A FIELD TRIAL USING LOW APPLICATION RATES OF POLYACRYLAMIDE (PAM) TO REDUCE SOIL EROSION FROM DISTURBED PIEDMONT SOILS

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Abstract. Land disturbing activities during urban and suburban development are increasing soil erosion and leading to increasing turbidity in surface waters of Georgia. In two field trials, we tested the efficacy of low applications rates of polyacrylamide (PAM) for reducing soil erosion on recently disturbed slopes of 15 and 35%. The total suspended solids (TSS) of runoff waters for treatments of PAM in combination with hydroseeding were compared to hydroseeding alone or to controls. TSS of runoff waters from PAM with hydroseeding or hydroseeding alone was similar and both treatments were lower than controls. All treatments, however, showed >20-fold decreases in TSS with time. Currently, we are testing higher rate applications of PAM as a potentially more effective means of reducing soil erosion.

INTRODUCTION

Recently, the Manual for Erosion and Sediment Control in Georgia (GSWCC, 2000) has developed more restrictive best management practices (BMP) for urban land-disturbing activities. These more restrictive BMPs have been adopted due to increasing urban development of slopes and highly erodable soils in the Piedmont. In the Upper Chattahoochee River, such development has led to a six-fold increase in average suspended sediment concentrations (1993-1998) from upstream to downstream of the Atlanta metropolitan area (Frick and Buell, 1999).

Current BMPs include installation of silt fences, sediment basins, proper construction exits, as well as other structural and vegetative measures. Unfortunately, current BMPs have failed to reduce the problem of soil erosion sufficiently. Improper installation of existing structural BMPs (mainly silt fences) is one reason for the insufficient protection while the limited use of BMPs other than silt fences is also a contributing factor. Polyacrylamide (PAM) is a lesser known and a lesser used BMP that might provide great benefit for minimizing sediment delivery to streams. Government regulatory agencies recently approved the use of PAM as an acceptable BMP.

The objective of this study was to test the efficacy of low application rates of PAM for minimizing erosion on recently disturbed construction sites.

BACKGROUND

Early studies of synthetic soil conditioners were begun over 51 years ago (Quastel, 1954). Recently, much has been written on the use of PAM, one of many types of synthetic soil conditioners, on irrigated agricultural soils (Helalia and Letey, 1988). Despite promising results with PAM in agricultural systems some researchers still believe that there is not enough conclusive information regarding the proper application of PAM or its cost effectiveness (Mitchell, 1986; Nadler, et al. 1996). Most do agree, however, that anionic polymers, such as PAM, have great potential for stabilizing soil if they can be applied at low rates and at low cost (Nadler, et al. 1996).

PAM is a water-soluble organic polymer. Applied as a soil conditioner, PAM functions by improving soil structure through the binding of clay aggregates in the soil to long chain synthetic molecules (Mitchell, 1986). The process of binding clay particles together through the use of PAM increases pore space and water infiltration rates, and reduces soil crusting and rill erosion (Zhang and Miller, 1996). Helalia and Letey (1988) showed that when applied to clay rich soil PAM increased the soil infiltration rate. Clay rich southeastern soils, similar to those present in the Georgia piedmont, are particularly susceptible to rill erosion as a result of poor structural stability (Miller and Baharuddin, 1987).

Environmentally, anionic PAM (as opposed to cationic PAM) has been found to have a very low rate of toxicity in mammalian and aquatic environments (Barvenik, 1994). The U.S. EPA has listed PAM under the category of "Acceptable Drinking Water Additives" and PAM meets "ANSI/NSF" Standards for drinking water (Barvenik, 1994). These regulations rate PAM safe for application as an agricultural amendment, as it will break down over time (Barvenik, 1994). The low toxicity levels of PAM allow it to be used in addition to, or in the place of, organic amendments currently used in agriculture (Wallace et al., 1986).

METHODS

Five research sites with three different experimental treatments have been placed in the field. The experimental design is an incomplete, randomized block with site locations serving as blocks. Site locations include Watkinsville ARS, Park Creek in Woodstock, GA, and three sites near Ball Ground, GA. The Park Creek and Ball Ground sites were recently cleared of forest and prepared for residential development or power line installation. All slopes were engineered and graded by a bulldozer prior to treatment. At four sites experimental treatments were: (1) PAM with hydroseed (i.e. mulch and seed sprayed from a water tank), and a silt fence; (2) hydroseed and a silt fence; and (3) a silt fence alone as a control. The ARS plots are on the back of an earthen dam and thus contain a half PAM plus hydroseed treatment instead of a silt fence only control. The locations have varying slopes and soil types. In this paper only results from Park Creek and ARS are reported.

Plot size for each treatment is approximately 10 m x 12 m. At the ARS and Park Creek locations, applications of PAM 630 (Applied Polymer Systems, Norcross, GA) were sprayed on the plots at a rate of 150 ml/ha. This application rate is 100-fold less than current recommendations but little information is available regarding spray application of PAM on construction slopes thus a conservative approach was taken for the first two plots. The Ball Ground locations have received the recommended rates of PAM. A type C silt fence with wire back was placed at the bottom edge of each plot. Meter sticks were placed in front of the silt fence to estimate the volume of sediment runoff reaching the bottom edge of the plot. Rainfall intensity and amount were measured at each site with a HOBO data logger and tipping rain gage. To estimate vegetative grass cover we cut the grass in a defined area from a number of locations in the plots on a periodic basis. Using this information we quantified the percent cover of grass and bare soil over time in each plot.

In addition to the plot level measurements, within each plot three 1-m wide by 3-m long defined area samplers were installed. The samplers are enclosed on all sides and drain into 120-L containers to estimate surface water and sediment runoff. Nephelometric turbidity units (NTU) of the collected waters were analyzed in the laboratory (Clesceri et al., 1998). Samples with NTU>200 were diluted as necessary. Measured turbidities were converted to total suspended solids (TSS) in mg/L using a regression (TSS in mg/L=0.7147*NTU – 1.1523) based on kaolin standards (N=5) of known concentration. Total solids were also measured by oven drying a known volume of sample water (Clesceri et al., 1998). These defined area samplers provide greater precision in estimating rainfall vs. runoff relationships as well as a means to quantify sediment loads in the runoff waters.

Finally, along with the above measurements, we have quantified some general chemical and physical properties of the surface soil at each site to correlate with PAM effectiveness. Chemical properties include soil pH in water and salt (2:1 water or 0.01 M $CaCl_2$ to soil {v/w}), and base cation (Ca, Mg, and K) concentrations (double acid extraction followed by measurement on atomic absorption). Physical properties include soil particle size analysis for sand, silt, and clay following the hydrometer method (Gee and Bauder, 1986).

Table 1. Particle size analysis for 0-5 cm soils at the sites used for the low application rate PAM treatments.

Site	Location	Sand	Silt	Clay
	County	----------	%	----------
Watkinsville, ARS	Oconee	50	31	19
Park Creek	Cherokee	86	7	7

RESULTS AND DISCUSSION

Sand, silt, and clay contents of the upper 0-5 cm of soil from the ARS and Park Creek locations were substantially different (Table 1). ARS had clay contents of ~19% while those at Park Creek were ~7%. In both locations soils were from cut and fill operations and thus represented a mixture of local soils and fill material. The TSS measurements from ARS and Park Creek ranged over a four-month period that was marked by a record drought in the state. Regardless, for the available rain events TSS measurements at both locations ranged between 5 and 1100 mg/L (Figure 1 and 2). At both locations TSS decreased in runoff waters during the period of measurement by >20-fold. The effect of PAM on runoff water TSS was minimal at both locations when compared to hydroseed treatments

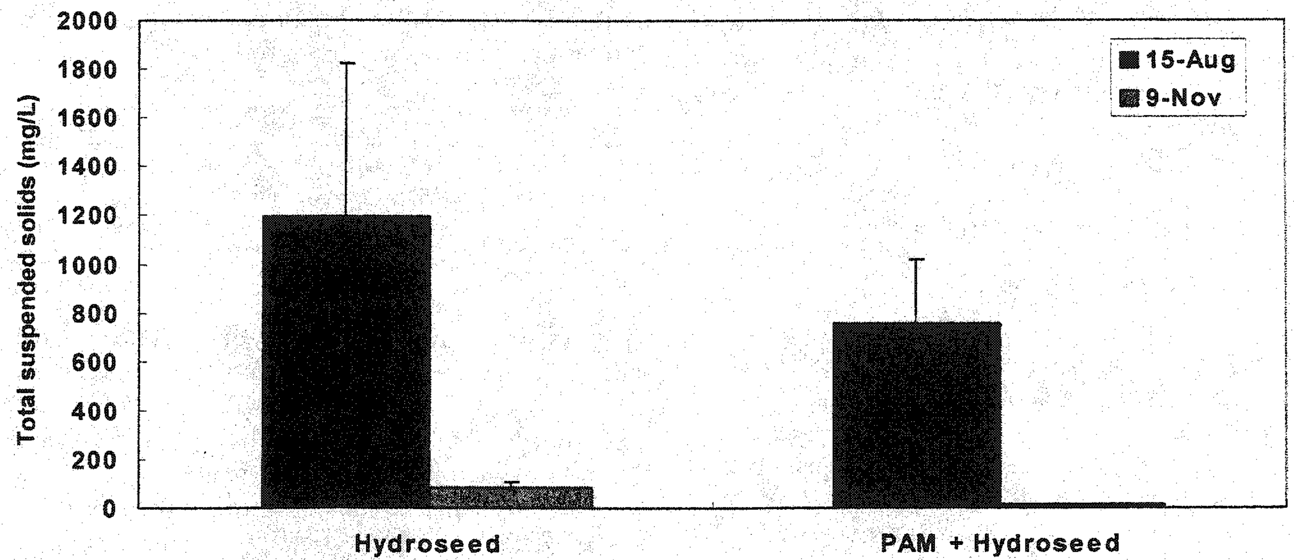

Figure 1. Turbidity of runoff waters collected from defined area samplers (N=2/plot) at the Agricultural Research Station (ARS) in Oconee County, GA. Treatments are a low application rate of PAM+Hydroseed and Hydroseed alone. Error bars equal one standard deviation.

although PAM+hydroseed and hydroseed treatments were clearly superior to the control at Park Creek (Figure 2).

In this low application rate study with PAM no differences in effectiveness were apparent between the sites despite differences in particle size distributions. Other work with a rainfall simulator (Green et al., 2000) also indicated that off-the-shelf PAMs may function similarly across soils with 13 to 57 % clay. The higher clay content soil of the ARS site did, however, have the highest measured TSS (~1100 mg/L) after the first rainfall event. Although the measured

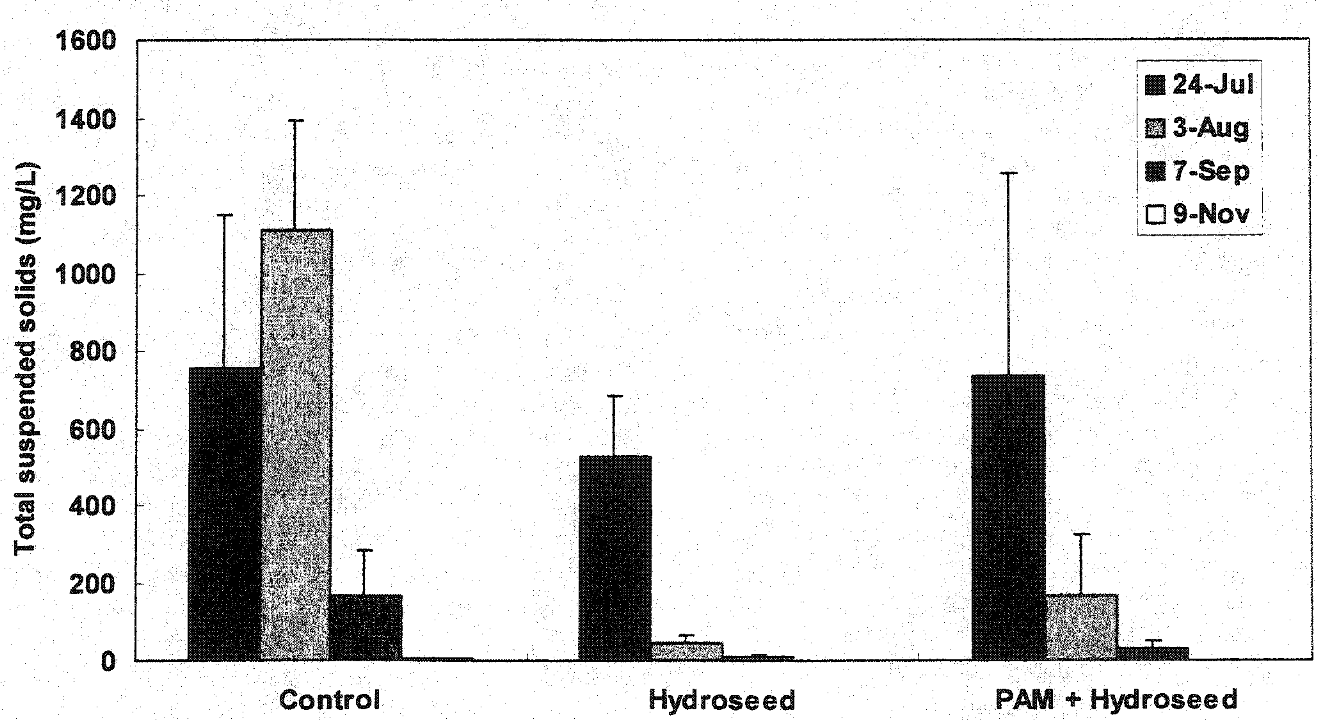

Figure 2. Turbidity of runoff waters collected from defined area samplers (N=3/plot) at the Park Creek location in Cherokee County, GA. Treatments are a low application rate of PAM+Hydroseed, Hydroseed alone, and a bare soil control. Error bars equal one standard deviation.

TSS at both sites during the first rainfall events likely exceeded enforcement standards for a National Pollution Discharge Elimination System (NPDES) permit. The NPDES permit limits TSS discharge into a warm water stream at a 25 NTU increase up to a 25-year 24-hour rainfall event (GDNR, 2000). The PAM+hydroseed and hydroseed treatments applied to the slopes probably did not reduce sediment entrained in runoff water below this limit. This does not indicate, however, that all sediments would reach local stream waters. In fact, PAM may provide some benefit to erosion control by continuing to act as a flocculent in sediment enriched waters even if washed down slope. PAM has not been approved for direct application into stream waters, however, and thus PAM inputs to streams would not be acceptable.

CONCLUSION

The low application rates of PAM used in the first two field trials did not show a marked improvement in reducing erosion. These applications were well below recommended rates, however, thus we are currently performing field trials with 100-fold higher rates or ~15 L/ha (1.5gal/ac) of PAM. PAM has a proven effectiveness as a flocculent and thus maintains promise as an effective BMP for controlling erosion although continued research for spray applications on constructions sites is required.

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