surviving markets for natural indigo. There was no denying that in the "semi-civilized" countries like Russia and Persia the use of natural indigo had persisted. The dyers in those countries only knew how to test and use the natural dye. The carpet-makers of places like Smyrna had their carpets dyed with natural indigo in England. The smell of the natural dye emanating from the carpets was considered a confirmation of its genuineness. Thirdly, in the countries that produced natural indigo a sufficient demand had persisted. The three groups together accounted for 3/5th or about 30,000 *maunds* of natural indigo consumption. The remaining 20,000 *maunds* was used by the dyers in England and other foreign countries

[32] Appendix A, "Note on Indigo Research in India," by Bernard Coventry: 9-10, "Memorandum of Proceedings of the Indigo Conference held at Delhi on 22nd February 1915," No. 44, Serial No. 17, Government of India, Proceedings of the Department of Revenue and Agriculture for April 1915, IOR, GOI, Proc. Rev & Agr, P/9726

for a certain class of dyeing of heavy woollens in which the impurities of natural indigo appeared to have some tinctorial value. The surviving use of the old-fashioned fermentation wooden vats also drove the demand for the natural dye to an extent. The superiority of natural indigo was acknowledged in these parts of the world and for certain classes of dying. But based on their claims some had rushed to the conclusion that the natural indigo "was intrinsically a better thing." This was simply not true, said Coventry.

In fact, the contrary was true. The majority of the dyers the world over considered natural to be relatively the "inferior" dye. This was for two reasons, Coventry explained. One reason was simply that the synthetic was intrinsically more suitable for use with certain classes of dyeing than the natural. In printing, the synthetic was preferred because the impurities present in the natural were an obstruction in the obtaining of fine prints. In the case of dyeing with lighter shades, too, the use of synthetic was dominant. The second reason for the dominance of synthetic was its cheapness and better usability. The lower price of synthetic indigo was an important factor especially considering that indigo was a particularly expensive dye. The standardized synthetic offered the advantage of easier manipulation. Since it was known to be of standard strength its quantity in the vat and the nature of shades could be controlled and any possible wastage also avoided.

Keeping these facts in mind Coventry called for the appointment of a chemist. The aid of chemistry was needed. Such a chemist could be on the rolls of the Pusa Institute. The team of agricultural experts at Pusa was doing everything possible on the agricultural front. The chemist was needed to make the natural dye more "user friendly." The chemist could also focus on improving yield from manufacturing since there was a belief that their efficiency could be improved. But improvement of yield, Coventry asserted, should only be "a secondary object of investigation." [33]

The conference also discussed purely commercial factors. Producing indigo in a paste form for the consumers was not the end of the matter. It was admitted that the indigo planters did not have any trade organization to push their product in the market place. It was important "to get in touch with different markets." The members discussed the possibilities of starting such organizations to push natural indigo in the Western markets to begin with. Such a step to facilitate "distribution" as against "production" was again a new aspect that the indigo planters in India were addressing frontally now.

The central government extended its wholehearted support to the indigo industry on the matter of the appointment of a chemist. A letter from the Viceroy's Council was sent to the Secretary of State in London requesting that a chemist be dispatched to Pusa. They justified the need for a chemist. They also argued that the government should bear the expenses incurred towards the salary of the chemist and the establishment of a separate indigo research section at Pusa. Such assistance seemed like a legitimate aid that could be provided by the government to an industry. [34]

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[33] Appendix A, "Note on Indigo Research in India," by Bernard Coventry: 10, "Memorandum of Proceedings of the Indigo Conference held at Delhi on 22nd February 1915," No. 44, Serial No. 17, Government of India, Proceedings of the Department of Revenue and Agriculture for April 1915, IOR, GOI, Proc. Rev & Agr, P/9726

[34] Letter from the Indian Viceroy to the Secretary of State, dated June 17, 1915, No. 204 of 1915, Government of India, Finance Department, No. 22, Serial No. 1, Government of India, Proceedings of the Department of Revenue and Agriculture for June 1915, IOR, GOI, Proc. Rev & Agr, P/9726

The influence of the metropolitan chemists was perceptible in this entire exercise. The influence of Henry Armstrong was now pervasive among both the officials and the planters. His suggestions influenced the forming of consensus among the planters for the appointment of a chemist. In his letter the Viceroy in India suggested to the Secretary of State that the opinion of the English chemist should be elicited for the selection of the chemist that they were demanding. The letter from the Viceroy also quoted another prominent chemist in England, A G Perkin who had said that the natural indigo industry had to be saved "by purely chemical means."

The Initiatives Of The Secretary Of State In The Metropolis

India House wanted to develop its own perspective on matters related to the natural indigo industry. Its officials called their own conference on indigo on September 20, 1915. The two chemists, Armstrong and Perkin, four planters or ex-planters T Martin Macdonald, Lewis J E Hay, C J Wilson, C B Gregson, and a representative of the Moran Company attended the conference. Sir William Duke from India House chaired the meeting.

The deliberations at this conference turned out to be crucial in shaping the perspective of the Secretary of State who held the reins of decision-making in the metropolis. In particular, the Secretary of State accepted the argument of the two chemists. These men were not only accomplished scientists who had a long association with the world of dyes. Having lived in the metropolis they also had a privileged perception of the developments in the market.

Armstrong and Perkin persuasively argued that the planters should become more responsive to the market. They were invited to evaluate and re- consider consumer preferences and reorient the organizational basis of production and distribution. Planter T M Macdonald was tentative on the issue of consumer choices. He made a reference to some of the efforts that had been made from time to time to make and sell natural indigo paste, though without success. Some preliminary effort at producing the natural indigo paste was made way back in 1898. This effort and the subsequent efforts had been only made on an experimental basis. But the handful of dyers contacted demanded that the paste be provided to them at the same price as the synthetic paste. That doomed any further coordinated effort to produce natural paste. [35]

The discussants then converged on the view that the competition with synthetic indigo would have to be met on two planes. The natural would have to be offered at a reasonably comparable price on the one hand and in the form of a paste on the other. For cheapening the dye the most likely path lay through agricultural trials to improve the yield per acre. Marginal scope to cheapen the dye also existed through streamlining the production process. But more concerted efforts than those attempted previously were required to make natural indigo paste in a commercially viable manner. The participants wanted the employment of a chemist *primarily* to advance the efforts on standardizing the production of paste.

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[35] "Note of proceedings of Conference on the subject of Natural indigo held at the India Office on the 20th September, 1915," p., 1, enclosure, Letter from India House to the Viceroy, dated November 19, 1915, Revenue, No. 123, Government of India, Proceedings of the Department of Revenue and Agriculture for May 1916, IOR, GOI, Proc. Rev & Agr, Z/P/1980

The other major recommendation concerned changing the organizational basis of manufacturing. Armstrong argued that the production of a standardized paste required that the planters set up a centralized factory or a few factories where the indigo planters should forward their indigo in a semi-manufactured state. Such a consignment would possibly be in a liquid or semi-liquid state and would have to be sent in tanks. At the factories the raw product would be assessed for *indigotin*, bulked, standardized, and made into a paste ready for export. What Armstrong had in mind is that indigo of different strengths be collected at central locations. The actual number of factories would depend on a consideration of the costs of carriage etc. The individual planters would be compensated according to the quality of their consignment. Thereafter the indigo would be mixed and turned into standardized paste of 20% strength.

The planters present on the occasion pointed to the problems at ground level. C B Gregson stated that indigo acreage had shrunk and many factories were deserted in Bihar. A revival of those factories required major financial investment. Before the planters showed a willingness to invest afresh they would need assurance of some form that their indigo would be purchased at a remunerative price. There was also a fear that at the end of the War the Germans would once again sell synthetic cheaply. Some even feared a "dumping" of inventories from Germany at throwaway prices. Gregson suggested that government contracts should be made available to the planters as a sop. Such a suggestion was not seriously entertained. However, the meeting conceded that if English entrepreneurs manufactured synthetic indigo in the future, Indian natural indigo should be afforded the same type or protection as the English synthetic indigo against the German synthetic indigo.

Martin T Macdonald was unsure how successful the efforts would be to induce cooperation among the planters for production and especially distribution/selling. The sending of indigo to the factories in a semi-finished condition did not pose too much of a difficulty though. There were ways and means to forward the consignment. The main problem, according to him, would accrue in forcing co-operation among the planters. Lewis Hay was also doubtful that the planters would be able to co-operate to have their ware centrally processed. Gregson was relatively more optimistic. He thought that the planters could be induced to cooperate "if the advantages were clearly demonstrated." [36]

Henry Armstrong was very assertive on this issue. He made it clear in no uncertain terms that unless the planters cooperated towards the production of standardized paste there was no point in the government sanctioning the appointment of a chemist. In the absence of corresponding efforts from the planters the mere appointment of the chemist would be a waste of public money. Incidentally this was a line that the Secretary of State would later take, insisting that the planters do their part by getting organized in co-operatives if they wanted any state help.

The participants also established the need for reducing transaction costs and for dealing "in the most direct manner with the consumer." By organizing for distribution the planters could ensure both "economy" and "continuity of supply." It was also suggested that the disposal of the product should be under the control of the proprietors. The present arrangement wherein the planters lost all control over indigo once it passed into the hands of the brokers was faulty. Two boards should be established. One board would be at

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[36] "Note of proceedings of Conference on the subject of Natural indigo held at the India Office on the 20th September, 1915," p., 2, enclosure, Letter from India House to the Viceroy, dated November 19, 1915, Revenue, No. 123, Government of India, Proceedings of the Department of Revenue and Agriculture for May 1916, IOR, GOI, Proc. Rev & Agr, Z/P/1980

Muzaffarpur and its subsidiary at London. The primary responsibility of the boards would be "to supervise within their respective spheres all [activities] pertaining to marketing."

"Eminent men of both business and science" should head the proposed boards, it was suggested. The role envisaged for the board was to make it the overall hub of industry-wide reforms in trade and marketing. But the agenda of standardization, an important aspect of marketing of the product, involved the spheres of both science and the market. Scientists were to work out the methods for turning out standardized paste to be sold to all consumers. Norms regarding color percentage, test assays, and units of measurement had to be established and popularized among the producers and the consumers. With that end in mind the members of the conference planned to constitute this board with scientists and businessmen equally represented. [37]

On the issue of how scientific research was going to be administered, once again the metropolitan chemists were able to corner the initiative. Perkin was in favor of the formation of a committee of experts in England that would supervise and direct the work of the chemist if he was appointed to work in India. "In the past young men sent out had been without expert advice or criticism," Perkin noted. Such experts had more or less worked in isolation and had made errors in judgment. There was a need to take corrective measures in this regard. Henry Armstrong agreed with the proposal to appoint a committee. In fact the two scientists spoke in absolutely one voice on the issue of

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[37] "Note of proceedings of Conference on the subject of Natural indigo held at the India Office on the 20th September, 1915," pp., 2-4, enclosure, Letter from India House to the Viceroy, dated November 19, 1915, Revenue, No. 123, Government of India, Proceedings of the Department of Revenue and Agriculture for May 1916, IOR, GOI, Proc. Rev & Agr, Z/P/1980

“management” of research in colonial India by a team of experts in England. [38] The suggestion on the appointment of a committee in the metropolis was another idea taken up by the Secretary of State.

The Secretary of State was in broad concurrence with the major recommendations of the conference. The India Office without delay forwarded the minutes of the conference to the Viceroy in India for information. In a subsequent telegram, the Secretary of State asserted that the production of standardized paste on a commercial basis was “essential to success and the first step towards all other improvements [of indigo].” He agreed to appoint a chemist to carry out that work. But he put some conditions before the planters. The planters were required to commit that within a year of the appointment of the chemist they would also take steps to get organized for co-operative production and selling of natural indigo. Lastly, the telegram also indicated that an expert committee would be formed in England to monitor the experiments in India. [39]

In a significant development support for the idea of standardized natural indigo paste came from the largest organization of the dyers in England – the Foremen Dyers’ Guild. On November 20, 1915 at a public meeting the dyers of the Lancashire and Yorkshire region belonging to this body gathered to discuss the shortage of the blue dye that they were facing. For the past six weeks the dyers had not received any supply of synthetic indigo. A member of the Board of Trade, who had been invited to attend the

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[38] “Note of proceedings of Conference on the subject of Natural indigo held at the India Office on the 20th September, 1915,” p., 4, enclosure, Letter from India House to the Viceroy, dated November 19, 1915, Revenue, No. 123, Government of India, Proceedings of the Department of Revenue and Agriculture for May 1916, IOR, GOI, Proc. Rev & Agr, Z/P/1980

[39] Telegram from the Secretary of State to the Viceroy, dated October 28, 1915, endorsement, No. 640 EA, dated November 3, 1915, No. 8, Serial No. 2, File No. 122 of 1915, Government of India, Proceedings of the Department of Revenue and Agriculture for May 1916, IOR, GOI, Proc. Rev & Agr, Z/P/1980

meeting, asked why the dyers were, then, not using natural indigo? The dyers present confessed that they could only use the dye in a paste form. [40]

Rowland E Oldroyd, the President of the Guild, who addressed the public meeting, further elaborated on the need for a standardized paste. In a scathing attack on the planters he condemned them for their thoughtlessness with regard to consumers' requirements. In his opinion that was the primary cause why the planters had lost the race against synthetic indigo. The indigo obtained out of the boiler was in a semi-liquid state and actually in a more appropriate form for use by the dyers. Then the planters put it through several stages so as to dry it and finally cut it in the form of a cake making the indigo far less usable. In this way he brought out the irony and highlighted the sheer lack of interest of the planters in putting their product in the market in an appropriate form.

"The Indigo Planter … has never been in touch, or taken any interest in the actual user of his product," charged Oldroyd. The President argued that it was now the duty of the Guild to have the situation remedied. They needed to communicate with the planters and tell them in what form the dyers needed natural indigo. To do so was patriotic, as it would promote a product from the "Empire." But it was also sensible from a business standpoint. Therefore, he argued, "If these people [meaning the planters] will not come and see what the users require, the users as represented by the "Guild" must … go to them." [40]

[40] Letter from Secretary of Foremen Dyers' Guild to Sir William P Byles, dated November 25, 1915, No. 37, Serial No. 1, Government of India, Proceedings of the Department of Revenue and Agriculture for May 1916, IOR, GOI, Proc. Rev & Agr, Z/P/1980

[40] "Report, Natural Indigo. A chat to the Dyers' Guild by the President," No. 37, Serial No. 1, Government of India, Proceedings of the Department of Revenue and Agriculture for May 1916, IOR, GOI, Proc. Rev & Agr, Z/P/1980

A resolution was passed at the end of the meeting imploring the planters in India to start making indigo paste. It was supposed to sensitize everyone connected with the natural indigo trade – planters, businessmen, and administrators – to become aware of the user's requirements. The resolution also directly addressed the Secretary of State and asked him to intervene urgently on this matter. It said, "We … ask you to press the Indigo Planters' Association and similar bodies interested in natural indigo, to make some arrangements to supply to us Indigo in the condition we require it for our work, i.e., in the form of a paste similar to …Synthetic Indigo."

This was the clearest articulation ever of consumer requirements. And it had the desired effect. It got the Secretary of State passionately interested in the issue of consumer requirements and the operation of the market. The natural indigo market comprising of the indigo planters/producers in India, the vast number of intermediaries including the shippers and brokers, and the consumers in England was not rationalized to an extent where the laws of demand and supply would take their course sui generis. At a time like this when the War had disrupted the supplies of synthetic indigo, the consumers required the political intervention of the Secretary of State to get their product in an appropriate form.

The office of the Secretary of State contacted Oldroyd seeking his further opinion on the competition between natural and synthetic indigo in the market. He had an interest in the issue. He wanted more information on whether at all, and in what manner natural indigo could be made to compete with synthetic indigo on its own. Before putting any additional resources in the improvement of the natural dye the Secretary wanted to assure himself and the political classes in Britain that the natural dye had a fair chance. The

President of the Foremen Dyers' Guild seemed to be the most appropriate person for the purpose. The Guild represented the majority of dyers in England that used the blue dye. His opinion mattered. Indeed what he told the Secretary of State influenced the decisions taken by him.

Oldroyd was willing to oblige. He responded promptly to the Secretary of State's query. In his response he focused on the inadequacy of efforts in the past by the planters in organizing the sale of natural indigo. In particular he praised the German method of selling "from Manufacturer to Consumer direct." This gave the German producers a better control over their product. In contrast the profits of the natural producers were compromised by the "profits of the intermediate handlers." This was just one example of the lack of "proper organization" in the natural indigo business. Oldroyd was also cautious. He wanted the officials in England to be careful that "the planters will not be allowed to whittle away the new opportunity." He suggested watchfulness over the planters and that "constant pressure is brought to bear" [41] on them.

The views of Oldroyd imparted additional credibility when India House sent them across to the Government of India. The Revenue Secretary at the center in turn forwarded them to the BPA for information and action. [42] The officials in England and India thus made it clear that in their view the recommendations of the dyers in England could not be

[41] Letter from R E Oldroyd to the Secretary of State, dated December 17, 1915, No. 37, Serial No. 1, Government of India, Proceedings of the Department of Revenue and Agriculture for May 1916, IOR, GOI, Proc. Rev & Agr, Z/P/1980

[42] Letter from F Noyce, Under-Secretary, Government of India to the General Secretary, BPA, dated February 3, 1916, letter no. 112, No. 38, Serial No. 2, Government of India, Proceedings of the Department of Revenue and Agriculture for May 1916, IOR, GOI, Proc. Rev & Agr, Z/P/1980; Letter from F Noyce, Under-Secretary, Government of India to the General Secretary, BPA, dated February 10, 1916, letter no. 125, No. 40, Serial No. 4, Government of India, Proceedings of the Department of Revenue and Agriculture for May 1916, IOR, GOI, Proc. Rev & Agr, Z/P/1980

ignored. In the light of Oldroyd's comments they were now expecting the planters to acquiesce with the wishes of the dyers.

The Reaction In India

The central administrators thought that the demand from the metropolis that the planters organize their production and distribution as a pre-condition for the continued appointment of research chemist was a legitimate one. They implored the planters to assure the authorities that this would be done. The message from England had clarified that the chemist's tenure would be reviewed after one year. If the planters had not taken the initiative to get organized in cooperatives his term would not be renewed. But the central officials told the planters that they would request the Secretary of State to appoint the chemist for an initial term of three years. This was because they felt that no concrete results could be expected from the chemical experiments in less time. [43]

But the Secretary of State was insistent on planter's commitment to fulfill the condition. He explained why he thought this was necessary. Experts had assured him that finding methods for bulking and standardizing indigo and producing a paste would not pose too many difficulties. One year was a reasonable time in which to expect results. Neither would the procedure be very expensive to put up on an industrial scale. Therefore he wanted the planters to be ready to proceed as soon as the methods had been devised and perfected. At the same time he was very impatient with the fact that much of the natural indigo industry was still conducted "on old lines." He was sure that such

[43] Letter from F Noyce, Secretary, Revenue and Agriculture, Government of India to T R Filgate, BPA, dated December 9, 1915, letter no. 77-C, No. 12, Serial No. 6, Government of India, Proceedings of the Department of Revenue and Agriculture for May 1916, IOR, GOI, Proc. Rev & Agr, Z/P/1980

industries would necessarily wither away as soon as free competition with the synthetic resumed. Thus he wanted a re-organization of the industry implemented within the first twelve months failing which, in his opinion, the government should withdraw from the "special efforts" for indigo. [44]

The BPA decided to call an Extraordinary General Meeting of the association to discuss all aspects of the proposals from England. They were of a wide-ranging nature. They involved a shift in the focus of experiments. They also required a re-organization on an industry-wide scale. A consensus had to be built among the planters on the issue of forging cooperation. Such proposals could only be considered at a general meeting, which represented the planters as widely as possible. [45]

The planters expressed broad agreement with all the recommendations made in the letter from the Secretary of State. They agreed that a chemist should be gainfully employed to make the standardized paste. As an aside, of course, they even ventured to suggest the name of a chemist already in India for consideration of the post – one Mr. Barnes, the Principal of the Lyallpur Agricultural College in Punjab. He could be available on short notice. He also had knowledge of the indigenous conditions. However the planters claimed that it was difficult to give "an absolute guarantee" that they would set up a central factory or factories for making the paste. The chemist would first have to work out the exact cost and other details and convince them of the viability before such

[44] Letter from Secretary of State to the Viceroy, dated November 19, 1915, Revenue, No. 123, Government of India, Proceedings of the Department of Revenue and Agriculture for May 1916, IOR, GOI, Proc. Rev & Agr, Z/P/1980

[45] Letter from the BPA to Secretary, Revenue and Agriculture, Government of India, dated January 7, 1916, No. 16, Serial No. 10, Government of India, Proceedings of the Department of Revenue and Agriculture for May 1916, IOR, GOI, Proc. Rev & Agr, Z/P/1980

steps could be undertaken. [46] In support of this line they cited the opinion expressed by Prof Henry Armstrong and Prof Arthur Smithhells (Professor of Chemistry at Leeds) who had stated that the first task was to show by concrete examples that such a paste could be commercially produced, and only then the planters could be expected to take requisite measures. [47]

The planters assured the local authorities that they would keep in contact with the chemist. They undertook to take steps to cooperate in producing at centralized factories as soon as the chemist's trials were deemed to be successful. They were also ready to cooperate in the marketing of indigo. They were already working out the modalities of a co-operative sale of indigo at Calcutta. This was going to be tried out in Calcutta in the coming season. Once the paste was available they would set up offices in Calcutta and London where co-operative sale of indigo could be effected.

Such assurances sufficed for the time. The Viceroy wrote to the Secretary of State that he considered the assurances from the planters "sufficient." He therefore requested the appointment of the chemist at the earliest possible date so that maximum advantage could accrue from it. [48]

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[46] Letter from J M Wilson, General Secretary, BPA to Secretary, Revenue and Agriculture, Government of India, dated March 13, 1916, No. 22, Serial No. 16, Proceedings of the Department of Revenue and Agriculture for May 1916, IOR, GOI, Proc. Rev & Agr, Z/P/1980

[47] Confidential, "Notes by Sir William Duke of two interviews he had subsequent to his Conference with Professors Smithells and Armstrong," enclosure, Letter from India House to the Viceroy, dated November 19, 1915, Revenue, No. 123, Government of India, Proceedings of the Department of Revenue and Agriculture for May 1916, IOR, GOI, Proc. Rev & Agr, Z/P/1980

[48] Telegram from the Viceroy to the Secretary of State, dated March 29, 1916, No. 25, Serial No. 19, Government of India, Proceedings of the Department of Revenue and Agriculture for May 1916, IOR, GOI, Proc. Rev & Agr, Z/P/1980

The planters also responded to Oldroyd's comments that had been sent to them earlier. They totally agreed with the general point made by the President of Foremen Dyers' Guild that efforts were required to present the natural in the form of paste to the consumers in England. But they took strong exception to "the extraordinary nature of the communication addressed to the Secretary of State by Mr. Oldroyd." Oldroyd had in fact gone overboard in painting the planters as a class barely interested in making quick profits and totally unresponsive to the needs of the market. The planters considered such criticism to be totally unwarranted. They documented the entire range of efforts that had been made to date in producing and selling natural indigo as powder and paste. While it was true that the planters had been unsuccessful in meeting their goals that was not because of a lack of effort on their part. [49]

The Appointment Of The Indigo Chemist And The Establishment Of The Indigo Committee

The next stage in the evolution of a strategy to improve natural indigo was drawing to a close. The first manifestation of the culmination of this process was the appointment of W A Davis, a chemist recommended by Prof Armstrong, as the Indigo Research Chemist. He was to leave for Bombay on April 29, 1916. [50] He was to be placed within the Imperial Department of Agriculture in India. He was therefore asked to

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[49] Letter from J M Wilson to the Secretary of State, dated April 3, 1916, No. 41, Serial No. 5, Government of India, Proceedings of the Department of Revenue and Agriculture for May 1916, IOR, GOI, Proc. Rev & Agr, Z/P/1980

[50] Telegram from the Secretary of State to the Viceroy, dated April 14, 1916, No. 32, Serial No. 26, Government of India, Proceedings of the Department of Revenue and Agriculture for May 1916, IOR, GOI, Proc. Rev & Agr, Z/P/1980

proceed to Pusa on arrival in Bombay. [51] The choice of Davis once again reveals the determination in the metropolis to take charge of the situation in India: the imperial authorities apparently had no interest in appointing the planters' preferred man, Mr. Barnes.

They also made organizational changes. To provide focus to the impending work on the indigo paste they formed an Indigo and Paste Committee within the Bihar Planters' Association.

The other major landmark for this phase was the formation of an Indigo Committee in England to liaison with and to monitor the work of the Indigo Research Chemist. The Secretary of State announced the formation of this committee headed by the Revenue Secretary at India House, L J Kershaw. Two other members were the chemist Henry Armstrong and a dyer, Mr. Burgess of Burgess, Edward and Company. The third member was to be a planter. India House wanted the planters to nominate their own representative on this committee. [52]

The administrators in England also wanted the committee to interact as directly as possible with the Indigo Chemist. A close monitoring of the experiments and trials in the colony by actors in the metropolis was a hallmark of the plans being formulated in England. Therefore the Secretary of State proposed that the committee correspond with W A Davis through the Agricultural Adviser to the Government of India, J MacKenna,

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[51] Letter from A E Gilliat, Under-Secretary, Revenue and Agriculture, Government of India to Secretary, Government of Bombay, dated May 4, 1916, No. 36, Serial No. 30, Government of India, Proceedings of the Department of Revenue and Agriculture for May 1916, IOR, GOI, Proc. Rev & Agr, Z/P/1980

[52] Telegram from the Secretary of State to the Viceroy in India, dated August 6, 1916, No. 14, Serial No. 8, Government of India, Proceedings of the Department of Revenue and Agriculture for August 1916, IOR, GOI, Proc. Rev & Agr, Z/P/1980

by-passing the provincial administrators. The stationing of W A Davis at Pusa was also supposed to ensure a close liaison through the Agricultural Adviser who also had his office there. The Viceroy in India did not have any problems with that arrangement. He approved the arrangement. [53]

The planters proposed L J Harington to be the planter representative on the Indigo Committee in England. The name of another member, T Martin Macdonald, was proposed as a standby. An "Indigo Committee and Paste Committee" was also formed within the Bihar Planters' Association to coordinate efforts with the Indigo Committee in England. Thus the stage was finally set for the conduct of next round of experiments on natural indigo. [54]

New Experiments And New Results, 1916-17

W A Davis, The Indigo Paste, And Its Marketing

Indigo Research Chemist W A Davis achieved considerable progress toward the making of indigo paste during the 1916-17 manufacturing season. In a letter of November 1916 the Agricultural Adviser pointed out, "Mr. Davis has been able to demonstrate the possibility of making a paste."[55] There remained some work on bringing the consistency

[53] Telegram from the Viceroy to the Secretary of State, dated August 9, 1916, No. 16, Serial No. 10, Government of India, Proceedings of the Department of Revenue and Agriculture for August 1916, IOR, GOI, Proc. Rev & Agr, Z/P/1980

[54] Telegram from Viceroy to the Secretary of State, dated August 25, 1916, No. 17, Serial No. 11, Government of India, Proceedings of the Department of Revenue and Agriculture for August 1916, IOR, GOI, Proc. Rev & Agr, Z/P/1980

[55] Letter from J MacKenna to Secretary, Revenue and Agriculture, Government of India, dated November 8, 1916, letter no. 1879, No. 4, Serial No. 3, File No. 191 of 1916, Government of India, Proceedings of the Department of Revenue and Agriculture for June 1917, IOR, GOI, Proc. Rev & Agr, Z/P/1981

to an exact 20%. There were also problems of fermentation in consignments. But the basic path to the making of the paste had been demonstrated. The Bihar Planters' Association also appeared optimistic. Analyzing the progress made by Davis until then they saw "no insuperable difficulty in producing a paste of 20 per cent indigotin."

In a follow up communication Davis explained the procedures he had followed for making the standardized paste. The natural dye contained 15-20% indigo *glutten* and another 15-20% indigo-brown. Davis removed the former by boiling with dilute acid and the latter by boiling with alkali (caustic soda). By successive boiling with the acid and the alkali a dye of 90% consistency was obtained. There was yet another impurity, the isomer *indirubin* present in the dye. Its removal required the use of complex procedures that would be impractical to implement on an industrial scale. The amount of *indirubin* in the dye produced in Bihar was anyway negligible and thus Davis decided to ignore its presence. Davis was confident that a paste containing 35% color could be fabricated for sending to England. [56]

Davis also suggested the de-centralized manufacturing and standardizing of indigo paste at separate factories. He dropped the previous idea of a "Central Factory" as proposed in particular by Armstrong . The distance between the individual factories and the state of the transportation system in Bihar would make consigning and bulking too difficult a task. The Indigo Chemist instead suggested that standardizing should take place "factory by factory." That would of course involve employing analytical assistants at the different factories who would monitor that 20% consistency was maintained in the

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[56] Letter from J MacKenna, Agricultural Adviser to L J Kershaw at India House, dated May 18, 1917, No. C-50, enclosure, No. 108, Bihar Planters' Association Limited, No. 36, Government of India, Proceedings of the Department of Revenue and Agriculture for June 1917, IOR, GOI, Proc. Rev & Agr, Z/P/1981

daily output at individual factories. But this was considered to be a less challenging task than bulking. Possibly the training of native hands in the task of analysis might have solved the problem of technical manpower in the numerous factories. The engagement of the natives at subordinate levels of the scientific establishment had anyway become a common practice by now. [57]

Very soon, however, a new perspective began to emerge independently in India and England that favored making of the standardized paste in England. The immediate impetus for this, at least among the planters in India, was the high freight costs prevailing on account of the War. The BPA passed a resolution highlighting the higher cost incurred on freight for the 20% paste as against the cake that had a dye content of about 60%. In the case of paste the freight charges went up simply because the weight of the consignment went up three times for an equivalent amount of the dye. The planters therefore wanted the London Committee to explore the prospects of making the paste in England out of cakes sent from India. The BPA secretary wrote to the planter member on the Indigo Committee in England L T Harington in this regard. [58]

The proposal was put before the London committee that in turn "unanimously" favored the route of standardizing the natural dye in the metropolis. In a personal communication to the General Secretary of BPA, Harington seconded the latter's views on the matter, saying that undertaking the standardizing work in England offered many

[57] Letter from J MacKenna to Secretary, Revenue and Agriculture, Government of India, dated November 8, 1916, letter no. 1879, No. 4, Serial No. 3, File No. 191 of 1916, Government of India, Proceedings of the Department of Revenue and Agriculture for June 1917, IOR, GOI, Proc. Rev & Agr, Z/P/1981

[58] Letter from J M Wilson to L T Harington, dated December 6, 1916, No. 109, No. 36, Government of India, Proceedings of the Department of Revenue and Agriculture for August 1917, IOR, GOI, Proc. Rev & Agr, Z/P/1981

advantages. It would save the higher cost of packing the paste and of freight. Additionally, the new scheme would allow those responsible for the final processing in England to keep in close touch with the consumers locally and make the product to customer specifications. Salesmen could also be hired to travel among the dyers and printers. [59]

Harington also warned that the planters must expedite the work on the making of natural indigo paste. The Levinstein family, who had a long association with the business of dyes, had taken over the previous MLB factory at Ellesmere Port Works. They soon planned to turn out 1,000 tons of synthetic indigo paste of 20% concentration at the sequestered factory. The output in the short-term from the English sources was not going to be considerable. But slowly they were likely to augment supplies. The Swiss and the French sources were also likely to very soon begin sending synthetic indigo into the British markets. Therefore the planters needed to make their mark in the British markets before other synthetic producers established their dominance.

Another letter followed from the Indigo Committee in London that detailed the plans in order to expedite the production of a standardized paste in England. It involved the establishment of a "Home Syndicate" in England. The planters were to send the assortment of indigo to England. They would be paid individually according to the quality of their consignment. The home syndicate would oversee the making of paste to

[59] Letter from L T Harington to J M Wilson, dated March 26, 1917, No. 36, Government of India, Proceedings of the Department of Revenue and Agriculture for August 1917, IOR, GOI, Proc. Rev & Agr, Z/P/1981

specifications. The London Committee recommended that the planters immediately subscribe funds for the steps to be taken towards the setting up of the syndicate [60]

The response from the planters was very positive. They immediately collected the funds for meeting the expenses of the work to be done by the proposed Indigo Paste Committee in England. They nominated three members to serve on the organization. One was L T Harington who was already serving on the erstwhile Indigo Committee formed by the Secretary of State. The other two were George Macdonald and T Martin Macdonald. [61] Later Sir George Sutherland of the Calcutta-based Moran Company was added. The actual scientific work was to be undertaken by Henry Armstrong and Reginald Brown. Brown was intentionally chosen because of his close association previously with the manufacture and marketing of *synthetic* indigo. It was thought that he could use his intimate knowledge of synthetic indigo and consumer's preference for it to improve natural indigo along the same lines.

The Re-Interpretation Of The Causes Of Wilt

Davis also contributed to the ongoing agricultural investigations. In particular he studied the incidence of wilt on the plantations. Before Davis began his duties at Pusa it was primarily the Economic Botanist Albert Howard who carried out the agricultural investigations on indigo. As discussed in the first section of this chapter, Howard had

[60] Letter from J MacKenna, Agricultural Adviser to L J Kershaw at India House, dated May 18, 1917, No. C-50, enclosure, No. 108, Bihar Planters' Association Limited, No. 36, Government of India, Proceedings of the Department of Revenue and Agriculture for June 1917, IOR, GOI, Proc. Rev & Agr, Z/P/1981

[61] Letter from J MacKenna, Agricultural Adviser to L J Kershaw at India House, dated May 18, 1917, No. C-50, Government of India, Proceedings of the Department of Revenue and Agriculture for June 1917, IOR, GOI, Proc. Rev & Agr, Z/P/1981

achieved some success in overcoming the problem of wilt. He had succeeded in growing Java seeds through August cropping. That had solved the immediate problem of dwindling supplies of Java seeds.

But Howard had not been able to solve the problem of wilt in plants grown for harvesting of leaves as opposed to those grown for seeds. Wilt usually attacked the plant before the time of *khoontie* or the second harvest. Howard's solution had largely been to promote the cultivation of fast-growing varieties with characteristically shallow roots that gave maximum output in the early stages before succumbing to wilt by the time the plant would ordinarily give the second harvest. Davis considered the eradication of wilt to be an important instrument in meeting the competition from synthetic. Removing wilt offered the chance to increase yield through a second harvest.

As Davis analyzed the causes of wilt and made efforts to overcome its occurrence, he offered a radically different explanation for the onset of wilt in the indigo crops of Bihar. [62] Davis claimed that wilt was connected with the deficiency of "available" phosphates in the soil, especially deeper in the ground. He defined available phosphate as that component of phosphates in the soil that could be dissolved in the carbolic acid produced by the bacteria in indigo nodules and was thus "available" to the plant, as against the phosphate that could not be dissolved and therefore whose presence was irrelevant to the growth of the plant.

Davis warned that unless the soils of Bihar were immediately supplemented by adding super phosphates the future of the indigo industry was doomed. While the alluvial plains of Bihar had some amount of "available" phosphates in the topsoil, the lower part

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[62] W A Davis, *A Study of the Indigo Soils of Bihar: The urgent necessity of immediate phosphate manuring if crops are to be maintained*. (Calcutta: Agricultural Research Institute, 1918): 1-77

was absolutely deficient. Indigo, especially Java indigo, possessed deep roots. The young plant showed normal growth as it kept using whatever little amount of phosphates were found towards the upper portion of the soil. But by the time the roots grew six inches or more they ran into that portion of the sub soil that was totally deficient in phosphates. The growth of the plant then suffered.

Davis countered Howard's claim that the onset of wilt was connected with waterlogged conditions and the resultant unavailability of air in the sub soil for the proper functioning of bacteria. In a trial in three fields in three different locations he monitored the growth of the plants (see Table 8.2 below). In the three plots the soil was well drained and there was practically no water logging. In the case of one of them, the Dholi field, the soil had actually been mixed with *thikara* in order to further improve its aeration.

Table 8.2
Trial to ascertain the effect of phosphate deficiency on the growth of indigo plants

	Dholi Field No. f	Turkowliah Field No. 4	Byreah Field No. 1
Available phosphate in top 6 inches	0.00154%	0.0012%	0.0050%
Available phosphate in 6-12 inches from the top	0.0004%	0.0003%	0.0014%
Available phosphate from 1-3 feet from the top	Nil	0.0003%	0.0002%

Source: W A Davis, *A Study of the Indigo Soils of Bihar*

Also, the three fields did not lack in any other nutrient in significant amounts except for phosphates. In all three cases the plants grew exceedingly well till they reached a height of about 12-18 inches. Finally the crops in all three experimental plots wilted. and died. Davis explained that crop failure in these trials was the direct result of a deficiency of soils in phosphates especially at the deeper levels. [63]

Davis also collected evidence from different plantations to prove that wilt was not caused by water logging, but rather by phosphate deficiency. He had evidence for this from Jorhat, Assam. The plantation at Jorhat had received 90 inches of rainfall during the season. One-sixth of the land was waterlogged for three weeks. Even May and June, usually the pre-monsoon months without rains, were not dry. Yet indigo grew well on this plantation. More evidence came from Jalpaiguri also in Assam. The plantation had sandy, black soil that normally remained "badly waterlogged" for three months every year. The annual rainfall in the area in the current season was 150 inches as against the average 40-50 inches in Bihar. The plants on this estate grew well to give an excellent *khoontie* crop despite the water logging. This was quite unusual given the general pattern of the destruction of *khoontie* in Bihar. J M Wilson, the General Secretary of Bihar Planters' Association, visited the Jalpaiguri estate to witness and report on this plantation. The planters wanted to see for themselves if the news of successful *khoontie* was accurate, and if there were any lessons to be drawn from Jalpaiguri. Wilson confirmed the good health of the plants and a successful *khoontie* harvest. He brought back samples of soil from the plot so that Davis could examine them.

On testing the soil Davis found out that the Assam soil overall had up to 200 times the amount of available phosphate as compared with Bihar. The sub-soil had up to 1,000 times more phosphate than in Bihar. This re-confirmed what Davis had long

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[63] W A Davis, *A Study of the Indigo Soils of Bihar: The urgent necessity of immediate phosphate manuring if crops are to be maintained.* (Calcutta: Agricultural Research Institute, 1918): 7-8

maintained – that wilt was the result of soil depletion and not waterlogged conditions. Davis also disclosed that two-thirds of soils tested by him in Bihar to date were found deficient, containing between 0.002 to 0.001 percent phosphates. He used this statistic to underscore his thesis that wilt was caused by mineral deficiency. [64]

Davis explained that the soil in Bihar had been progressively depleted. Bihar had traditionally grown shallow root crops in the past that consumed the phosphates in the upper levels of the soil. When Java was introduced into Bihar in 1903 it did well during the first few years. Its deep roots could tap the available phosphates in the sub soil that had never been used before. But after a few years the stock of nutrients was exhausted. These minerals had not been replaced through the use of fertilizers. Davis recommended an immediate use of super phosphates during the rainy season so that they could be drained down. But at the same time he also warned that the rate of recovery would be very slow for these depleted soils. This was because it took a long time for the phosphates to descend to the lowest levels.

Davis' claims on the cause of wilt generated a fresh controversy. He had disturbed the picture painted by Howard earlier who had attributed wilt to waterlogged conditions. The planters were predictably confused. In an important meeting of their association they noted the 'sharp divergence of opinion" between the two experts over what caused the onset of wilt and the possible methods for its elimination. [65] The

[64] W A Davis, *A Study of the Indigo Soils of Bihar: The urgent necessity of immediate phosphate manuring if crops are to be maintained*. (Calcutta: Agricultural Research Institute, 1918): 13, 17-19

[65] Letter from J MacKenna to Secretary, Revenue and Agriculture, Government of India, dated December 8, 1916, letter no. 315-C, No. 7, Serial No. 6, Government of India, Proceedings of the Department of Revenue and Agriculture for June 1917, IOR, GOI, Proc. Rev & Agr, Z/P/1981

deadlock over this issue was never really resolved even as wilt continued to ravage the second harvest in Bihar.

Davis And Hutchinson On Steeping

Davis also favored the improvement of the manufacturing processes. Like many experts before him, he too believed that the efficiency of the production processes in use currently in India was low. In his estimate the efficiency was a mere 50%.

According to Davis the problem lay in the steeping stage of manufacture. The solution according to him was in controlling the presence of bacteria and the conditions in the vat to catalyze the appropriate type of fermentation. Firstly *indican* was not getting extracted fully from the leaves. Secondly some of the color-giving body was getting dissipated in the fermentation vat. In order to devise a way to regulate fermentation the scientist collaborated with the new Imperial Bacteriologist at Pusa - C M Hutchinson. [66] Indeed the improvement of the fermentation processes turned out to be the most promising line of investigation between 1916 and 1920 and were those in which the planters and their experts had maximum hopes.

Incidentally in 1903 Cyril Begtheil had also considered the option of "artificial regulation" of microorganisms in the steeping vat in order to improve the yield of color. His plan was to kill all the bacteria present with the help of disinfectants and then to induce fermentation with especially cultured bacteria. The task of culturing appropriate strains of bacteria at that time proved formidable and was given up. The experts at Pusa *now* wanted to follow up those threads. Pusa was a more resourceful organization. It had

[66] Scientific Reports of the ARI, *1916-17*. (Calcutta: Agricultural Research Institute, 1917), India Office Records, IOR/V/24/17

a larger budget for scientific research and a complete team of numerous experts including a chemist, mycologist, bacteriologist, entomologist, economic botanist etc. At Pusa, it seemed more plausible now that the pursuit of the bacteriological line might produce results. In a way, research had come full circle and attention was again focused on the fermentation stage of indigo manufacturing.

Davis and Hutchinson foresaw two major problems: (a) that the *indican* was incompletely extracted from the leaves, and (b) that the hydrolysis of *indican* was inappropriately performed. There was an alternative: extract the color principle from the leaves with hot water. But the procurement of hot water on a large-scale was still considered prohibitive due to the high costs involved. Thus the fermentation route had to be persisted with for the time being. [67]

To overcome the impediments connected with the hydrolyzing of *indican* the experts thought of developing an appropriate strain of bacteria. Davis found that a connection existed between fermentation in an acidic environment and higher output. Along with Hutchinson, he hoped to isolate a bacterium that would combine an acid-producing power with the power to hydrolyze. Working towards that goal numerous strains of bacteria were isolated. They were cataloged according to their power of hydrolyzing. [68]

Further trials were required before the procedures for output enhancement from the fermentation tank could be finalized for adoption. According to the annual scientific report published from Pusa the experts were far from the stage where they could claim

[67] *Scientific Reports of the ARI, 1916-17*. (Calcutta: Agricultural Research Institute, 1917): 108-109, India Office Records, IOR/V/24/17

[68] *Scientific Reports of the ARI, 1916-17*. (Calcutta: Agricultural Research Institute, 1917): 109-110, India Office Records, IOR/V/24/17

that they had the means to control bacterial action in the fermentation vats. The biggest challenge was to make the laboratory processes replicate on a factory scale. [69] But the planters were hopeful that further experiments on fermentation would provide positive results. The Agricultural Adviser in a letter of December 1916 quoted the planters as saying that numerous bacteriological questions connected with fermentation deserved further detailed investigations. In a latter of March 1917 Harington, the planter-member on the London Indigo Committee, expressed great faith in the ongoing fermentation experiments by Hutchinson and Davis at Pusa. [70]

New Challenges For Science And Its Organization, 1917-18

Carrying Research Forward: Different Perspectives

A novel idea that the indigo experiments should be financed through the imposition of an export duty on indigo was born during this period. Since the beginning of indigo experiments in India in 1898, the planters in Bengal/Bihar and the government had provided all the funds for the conduct of indigo experiments. The Bengal Government had largely supplied the government's share until 1913 after which the imperial government took over the responsibility for the experiments out of central funds at Pusa.

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[69] *Scientific Reports of the ARI, 1916-17*. (Calcutta: Agricultural Research Institute, 1917): 110, India Office Records, IOR/V/24/17

[70] Letter from J MacKenna to Secretary, Revenue and Agriculture, Government of India, dated December 8, 1916, letter no. 315-C, No. 7, Serial No. 6, Government of India, Proceedings of the Department of Revenue and Agriculture for June 1917, IOR, GOI, Proc. Rev & Agr, Z/P/1981; Letter from L T Harington to J M Wilson, dated March 26, 1917, No. 36, Government of India, Proceedings of the Department of Revenue and Agriculture for August 1917, IOR, GOI, Proc. Rev & Agr, Z/P/1981

The demand for the imposition of a duty on indigo first came from the indigo planters in Bihar. At their meeting held towards the end of 1916 the members of the BPA passed a resolution recommending that a duty of Rupees 1 should be imposed on every *maund* of indigo shipped out of the Indian ports. They asked the government to legislate the imposition of the duty. They also wanted the government to be responsible for the collection of the duty. Then after setting aside the amount spent on its collection the rest of the money could be made available for the indigo experiments. D J Reid, the Chairman of BPA, calculated that at the present level of exports from India Rs. 70,000-75,000 could be collected through the duty. If up to Rs. 10,000 was left as charges for its collection then Rs. 60-65,000 could be utilized for the experiments. The Chairman disclosed that the planters hoped to pay the salaries of the experts through this amount. The Indigo Research Chemist would receive up to Rs. 40,000. The planters also wanted to employ a new botanist to specifically work on improving the *indican* content of the leaves. The botanist would also receive his salary of about Rs. 30,000 out of the collected funds. [71] The size of funds would be further enlarged if the exports increased, as it seemed they would.

The planters reasoned that new realities had emerged, which required that the indigo planters in the other parts of the country also contribute towards the indigo experiments. The cultivation of indigo had gradually spread to the other provinces. Especially in Madras, United provinces, and Punjab the expansion of indigo cultivation

[71] Letter from J MacKenna to Secretary, Revenue and Agriculture, Government of India, dated December 8, 1916, letter no. 315-C, No. 7, Serial No. 6, Government of India, Proceedings of the Department of Revenue and Agriculture for June 1917, IOR, GOI, Proc. Rev & Agr, Z/P/1981; It may also be mentioned that there was a growing sense of disenchantment among the planters with regard to the selection work of the present Economic Botanist Albert Howard. The planters instead wanted a new botanist to work on improving the color in the leaves through the application of manures and by controlling other conditions of plant growth.

had been rapid. In terms of acreage Bihar no longer occupied the first position. The annual figures for 1916-17 showed that Bihar and Orissa had 76,000 acres of land under indigo while Madras and United Provinces had 344,300 and 150,300 acres under indigo respectively. Of course in terms of quality and value of indigo exported the province of Bengal still enjoyed preeminence. But since the other provinces had bridged the gap with Bihar in terms of indigo value, the planters in Bihar wanted them to share the burden of scientific research to improve the farming and manufacturing of indigo. [72]

The idea of imposing a tax on the export of indigo was well received by the administrators. It seemed a step in the direction of the organization of the planters on an industry wide scale. It was an attempt by the planters to self-finance their experiments. The bureaucrats were more than willing to act as facilitators. They initiated steps to forge consensus among the indigo planters and traders across the country on the issue. They dispatched letters to the concerned provinces and to the Bengal Chamber of Commerce telling them of the new levy that was intended to fund scientific experiments on indigo. They declared themselves to be in favor of the levy. And they wanted to be informed as to what the other indigo producers and sellers across the country thought of the measure. In case there was agreement in principle over the levy the central government also wanted to be advised as to the form which the indigo interests wanted it to take– as a fixed duty or as an *ad valorem* tax.[73]

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[72] Letter from J MacKenna to Secretary, Revenue and Agriculture, Government of India, dated December 8, 1916, letter no. 315-C, No. 7, Serial No. 6, Government of India, Proceedings of the Department of Revenue and Agriculture for June 1917, IOR, GOI, Proc. Rev & Agr, Z/P/1981

[73] Letter from the Secretary, Revenue and Agriculture, Government of India to Secretaries of Madras, Bombay, Bengal, United Provinces, Bengal, Bihar and Orissa, dated January 9, 1917, No. 99C, No. 9, Serial No. 8, Government of India, Proceedings of the Department of Revenue and Agriculture for June 1917, IOR, GOI, Proc. Rev & Agr, Z/P/1981

The governments of Bihar and Orissa, Bengal, Punjab, and the United Provinces agreed in principle that a duty should be imposed. The Bengal Chamber of Commerce also agreed with the proposal, but added that the incidence of the tax should fall on the producers and not the traders. However, the government in Madras had reservations. They wondered what benefit such a payment would bring to the small-scale cultivators in their province. Natives undertook indigo manufacturing in Madras. These producers worked independently and their farms were located in isolated pockets leaving minimum chance of coordination between them. They employed primitive techniques of cultivation and production and the indigo produced by them was predictably of an inferior quality that fetched a low price in the market. In such a situation the Madras bureaucrats did not see a real chance of promoting better techniques of farming and manufacturing among the natives even if such methods were devised through scientific research. The situation was different in Bengal where the European planters who were relatively well organized controlled large plantations. The undertaking of scientific measures to improve production was more possible in Bihar. They would be the likely beneficiaries of the results of scientific research and therefore the Madras administrators argued that they should alone pay for them. [74]

The central government was not going to let Madras off the hook. They were ready to go the extra distance in persuading the Madras officials and fostering organization in the industry. More letters were sent to Madras. Finally, the administrators

[74] Letter from Secretary, Revenue, Madras to Secretary, Revenue and Agriculture, Government of India, dated February 10, 1917, letter no. 40, No. 17, Serial No. 16, Government of India, Proceedings of the Department of Revenue and Agriculture for June 1917, IOR, GOI, Proc. Rev & Agr, Z/P/1981

in Madras agreed to the proposal. They demanded that in the new plans special consideration be given to address "Madras conditions and problems." [75]

The letter sent to London requesting the approval of the Indigo Cess clarified not only the consensus built on the issue of imposing a duty for carrying forward indigo experiments, but also brought into relief the different elements of the experiments that were being planned. [76] The Viceroy's letter expressed satisfaction over the fact that the proposal would enable the indigo planters themselves to pay for part of the experiments being conducted for their benefit. This would justify the expenditure on indigo experiments made by the government out of money belonging to "the general tax payer."

The letter broadly delineated the directions in which the funds collected through the cess would support scientific pursuits. Part of the funds was to go towards providing the salaries for the chemist Davis, the bacteriologist Hutchinson, and the economic botanist Howard, all of whom were at Pusa. Thus a broad continuity in the experiments from the previous years was being envisaged. In addition, it was planned to employ a new botanist. This new specialist was expected to work specifically on improving the *indican* in the leaves through the application of manures and by controlling other conditions of plant growth. This work was considered beyond the remit of the current economic botanist. Lastly, a portion of the funds to be collected was earmarked specifically to study

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[75] Letter from F J Richards, Deputy Secretary, Revenue Department, Government of Madras to Secretary, Revenue and Agriculture, Government of India, dated April 2, 1917, letter no. 591 F-17-1, File No. 191 of 1916, No. 35, Serial No. 27, Government of India, Proceedings of the Department of Revenue and Agriculture for August 1917, IOR, GOI, Proc. Rev & Agr, Z/P/1981

[76] Letter to the Secretary of State, dated August 3, 1917, No. 7 of 1917, No. 37, Serial No. 29, Government of India, Proceedings of the Department of Revenue and Agriculture for August 1917, IOR, GOI, Proc. Rev & Agr, Z/P/1981

conditions of the indigo industry in Madras. The regional administrators from Madras had succeeded in having this special clause on Madras inserted. [77]

The Experiments During 1917-18

The experiments to improve indigo continued at a certain pace on several fronts during the year. But the mood overall was somber. The agricultural experts did not devise anything that could drastically alter the prospects of natural indigo. The manufacturing experiments on steeping moved forward and then finally hit a ceiling leaving the experts clueless as to what their next steps were going to be. The trials on making natural indigo paste in England were successful. But the natural paste faced a new challenge from an unexpected quarter – the synthetic indigo now manufactured by the Levinstein family in England.

Albert Howard at Pusa continued the agricultural line of query as before. Much of his focus was on Java indigo. He expanded on his findings of the previous years. The growing of Java seeds was undertaken on a larger scale. Howard also studied soil conditions and other conditions of plant growth in order to understand the ways to stimulate a larger harvest of leaves from the Java plant. [78]

The plans to employ a botanist to complement Howard's work in the field did not materialize. By the summer of the next year one had still not become available. The exact reason for the failure of this search is not mentioned in the sources. But getting an expert

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[77] Letter to the Secretary of State, dated August 3, 1917, No. 7 of 1917, No. 37, Serial No. 29, Government of India, Proceedings of the Department of Revenue and Agriculture for August 1917, IOR, GOI, Proc. Rev & Agr, Z/P/1981

[78] "Report of the Imperial Economic Botanist," *Scientific Report of the ARI, 1917-18*. (Calcutta: Agricultural Research Institute, 1918): 43-47, India Office Records, IOR/V/24/17

from England was always a relatively difficult task. It always required more effort and cost additional time and money. Usually the colonial administrators in India tried to hire someone from the pool of European experts already available within the cadre of the Indian Agricultural Services. But on this occasion the planters wanted a "full time" botanist who would be versatile in the latest knowledge emerging in the field of botany. Such an expert was probably not available in India. In the end the administrators were unable to hire a qualified botanist in the home country and have him or her sent to India. The endless delay frustrated the planters. They put the plan on hold, declaring, in a meeting of the Bihar Planters' Association on May 17, 1918, "the question of indigo yield in the plant will be again studied [later]." [79]

The planters also invested efforts along chemical/bacteriological lines. They were solidly behind chemist W A Davis. They looked at his work performed on the making of the indigo paste, on wilt, and on steeping with favor. They recommended that Davis's tenure at Pusa be extended for a further period of "at least five years." The Agricultural Adviser, J MacKenna, wanted to retain Davis at all costs. He argued that having "an officer of Mr. Davis' age and standing in the chemical world" would be advantageous anyway regardless of his contributions to the indigo experiments. The scientist was an asset to the imperial agricultural department. He would be extremely valuable in the development of commercial agricultural chemistry in the colony when new opportunities

[79] No. 99, "Bihar Planters' Association Ltd., An informal meeting of the Board of Directors of the Bihar Planters' Association," Government of India, Proceedings of the Department of Revenue and Agriculture for March 1919, IOR, GOI, Proc. Rev & Agr, Z/P/1983

presented themselves at the end of the War. In the light of the forceful demand for the retention of W A Davis the government extended his tenure for another three years. [80]

In fact, the collaboration between Davis and Hutchinson on the improvement of the steeping processes turned out to be the direction in which most work was performed at Pusa during 1917-18. [81]The experts followed the basic approach of controlling the character of the bacterial flora in the steeping vats. Davis made numerous analyses using the persulfate and isatin methods to determine the content of *indican, indoxyl,* and *indigotin* before and after the inoculation with bacteria. Hutchinson focused efforts on the mass culture of appropriate bacteria and on the processes of removal of unwanted microorganisms and inoculation with appropriate strains of bacteria.

Hutchinson experimented to determine the best ways for the mass culture of bacteria. He wanted to devise a way to produce sufficient number of bacteria that would ferment 6,000-10,000 gallons of water in the steeping vat, the usual quantity processed at an average sized factory on a daily basis. He successfully prepared a medium with ammonium sulfate, super phosphate, wood ash, and sugar. One gallon of this culture after six hours' incubation sufficed to induce fermentation in 1,000 gallons of water in the steeping vat. However, the optimum functioning of the artificial inoculums continued to be interfered with. There were problems with maintaining optimum temperature of the

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[80] J MacKenna's letter to Secretary, Revenue and Agriculture, Government of India, dated February 16, 1917, letter no. 3739, No. 22, Serial No. 21; Telegram from Secretary, Revenue and Agriculture, Government of India to the Agricultural Adviser, dated February 21, 1917, telegram no. 247-C, No. 23, Serial No. 22, Government of India, Proceedings of the Department of Revenue and Agriculture for June 1917, IOR, GOI, Proc. Rev & Agr, Z/P/1981

[81] "Report of the Imperial Agricultural Bacteriologist," *Scientific Report of the ARI, 1917-18.* (Calcutta: Agricultural Research Institute, 1918): 123-131, India Office Records, IOR/V/24/17

steeping liquor. But the trickiest problem lay with the activities of other "destructive" bacteria that more than offset the positive effects of the addition of appropriate bacteria.[82]

The biggest problem that defied solution was to get rid of the undesirable bacteria from the water, especially when a large amount of water was being processed on a factory scale. The two sources of these bacteria were identified as the water from *khazana* (reservoir) that supplied the steeping vats and the plant itself. Bacteria from the latter source were not that big a hazard. The leaves generally had a relatively small number of microorganisms. If the artificial inoculation was made quickly in the steeping vat, the effects of microorganisms present on the leaves could be very well countered. To rid the water of pre-existing bacteria a practical solution seemed to be the of use large reservoirs. If steeping water was stored in large tanks for some time much of the bacteria settled to the bottom along with other sedimentation. But this was only a partial solution. Not all of the harmful bacteria could be removed with this process. The experts struggled to overcome this problem of the presence of undesirable bacteria, but without immediate success. [83]

Natural Indigo Paste – The Challenge Of Levinstein Indigo And Fluctuating Agricultural Productivity

The Indigo Paste Committee in London proved adequate to the task of preparing standardized indigo paste of 20% concentration. Henry Armstrong and Reginald Brown

[82] "Report of the Imperial Agricultural Bacteriologist," *Scientific Report of the ARI, 1917-18*. (Calcutta: Agricultural Research Institute, 1918): 129-130
[83] "Report of the Imperial Agricultural Bacteriologist," *Scientific Report of the ARI, 1917-18.* (Calcutta: Agricultural Research Institute, 1918): 127-129

claimed that they had overcome all difficulties in the way of making "a standard and stable" paste.[84]

The first lot of natural indigo paste had been sent to several dyers who had expressed complete satisfaction with its quality. In fact, for dyeing loose wool in heavy shades, the natural paste was found superior to the English synthetic indigo. The War Office had ordered ten thousand pounds of natural indigo paste from the Indigo Paste Committee. Accordingly orders had been placed for the supply of 200 chests of natural indigo from India. It was planned to pay the owners of cake indigo after selling the paste and deducting the working costs.

The Indigo Paste Committee expressed confidence about the prospects of the natural indigo paste in the English market. The prevailing Calcutta rates for natural indigo were reasonable. If the consignment made its way to England the paste formed out of it could easily compete with the synthetic indigo supplied by Levinstein and Company in England. The English company was selling synthetic indigo (20% by weight) currently at a price between 2s. 3d. to 2s. 9d. The natural could be offered at a competitive price of 6s. (60% by weight) to the consumers.

The task of making paste having been completed, the chemists led by Henry Armstrong in London embarked on a new project of making "reduced indigo." Just before the War started the German manufacturers of synthetic indigo had begun supplying their indigo in a "reduced" form. The reduced indigo could be directly utilized in the vats as opposed to the previous form that had to be reduced with acids by the dyers

[84] MacKenna's letter to Secretary, Revenue and Agriculture, Government of India, dated August 10, 1918, letter no. C-199, No. 18, Serial No. 15, File No. 92 of 1918, Government of India, Proceedings of the Department of Revenue and Agriculture for March 1919, IOR, GOI, Proc. Rev & Agr, Z/P/1983

before dipping the fabric. It was thought that the new generation of synthetic indigo would indeed be presented to the consumers in this form, and therefore that the natural paste should also be offered in a similar, conveniently-usable form. There was another advantage in preparing reduced indigo. The process of making reduced indigo would impart further purity to the natural dye. This was crucial because that would help in capturing the market of cotton printing. The cotton printers were particularly wary of impurities in the natural dye. The market of cotton dyeing and printing was indeed the largest segment of the market for the blue dye. Additional funds were being demanded for the experiments towards making reduced indigo. These would pay the costs of chemicals and the fees for Henry Armstrong and a new chemist who was employed on a temporary basis, a Mr Robertson. [85]

The planters in India were broadly appreciative of the work done by the Indigo Paste Committee in London and were also supportive of the committee's new efforts to produce "reduced" indigo. They did make certain suggestions regarding the "stabilization" of the indigo paste. An important aspect of the packaging of the natural paste was its sterilization by chemicals. Poor sterilization caused the onset of anaerobic fermentation even while the consignment was in transit. There were some reports to the effect that the sterilizing chemical used in the natural paste was not very effective at temperatures above 90 F. The temperature during the manufacturing season in India was generally above this. The planters wanted to be assured that the chemical recommended by the chemists in England would hold good in the Indian temperatures. The second

[85] J MacKenna's letter to Secretary, Revenue and Agriculture, Government of India, dated August 10, 1918, letter no. C-199, No. 18, Serial No. 15, File No. 92 of 1918, Government of India, Proceedings of the Department of Revenue and Agriculture for March 1919, IOR, GOI, Proc. Rev & Agr, Z/P/1983

concern of the planters was related to the markets in China. There was a general consensus that the eastern markets would turn out to be the largest consumers of indigo in the near future. The planters once again wanted the chemists to confirm that the chemicals used as preservatives in the paste would not interfere with the dyeing process in the "fermentation vats" that were in use in China. The dyers in England had used and recommended the paste made available to them. But the dyers in the West generally used "chemical vats." The planters wondered if the chemicals would also be conducive to dyeing in the fermentation vats in China. [86]

But the biggest problem pointed out by the planters related to bad crops in the season and the inflation in the price of natural indigo. Due to the destruction of the indigo crop during the year the price of natural indigo in India had suddenly risen to Rupees 420 a *maund.* If cake were purchased at that price, the paste made out of it would be uncompetitive with the synthetic's price in the market. Much of the paste would have to be sold at a loss. This situation was a true eye-opener in the sense that it revealed the kind of problems that the natural indigo producers would continue to face in the future. The plantations in India were subject to the vagaries of nature. Insufficient, overabundant, or untimely rains as well as seasonal temperatures could potentially harm the harvest. Every time the crop was destroyed the lack of supply would force up the price of natural indigo. Inconsistency in agricultural output would forever threaten the market prospects of the

[86] Letter from J M Wilson, Secretary, BPA to J MacKenna, Agricultural Adviser, dated December 6, 1918, Government of India, Proceedings of the Department of Revenue and Agriculture for March 1919, IOR, GOI, Proc. Rev & Agr, Z/P/1983

natural paste despite the fact that the making of the paste had been successfully demonstrated. [87]

Funding Indigo Experiments –The Government Clarifies Its Position To The Planters

The Indigo Cess Act III of 1918 came into effect from April 1, 1918. The act mandated the imposition of a duty of Rupees 1 on every *maund* of indigo exported from any of the Indian ports in British India, as well as from the ports in the princely states of Travancore, Cochin, and Kathiawar. [88]The legislation was sweeping in its coverage. It had subjected all the indigo produced and exported from British India to a duty in order to pool funds for the conduct of scientific experiments on indigo.

Some debates arose on the matter of utilization of the proceeds from the cess. The planters and the government had different opinions as to how those funds should be utilized. These debates provide a window on the perspective of the planters and the government on indigo experiments and its organization.

Following the promulgation of the Indigo Cess Act the Board of Directors of the Bihar Planters' Association had met in May 1918 to formulate their recommendations on the nature of future scientific endeavors on indigo. Among other things they proposed that the expenses of the London India Committee (including the Paste Committee) should be a charge on the funds collected under the new law. They argued that much of the work being performed in London was of an "experimental" nature and therefore should

[87] Letter from J M Wilson, Secretary, BPA to J MacKenna, Agricultural Adviser, dated December 6, 1918, Government of India, Proceedings of the Department of Revenue and Agriculture for March 1919, IOR, GOI, Proc. Rev & Agr, Z/P/1983

[88] Notification, Government of India, Proceedings of the Department of Commerce and Industry for the month of June 1918, Nos. 1-6, India Office Records.

rightfully be financed through the cess. [89]The planters passed another resolution in a subsequent meeting of the association in July 1918 in which they demanded that the salary of the Indigo Chemist should continue to be borne by the government. Looking at the current level of exports from India, the total amount collected under the Act was not going to be considerable. Therefore the planters requested that the cess amount should be freed up for other projects on indigo improvement. Additionally, they demanded that the efforts of the Paste Committee on "marketing" should also be a charge on the cess. The Agricultural Adviser supported such a demand. He said," I would strongly recommend that the cost of the experimental work and trade propaganda be taken over by the cess." [90]

The expenses under the head of "trade propaganda" referred to the money spent in persuading the dyers in England to buy the natural indigo paste. The Paste Committee had kept in close contact with the dyers as they endeavored to produce the natural indigo paste. They had aspired to produce the paste to suit the requirements of the users. Once the paste had been prepared it was sent to a large number of dyers. The latter were induced to use the natural paste and communicate how it fared. Subsequently the committee also intended to employ a commercial traveler that would liaise between the paste producers and the dyers. All this money spent on associating with the dyers was considered inseparable from the money spent on making the paste.

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[89] No. 99, "Bihar Planters' Association Ltd., An informal meeting of the Board of Directors of the Bihar Planters' Association," Government of India, Proceedings of the Department of Revenue and Agriculture for March 1919, IOR, GOI, Proc. Rev & Agr, Z/P/1983

[90] MacKenna's letter to Secretary, Revenue and Agriculture, Government of India, dated August 10, 1918, letter no. C-199, No. 18, Serial No. 15, File No. 92 of 1918, Government of India, Proceedings of the Department of Revenue and Agriculture for March 1919, IOR, GOI, Proc. Rev & Agr, Z/P/1983

The Viceroy's Council, while communicating its recommendations to the Secretary of State, responded to the issues of making the expenses related to the work of the Indigo Chemist and the Paste Committee a charge on the cess. [91]The Council rejected the request to continue meeting the entire expense of the work of Indigo Chemist from the government's own sources as before. They also took the opportunity to explain to the planters that the government expected them to pay for their experiments, and that they should no longer take government's subsidy for granted. In fact, the Council members further explained that the government had taken the initiative on the issue of cess with the motive of getting the planters organized so that they could fend for themselves. It was quite in order that they should take responsibility for their indigo experiments.

They agreed to let some of the funds be used for the experimental work by the Indigo Committee. But they turned down the proposal that any of the work undertaken for the marketing of the indigo paste among the dyers should be a charge on the cess. They took the position that the indigo cess was imposed for scientific research alone. Therefore those funds should not be used for any purpose other than research.

While the Viceroy's Council did not say anything unexpected a certain change in attitude towards the natural indigo industry is perceptible in the government's stipulations at the end of 1918. The eagerness to help the natural indigo industry that the metropolitan and imperial government had shown in 1914 was no longer there. By 1918 the government was far less sympathetic than before towards the indigo industry. It was no longer willing to do anything exceptional to promote the planters' cause. One can perhaps

[91] Letter from the Viceroy's Council to the Secretary of State, dated December 26, 1918, letter no. 10 of 1918, No. 20, Serial No. 17, Government of India, Proceedings of the Department of Revenue and Agriculture for March 1919, IOR, GOI, Proc. Rev & Agr, Z/P/1983

hazard a guess that the changed attitude had something to do with the increasing availability of synthetic indigo in Britain. [92]

Diminishing Enthusiasm For The Indigo Experiments And Their Final Stoppage

Late in 1919, as the indigo manufacturing season progressed in India from August onwards, the scientific efforts of the previous years in the laboratory and farm stations were conspicuously modest. Indeed the manufacturing/*mahai* of 1919 seems like a useful cut off point in the history of efforts to scientifically improve the natural dye in India and England. The momentum of previous years carried the different scientific projects forward for some more time. But there is no doubt that the research was running out of steam. No new initiatives were emerging to use science for "improving" the natural dye. It was only a matter of time before they would completely fold up.

[92] The overall picture looked gloomy for natural indigo in 1919. The scientific experiments had reached their limits. The government did not appear to be overly enthusiastic to support the efforts on behalf of natural indigo. Yet, even at this late hour an initiative emerged in Bihar to produce indigo paste. It was part entrepreneurial and part official. A company called Industrial Engineering Works Limited was in the process of being formed that would undertake to manufacture indigo paste for the markets in China and Japan. The company contacted W A Davis asking if he would visit China at the company's expense to collect trade information. The manufacturers were interested in knowing the form in which the consumers in the eastern markets preferred to receive the supplies of natural indigo paste. Davis was willing. But as a government official he required official permission to undertake the journey. The new Agricultural Adviser, G A D Stuart contacted the central government asking if they would give Davis a month's extra leave to visit China. The government granted permission to the Indigo Chemist to visit China on assurances from the private company that the government would share all the information that W A Davis collected on his visit. Cf.: Letter from Agricultural Adviser, G A D Stuart to Secretary, Revenue and Agriculture, Government of India, dated July 26, 1919, letter no. 370, No. 14, Serial No. 5; Letter from P C Plowden, Under-Secretary, Revenue and Agriculture, Government of India to Agricultural Adviser, dated August 25, 1919, letter no. 762, No. 15, Serial No. 6; Letter from G A D Stuart to Secretary, Revenue and Agriculture, Government of India, dated September 12, 1919, Government of India, Proceedings of the Department of Revenue and Agriculture for November 1919, IOR, GOI, Proc. Rev & Agr, Z/P/1983

There were several dimensions to this decline. The specific projects were facing insurmountable impediments. But an overriding aspect of this gradual winding down of effort was the withdrawal of the government from its role as the primary sponsor of scientific experiments. Through the course of 1918 the government had made it clear to the planters that *they* must bear the responsibility and the costs of scientific research on natural indigo. The Indigo Cess Act came into effect from April 1, 1918. By announcing that the proceeds from this duty – and *not* any public funds – were to fund the experiments, the government passed the burden onto the indigo industry. This marked a watershed. Public funds and bureaucratic initiatives had been the main vehicle promoting indigo experiments in colonial India. Bereft of that support the efforts on behalf of natural indigo simply lost their motive force, lost direction, and soon folded up.

German Dye Technology Makes Its Way To England/Allies At The End Of The World War

The renewed assault from synthetic indigo played an important role in the demise of the natural product at this time. The appropriation of the German techniques of chemicals manufacturing by the Allied powers after the War is a well-researched topic, and a territory that has been well traversed by many scholars before. [93] The Treaty of Versailles provided the official sanction for the inspection of German chemical plants and for the dismantling of "warfare chemical processes" in Germany. But the phrases used in

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[93] Ludwig F Haber, *Poisonous Cloud: Chemical Warfare in the First World War.* (Oxford, New York,: Oxford University press, 1986); Anthony S Travis et al (ed.) *Determinants in the Evolution of the European Chemical Industry, 1900-1939: New Technologies, Political Frameworks, Markets, and Companies.* (Dordrecht, Boston: Kluwer, 1998); Werner Abelshauser et al (ed), *German History and Global Enterprise: BASF, the History of a Company*. (Cambridge: Cambridge University Press, 2004)

the Treaty were intentionally vague. Articles 168- 172 of the Treaty in effect provided the victors with unrestricted access to all chemical knowledge including those for the dyes.

The initial inspections of the German chemical factories by the Allies started as early as late 1918 beginning with the Rhineland. The Hartley Mission of 1919 was followed by the commercially motivated visit by the Association of British Chemical Manufacturers to Germany in May and June of 1919. Rigorous and continuous inspection of the German chemical plants continued under the powers of the Inter-Allied Commission of Control, which was the principal facilitator of the process of transfer of technologies. The military/political control over the German territories continued up to 1927, but there is a general consensus among historians that by the early 1920s most relevant chemical technologies had already passed into the hands of England and France.

As in the case of information on many other organic and inorganic compounds, the victors also appropriated the knowledge related to the processes of indigo manufacturing. Without going into detail we can confidently affirm that henceforth Britain and France did not face any technological impediments to the manufacture of synthetic indigo; the Allies were in a position to use or disregard the indigo technologies of German origin as the need be. [94]

Some specific instances of the transfer of dye techniques are well documented and too prominent to escape notice. To give a few examples, the French extracted the

[94] As a definitive discussion of the process of technology transfer is beyond the remit of this dissertation, our analysis does not dwell on questions such as: which specific German techniques did the British and French manufacturers subsequently employ for industrial production at home? To what extent did the "German" technologies complement the technologies for making synthetic indigo in England (and France) already available since 1917? Rather this section limits itself to pointing to the post-War appropriation of German technologies as indicative of the quest for the manufacture of synthetic indigo indigenously by England and France.

dyestuffs technologies through forced licensing arrangements with BASF and I G Farben. The British members of the Inter-Allied Military Commission of Control got the technique for producing ethylene and ethylene chlorohydrine, which were very important intermediates for the manufacture of synthetic indigo. And, the mission of the Association of British Chemical Manufacturers in May-June 1919 appropriated for the British entrepreneurs the Hoechst version of the indigo process. Apart from the official pathways the knowledge related to the production of indigo also exchanged hands through espionage and bribery by individual companies as in the well publicized case when Bayer accused the English indigo manufacturers Levinsteins of commercial espionage. [95]

The Indigo Paste Committee Stops Work In London

An essential corollary of the efforts to fabricate and sell synthetic indigo in England was a corresponding decline of metropolitan interest in the future of colonial/Indian natural indigo. Indeed there are clear indications that India House in London was beginning to lose interest in the affairs of the Indigo Committee and the Paste Committee in London formed with so much fanfare previously. This lack of interest emerged over several months and the period bears an uncanny coincidence with precisely the time when the production of synthetic indigo was rising in England and synthetic indigo technologies from Germany were making their way into the country

[95] I am thankful to Prof. Jeffrey Johnson of Villanova University for pointing to specific documents and information attesting the process of transfer of indigo-manufacturing technology to the allied powers.

Matters came to such a point where colonial officials in India had to remind India House in London to take a more active interest in the affairs of the indigo committees in London. In August 1918 J MacKenna, the Agricultural Adviser to the Government of India, was exasperated with the attitude of the officials in London. He reminded them that the Paste Committee "at its inception received the benediction of Mr. Kershaw [the Revenue and Statistics Secretary at India House, L J Kershaw]." Therefore he wanted India House officials to invest more time supervising its functioning. [96] But obviously matters were not going to improve. Thus in December the Agricultural Adviser again expressed dissatisfaction with the "half official half un-official" position of the indigo committees in London. The London Committees were formed with an "official benediction," but now the officials in London were neglecting the same committees that they had helped form. He wanted the authorities in London to review the work being done by the Paste Committee more carefully and to pass more information on to India about it. [97]Needless to say, the gentle reminder from India failed to change the situation or to make India House more interested in the work of the indigo committees.

The Paste Committee members were by and large left to fend for themselves. As 1919 drew to a close the committee began direct correspondence with the planters in India. Their first priority was to negotiate an arrangement whereby the planters would

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[96] J MacKenna's letter to Secretary, Revenue and Agriculture, Government of India, dated August 10, 1918, letter no. C-199, No. 18, Serial No. 15, File No. 92 of 1918, Government of India, Proceedings of the Department of Revenue and Agriculture for March 1919, IOR, GOI, Proc. Rev & Agr, Z/P/1983

[97] Letter from J MacKenna to Secretary, Revenue and Agriculture, Government of India, dated December 7, 1918, letter no. 2234 of 1918-19, No. 19, Serial No. 16, File No. 92 of 1918, Government of India, Proceedings of the Department of Revenue and Agriculture for March 1919, IOR, GOI, Proc. Rev & Agr, Z/P/1983

agree to ship their indigo to England for conversion into paste. The Paste Committee had standing orders for more paste from the dyers in England and they were running out of supplies. The continuing experimental work on the making of reduced indigo also required fresh supplies of cake indigo. They asked for an immediate supply of 350 chests of plant indigo.

The experts in England received an unfavorable response to this request. The modus operandi for the sale of indigo was in a state of flux. Those planters that still remained in business had pooled their season's indigo in an effort towards the co-operative sale of their produce. In a letter, the planters' representative, Moran and Company, pointed out to the indigo committee that the prices for indigo had picked up lately in Calcutta. A good portion of the season's cake indigo was already sold and the prospect of the rest being picked up by the buyers looked very good. Under the circumstances the planters did not see any need to send their indigo to England for conversion, knowing that the natural indigo paste would have to be sold at a loss in order to be offered at a competitive price vis-à-vis the synthetic indigo available in England. [98]

In fact the planters made counter-proposals to the Paste Committee with regard to the plans for making indigo paste. First of all they wanted the experts to examine whether the "low" grade indigo, containing 50-58% color [less than the 60-65% available in high quality indigo], could be converted into paste for selling in the Western markets. The low grade indigo was at present difficult to sell in the Calcutta market in the form of cake. It would be profitable for the planters if the experts could convert such cake into a paste of

[98] Letter from Moran and Company to Begg, Roberts & Company, Secretaries to the Indigo Paste Committee, dated August 28, 1919, Government of India, Proceedings of the Department of Revenue and Agriculture for May 1920, IOR, GOI, Proc. Rev & Agr, P/10846

consistent composition for the Western markets. Thus the planters were thinking more about the readily available, local market. They prioritized selling to the local market as long as the demand was good. What they could not sell locally, they would ship to the West. But the experts pointed out to them that the low grade indigo could not be converted into paste.

The planters were thinking more about the prospects of selling indigo paste in future in the Chinese markets. The markets in East Asia were being generally considered by all to be the best prospect for the sale of indigo in the future. China was closer to India and shipment to the Chinese markets would be easier. The planters wondered if a paste-making plant could be set up in China and if the present expert, Reginald Brown, would be willing to go to China. They were also willing to consider the appointment of a new chemist for sending to China. Once again there was a deadlock. Henry Armstrong overruled the idea of building the paste-making plant in China. Cheapness would be the single most important factor for the Chinese markets. He thought that 60% indigo in the form of a powder would work best for the Chinese markets. Chemist Brown anyway was not willing to travel to China and the appointment of a new chemist seemed too difficult a task in the given situation.

More correspondence followed between the planters and the Paste Committee, but the planters could not be persuaded to send the consignment of indigo to England. The experts made a scathing attack on the planters for their lack of action in sending the cake to England. They called their policy a “short-sighted” one. The future belonged to paste indigo. The experts argued that the traders were making a fundamental mistake in putting an obstacle in the way of the paste committee. Not only was the scientific work on paste indigo compromised, but also the carefully cultivated groups of buyers for the natural paste were being lost. Finally the Paste Committee wrote to the India House pointing to the scarcity of indigo and the consequent stoppage of their work. [99]

Meanwhile the government officials in India refused in principle to provide funds out of the Indigo Cess for the experiments on indigo paste and reduced indigo in England. The Indian officials insisted that they would use the proceeds from the cess to pay the salaries of the experts working at Pusa. Thus, following the nonchalant attitude in the metropolis, the administrators in India also washed their hands of the indigo committees in London. But in a way the issue of funding of the Paste Committee was redundant because without the indigo from India the Paste Committee was not even able to use the money already available for the current year.

The New Botanist Faces Disappointment At Pusa

Botanist Major W R G Atkins was the last dedicated staff member to be employed specifically for indigo research in India. His appointment was a long overdue administrative measure dating back from 1917. To recapitulate, the Indigo Cess Act was planned with the aim of raising money for the works of a chemist and a botanist at Pusa. The search for a full time botanist was carried out in England for one full year, and finally shelved when an appropriate candidate for the job could not be immediately

[99] Letter from Moran and Company to Paste Committee, dated August 28, 1919 and November 13, 1919; Letters from the Paste Committee to Moran Company in India, dated October 16, 1919 and November 20, 1919; Letter from the Indigo Paste Committee to the Under Secretary, Revenue Department, India House, dated November 25, 1919, Government of India, Proceedings of the Department of Revenue and Agriculture for May 1920, IOR, GOI, Proc. Rev & Agr, P/10846

found. [100] Now that the Indigo Cess Act was in place, and the proceeds from the act had started flowing, the search for the botanist was revived in England.

In August 1920, finally, the new botanist, Major W R G Atkins was hired in England. [101]He arrived at Bombay on September 29 and started his duties as the Indigo Research Botanist at Pusa from October 2, 1920. [102]

Atkins did not have a pleasurable experience in India or a fruitful time. Within three weeks of his joining, he dispatched a letter asking to be relieved of his duty. He complained of the tropical weather. The extreme conditions did not suit him and he was convinced that he could not live in India for long. He was not willing to make any commitment for a longer stay or to get involved in any long-term project. He offered to pay back the passage money given to him by the government if he could be immediately relieved. [103]

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[100] Letter to the Secretary of State, dated August 3, 1917, No. 7 of 1917, No. 37, Serial No. 29, Government of India, Proceedings of the Department of Revenue and Agriculture for August 1917, IOR, GOI, Proc. Rev & Agr, Z/P/1981; No. 99, "Bihar Planters' Association Ltd., An informal meeting of the Board of Directors of the Bihar Planters' Association," Government of India, Proceedings of the Department of Revenue and Agriculture for March 1919, IOR, GOI, Proc. Rev & Agr, Z/P/1983

[101] Letter from Secretary, Revenue and Statistics, India House to Secretary, Revenue and Agriculture, Government of India, dated August 30, 1920, letter no. R&S – 6476, No. 1, Serial No. 1, Government of India, Proceedings of the Department of Revenue and Agriculture for October 1920, IOR, GOI, Proc. Rev & Agr, P/10846

[102] Letter from S Milligan, Agricultural Adviser, Government of India to Secretary, Revenue and Agriculture, Government of India, dated October 2, 1920, letter no. 1540, No. 2, Serial No. 3; "Notification – By the Department of Revenue and Agriculture," letter no. 155-337, dated October 14, 1920, No. 4, Serial No. 4, Government of India, Proceedings of the Department of Revenue and Agriculture for October 1920, IOR, GOI, Proc. Rev & Agr, P/10846

[103] Letter from W R G Atkins to the Director, Agricultural Research Institute, dated October 20, 1920, Government of India, Proceedings of the Department of Revenue and Agriculture for July 1921, IOR, GOI, Proc. Rev & Agr, P/11050

But the more central problem pointed out by Atkins was on the research front that was being carried out for the benefit of the indigo industry. He was clearly despondent as to the application of botanical principles to improve the yield from the leaves. He said, "There is no work of a purely botanical nature to be done upon indigo that can give any results inside at least five to seven years." There were two ways to improve the amount of color in the leaves – by selecting and propagating their cultivation. Such a process would take a long time to come to fruition. He did not see any other way to improve yield. [104]

Atkins was also collaborating with Davis on some secondary processes of manufacturing. He had some previous experience on plant acidity. Davis had pointed to a certain positive relation between acidity introduced by bacterial action and the rate of fermentation. Also, beyond a certain level of acidity, the yield started decreasing. Therefore the control of acidity at an optimal level was an important aspect for the experts. Atkins with his background in similar pursuits proved helpful to Davis. But that certainly was not the main work for which he had been brought to Pusa.

The Agricultural Adviser forwarded the offer of resignation from Atkins to his superiors.[105] In a follow up letter the Agricultural Adviser supported the view that Atkins should be allowed to resign his position, and that there was no need to immediately replace him at Pusa. He forwarded a copy of the proceedings of a special meeting called by the Bihar Planters' Association and a letter from its secretary on the matter. The

[104] Letter from W R G Atkins to the Director, Agricultural Research Institute, dated October 20, 1920, Proceedings of the Department of Revenue and Agriculture for July 1921, IOR, GOI, Proc. Rev & Agr, P/11050

[105] Letter from S Millgam, Agricultural Adviser to Secretary, Revenue and Agriculture, Government of India, dated November 2, 1920, letter no. 2003, No. 1, File No. 337 of 1920, Proceedings of the Department of Revenue and Agriculture for July 1921, IOR, GOI, Proc. Rev & Agr, P/11050

planters apparently agreed with the view that the chances of success from selection work were "remote." Citing the planters' views the Agricultural Adviser recommended that the replacing of Atkins at Pusa be kept in abeyance. The centra[106]l government accepted those recommendations, allowed Atkins to leave India, and advised the Secretary of State not to make any efforts towards replacing him. [107]

W A Davis Leaves India

The curtain was formally drawn on the scientific experiments in India with the decision that the Indigo Research Chemist W A Davis would depart from India after May 1922. Actually Davis stayed on India much longer after the momentum of indigo experiments had withered away. There were two reasons for this. Davis's job contract with the government did not expire until May 1922. The government did not want to violate its contract. Besides, Davis was based at the Agricultural Research Institute where he could always be involved with other types of research on agricultural chemistry in the colony.

The decision not to renew Davis' contract was taken through the due democratic institutions. The post-War period had seen some progress towards the creation of the

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[106] Letter from S Millgam, Agricultural Adviser to Secretary, Revenue and Agriculture, Government of India, dated May 13, 1921, letter no. S 86, No. 15, Serial No. 19, Proceedings of the Department of Revenue and Agriculture for July 1921, IOR, GOI, Proc. Rev & Agr, P/11050

[107] Letter from J Hulich, Secretary, Revenue and Agriculture, Government of India, to the Under-Secretary of State in London, dated June 16, 1921, letter no. 91, No. 16, Serial No. 20, Proceedings of the Department of Revenue and Agriculture for July 1921, IOR, GOI, Proc. Rev & Agr, P/11050

democratic institutions in British India. [108] The Standing Finance Committee of the Central Legislative Assembly met in the month of January 1921. Its members decided that the retention of Davis after the expiry of his agreement in May 1922 was not desirable. [109] Armstrong disapproved of this decision but to no avail. [110] His recommendations to promote the natural indigo industry had carried weight in 1917, at a time when the English dyers and printers needed their supplies of the blue dye. With the manufacture of synthetic indigo going ahead full steam in England, the dyers and printers fully satisfied with the supplies, the metropolitan officials in England and the colonial officials in India saw no reason to pay any attention to him. There was no commercial future for natural indigo now, and the administrators knew it.

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[108] Some level of native political participation was now possible although all major decision-making powers stayed with the colonialists.

[109] Communication dated, March 4, 1921, File No. 350 of 1921, Part B, Proceedings of the Department of Revenue and Agriculture for March 1922; available among the indexes of the IOR.

[110] Letter from Henry Armstrong, Nos. 53-56, File No. 81 of 1921, Part B, Proceedings of the Department of Revenue and Agriculture for April 1922; available among the indexes of the IOR.

CHAPTER 9

CONCLUSION

It is perhaps pertinent to begin the concluding remarks by underscoring the importance of the present work. Is the story of the death of natural indigo a "dead" story? Not quite. In fact natural indigo is still produced by traditional means in small pockets, resulting in a dye, which, although it has a restricted market, is highly prized by many. [1] There is also a renewed consumer demand for "natural" dyes, in part to overcome pollution problems created by the manufacture of synthetic dyes. [2] Such demands have raised new possibilities for the colorants like indigo. In fact attempts are currently underway to produce the natural dye in 90% purity to cater to the newly emerging demand. Possible sources of indigo currently under investigation include the use of biotechnological approaches to produce genetically modified *Escherichia coli* (*Genencor international*), and the cultivation of suitable crops in Europe as part of the $3.2 million sustainable production of plant-derived indigo project (SPINDIGO), launched by the European Commission in 2001.

The significance of the indigo story, in terms of responding to disciplinary concerns, lies in providing a new history of science and technology for Modern South Asia based on the review and analysis of documents not used before, and the presentation of a fresh interpretation of the history of natural indigo industry from the perspective of science and technology. The events related to the history of indigo in India are well

[1] For a review of the prospects of plant indigo, see Jenny Balfour-Paul, *Indigo*. (London: British Museum Press, 1998)

[2] Anthony Travis, *Dyes Made in America, 1915-1980: The Calco Chemical Company, American Cyanamid, and the Raritan River*. Part II (Jerusalem: Edelstein Center/Hexagon Press, 2004)

documented. Not without a reason. Indigo was a major industry of transcontinental dimensions throughout the nineteenth century. For the time and place in question it was quite deeply capitalized; the European manufacturers and traders had invested sizeable capital into it. [3]By employing thousands of natives the indigo plantations also touched the lives of many Indians in critical ways. What generally happened on the plantations interested all – the colonial administrators, the nationalists, the native indigo growers, the business classes, and, after 1897, also the scientists working to improve the yield of indigo. But historians have previously only highlighted the roles of the first three categories of actors.

Much of the primary sources on indigo, especially those left by the colonial government, have been exhaustively used before for writing the history of indigo. The official records in conjunction with the vernacular newspaper reports have been utilized to recount the story of the growing nationalist movement in India wherein the middle class-based nationalist leadership was pitted against the "colonialists." In one stroke, this historiography huddles together the British civil servants, European indigo planters, and the scientists as belonging to a single "class." Such an approach is not sensitive to the fact that the official reports portray the perspective of the bureaucracy, not essentially of the planters. Such histories also disregard the publications of the experts, which were by all count the product of some of the most sophisticated scientific research on indigo conducted in colonial India.

[3] By the account of one planter, W Hudson, around the end of the nineteenth century the planters had invested a total capital of four and a half million pound sterling in the indigo plantations.

From another perspective, the past literature also assumed that the interests of the indigo growers ultimately coalesced with that of the Indian nationalist leadership. Some of the native landed elements collaborated with the nationalists on account of their vested self-interest. They had leased their lands to the indigo planters. In the new economic situation when the sale of food crops became more remunerative than indigo, they preferred to withdraw their land from indigo. They generally assumed local leadership in the agitations that broke out against the planters in the first two decades of the 20th century. But the teeming workers/indigo growers have left no record for themselves. Writing "their" history poses methodological challenges. [4]While being somewhat sensitive to the tenuous links between the immediate concerns of the peasantry and the nationalist agenda, the dominant literature on the history of indigo has assumed that the local and nationalist elites adequately and justifiably represented the aspirations of the under-class. [5]

On the one hand, this dissertation has turned attention to some of the other equally important alternate sources that owe their origin to the scientists and the planters. One, this research has utilized the publications of the indigo experts at the Anglo-Indian laboratories in several important scientific journals of the times. The major reports on the improvement of indigo left by the experts have also been discussed in detail.

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[4] It may be stated in parenthesis that some "subaltern" histories of the native peasants do exist though they do not focus on the indigo growers. This school believes in a creative interpretation of the sources left by the dominant classes to furnish a history of the under-class. But largely these writings are narrowly focused on isolated episodes, and stop short of providing a complete, alternative interpretation.

[5] This is the perspective that inheres in the most comprehensive account of the indigo plantations to date: Jacques Pouchepadass, *Champaran and Gandhi: Planters, Peasants and Gandhian Politics*. (Delhi: Oxford University Press, 1999)

Additionally, a reading of the sources belonging to the users of the blue dye in England, the dyers and printers, has enabled us to gain a unique perspective on the nature of demand that guided the scientific efforts in India. Two, the dissertation has used the holdings of the Indian Planters' Gazette that provides the indigo planter's perspective as businessmen.

On the other hand, going against the perspectives adopted in the past, this dissertation has provided a fresh interpretation of the history of the indigo industry. In both Deepak Kumar's and Jacques Pouchepadass's analyses the colonial government appeared as apologists for the indigo planters. This research has argued quite to the contrary that the fear of peasant discontent prompted the colonial government to dissuade the planters from implementing wage cuts on the plantations. This dissertation re-interprets the motivations of the national and colonial governments for the sponsorship of science in the colony through a more textured analysis of the official documents originating from London, Simla, and Calcutta – the three different levels of governance. The metropolitan government's response to the natural indigo industry's demand for support was shaped by its perception at different points of time as to how important the Indian indigo was to the dyers and printers in the home country. The central government in India always tried to balance its commitment to support indigo experiments vis-à-vis its commitment to initiate general agricultural research and development in the colony. The provincial government provided its limited resources to the indigo laboratories as a matter of priority based on the commitment to saving a regional industry.

This research distinguishes itself clearly from the current dominant literature on the history of science in colonial India [6] and the history of the indigo industry. [7]Deepak Kumar's *Science and the Raj* is an appropriate representative work of the genre that describes how science was organized in pre-independence India under the colonial regime. Likewise, Jacques Pouchepadass's *Champaran and Gandhi: Planters, Peasants and Gandhian Politics* represents well the state of the literature on the history of the indigo industry. For that reason the two monographs are useful for the purposes of drawing comparisons, and in showing how the present work advances the research on the history of colonial science and of Indian indigo.

Kumar's book fundamentally focuses on the early beginnings and the establishment of "science" in British India at the behest of the colonial administrators. His book displays the gradual establishment of scientific infrastructure in colonial India that included the setting up of research institutions, laboratories, building cadres of scientists, and popularizing science education. The focus is throughout on the efforts initiated by the officials in this regard.

In short, Kumar discusses colonial patronage of science. Such efforts were part of the slow modernization that the colonial administration introduced in India. At the same time, Kumar is critical of the lackadaisical attitude of the colonial administrators in this regard and the "limited" investments made in launching science in the colony. He implies that such feeble and half-hearted attempts compromised scientific and technological

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[6] Deepak Kumar, *Science and the Raj, 1857-1905* (Delhi: Oxford University Press, 1995)

[7] Jacques Pouchepadass, *Champaran and Gandhi: Planters, Peasants and Gandhian Politics.* (Delhi: Oxford University Press, 1999)

development in British India. Such critiques of "dismal" patronage of science have become untenable. In another context, historians have looked for reasons as to why and how imperial Britain lagged behind Germany and the United States in the fields of scientific development and technological innovations at the dawn of the twentieth century. [8]The implications of those studies for the debate on colonial science in India are clear - that limited investment in scientific R&D was a feature of Britain's colonial *and* national policies.

In a contrast to Kumar's approach, the present work investigates the organization and progress of scientific research from a Laboratory Studies perspective. It considers the expertise of the scientists and their actual work within the laboratories to understand the direction of the scientific experiments in the colony.

This dissertation does not simply explain the motivations for the organization and support of the laboratories in terms of "short-sighted colonial policies," as earlier done by Kumar. To understand the motivations for the sponsorship of indigo experiments, this research *additionally* connects the patronage of scientific experiments to the actual results obtained in the laboratories. To what extent did the scientific results in the laboratories help meet the requirements of the planters in the market place? How did the credibility of experts and their rhetorical authority inspire confidence from the national government in England and the central and provincial governments in India that natural indigo still had a chance?

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[8] For a synoptic review of the relevant literature, see Harm G. Schroter and Anthony Travis, "An issue of different mentalities: National approaches to the development of the chemical industry in Britain and Germany before 1914," in Ernst Homburg, Anthony S Travis and Harm G Schroter (eds.), *The Chemical Industry in Europe, 1850-1914: Industrial Growth, Pollution, and Professionalization*. (Dordrecht: Kluwer Academic, 1998)

In contrast to the works of both Kumar and Pouchepadass, [9] this research places the perspective of the planters at center stage. The unique access to planters' sources has enabled pointing to the priorities of this business class vis-à-vis the preferences of the government. The dissertation shows that the planters could not take the government's support for granted as they tried to find ways to withstand the synthetic's competition. Saving natural indigo was primarily the concern of the indigo planters. Once they found their resources insufficient to the task, they turned to the government to seek their support. They tried to persuade the government at various levels – the Secretary of State in London on the one hand, and the imperial administrators in Simla and the provincial bureaucrats in Calcutta on the other. In the end they received substantial state subsidy for their indigo experiments. In fact, in the colonial context, government's aid very soon became the principal vehicle for the progress of the indigo experiments in India.

In writing the history of the indigo industry Pouchepadass has not made use of any of the scientific documentation. [10] His econometric analysis of the production process of the dye has thus resulted in a critical omission by leaving out an engagement with the research and production issues.

This dissertation highlights the fact that the planters addressed the key problem of facing the competition in the market place. Their response towards particular laboratories and appreciation or disapproval of particular scientists was based on their assessment of the scientific results at different times. They evaluated the scientific results by asking:

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[9] It may be pointed out that Pouchepadass's account of the plantation industry does not make use of the *Indian Planters' Gazette*, the only source left by the planting community that has survived aside from a few personal memoirs left by the individual planters.

[10] B. Chaudhuri before him and P K Shukla after him have also not made use of any of the scientific publications.

which scientist was doing "practical" work? Whose work was of merely "academic interest"? On the basis of their assessment they singled out some experiments for appreciation and denounced others. After a time it was apparent that the initial promises made by the scientists that they could drastically improve the yield and the consistency of the natural dye appeared unduly optimistic. The scientists stopped delivering in the present, only promising results in the future. In such a situation the planters became despondent about the prospects of returns from "science," abandoning it altogether. Thus this dissertation draws the important conclusion that the lack of support by the planters to the indigo experiments at specific points of time does not imply that they were innately conservative.

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