# IMPROVING WATER QUALITY OF RETURN FLOWS IN FURROW-IRRIGATED SYSTEMS USING POLYMER-AMENDED INFLOWS

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## INTRODUCTION

Furrow irrigation is an inherently erosive process. When irrigating erosive soils or supra-optimal slopes soil loss can greatly exceed T-values (Carter,1990). Soil sediment lost in return flows and nutrients and other chemicals adsorbed on the sediment are major contributors to non-point pollution of surface water (Brown, et al., 1981). Although numerous practices have been developed to combat erosion from furrow irrigated systems their adoption has been hampered by cost and inconvenience (Sojka, et al., 1992). The Kimberly ARS group has recently conducted a series of field studies verifying the efficacy of minute polymer additions for halting erosion and stabilizing infiltration of irrigated furrows. Beyond its high efficacy, this approach is attractive because of its simplicity and low cost (Lentz, et al., 1992). The technology requires only the use of simple fluid injection devices to treat irrigation water, at a material cost below $3.00 per hectare per irrigation.

## PUBLISHED RESULTS

Extensive research has been conducted since the early 1950's exploring use of organic polymers for soil property amendments (Azzam, 1980). These studies concentrated on modifying solid phase properties of the surface 10-30 cm of soil using application rates of 250-500 kg $ha^{-1}$. Recently, the potential for soil erosion reduction and infiltration stabilization at much lower application rates, where polymers can be added to irrigation water, has been documented (Levy, et al., 1991; Mitchell, 1986; Lentz, et al., 1992).

We have investigated polyacrylamides (PAM) and starch/polyacrylamide co-polymers (SCP) for erosion and infiltration control in furrow-irrigated systems on Portneuf silt loam soils (Durixerollic Calciorthids) for 2 yrs. Using concentrations from <1 to 20 g $m^{-3}$ in the irrigation water results in applications not exceeding 2 kg $ha^{-1}$ per irrigation, depending on amount of irrigation water applied. Generally, both erosion and infiltration were controlled at half of the maximum rates studied.

In one study, furrow slope was 1.6%, length was 175 m, and irrigation rates ranged from 15 to 23 L $min^{-1}$. Inflow was treated the 1st 1-2 hr of the 1st 8-hr irrigation only. PAM or SCP solutions were injected into irrigation water entering furrows at concentrations of 0, 5, 10, and 20 g $m^{-3}$. Averaged sediment concentration of runoff and cumulative loss from polymer-treated furrows are shown in Fig.1. For untreated and co-polymer furrows, peak concentration occurred during the first two hours. Peak concentration of sediment for co-polymer treatments was higher than untreated furrows during the first two hours of the irrigation, but this had small impact on total sediment loss because flow rates of co-polymer treated furrows were less than those of controls during this period. Co-polymer effectiveness improved later in the irrigation, suggesting that this soil-polymer interaction was time dependent. In contrast, PAM controlled soil loss immediately. Sediment concentration in PAM treated furrows remained very low during application and for one to two hours thereafter, then increased slowly during the last part of the irrigation. Sediment concentration in PAM treated furrows never exceeded that of their nontreated counterparts.

Cumulative soil loss from PAM-treated furrows was significantly less than that of control furrows in the 1st (treated) and 2nd (untreated) irrigations, but not in the 4th (untreated) irrigation. While mean soil loss from SCP treated furrows was smaller than that of check furrows in each irrigation, only the 2nd irrigation's results were significant. We compare sediment reduction resulting from PAM and SCP treatments over three monitored irrigations in Fig. 2. Effectiveness of PAM 10 g $m^{-3}$ treatment at low flow rates was 97% in the initial irrigation but residual erosion abatement in the 2nd irrigation, without further addition of PAM, was 47%. The presence of negative, though nonsignificant, reductions for PAM furrows in the 4th irrigation, suggest the possibility that once PAM protection fails, erosion rates may exceed that of nontreated furrows. In general, PAM controlled erosion better than SCP, but PAM efficacy declined over time, whereas SCP efficacy increased (Fig. 2).

PAM efficacy varied with concentration, duration of furrow exposure, and flow rate. PAM and SCP applications at either 10 or 20 ppm promoted a significant 25-30% increase in the lateral extent of wetting. Application of PAM to furrows during the 1st irrigation produced a similar increase in net infiltration (Fig. 3).

## ONGOING RESEARCH

Various application strategies are under investigation to maximize erosion and infiltration control while minimizing polymer application amount. Polymer effects on soil properties are being assessed on long term plots. Polymer application efficiency (ratio of applied to lost) and escape is being evaluated at various distances from furrow outflow points. Various classes of polyacrylamides are being evaluated for immediate and long term potency For example, Helalia and Letey (1988) reported that soil flocculation by different polymer charge types occurred in the following order: neutral ~ cationic > anionic. However, with respect to controlling furrow erosion, we have found the order of effectiveness for initially irrigated furrows to be: anionic ~ neutral > cationic (e.g. Fig. 4). Other data (not presented here) suggest that the overall effectiveness of anionic PAM is greater than the neutral form. To date the most effective materials have been high mol. wt. (15 Mg $mol^{-1}$), medium to high anionic charge density (20-30%) polyacrylamides.

## RESEARCH CHALLENGES

Fortunately, some of the most efficacious polymers have little or no toxicity, and in fact have long been used in water treatment and food processing. Nonetheless, all continuing polymer development will continue to require environmentally benign properties. Eventually, starch-based copolymers may be much cheaper than pure polyacrylamides, and could have further advantages of being produced from agricultural starch sources, capitalize on the efficacy increasing properties observed by Lentz et al.(1992), and have rapid degradation characteristics. Engineering challenges will include development of application methods that restrict precipitation of suspended sediments to points beyond furrow inlets (if using a farm-by-farm strategy) or that allow high volume water treatment (if using an irrigation district-wide polymer treatment strategy).

## POTENTIAL BENEFIT

Polymer-treated irrigation water could be an effective new tool for preserving the soil resource on the 250 million ha global inventory of irrigated land. The application technology is sufficently simple to allow utilization even in underdeveloped nations. At the farm level, holding soil in place would retain fertilizers and pesticides on targeted application areas and reduce maintenance of drains, ditches, and ponds. Reduced soil-borne nutrients and pesticides in irrigation return flows would improve riparian and aquatic environments for wildlife and public health. Less sediment in rivers and reservoirs would slow impoundment filling, decrease abrasion damage to hydroelectric facilities, and reduce dredging of waterways.

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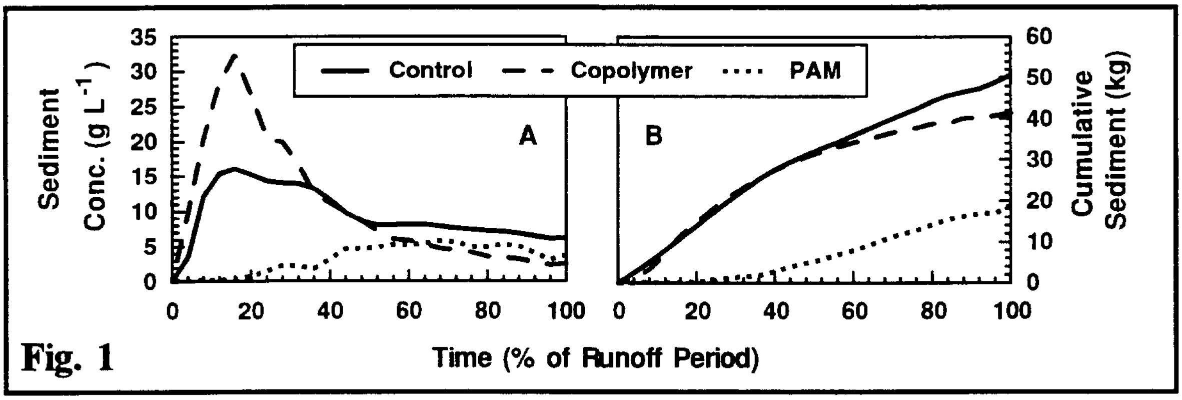


Fig. 1

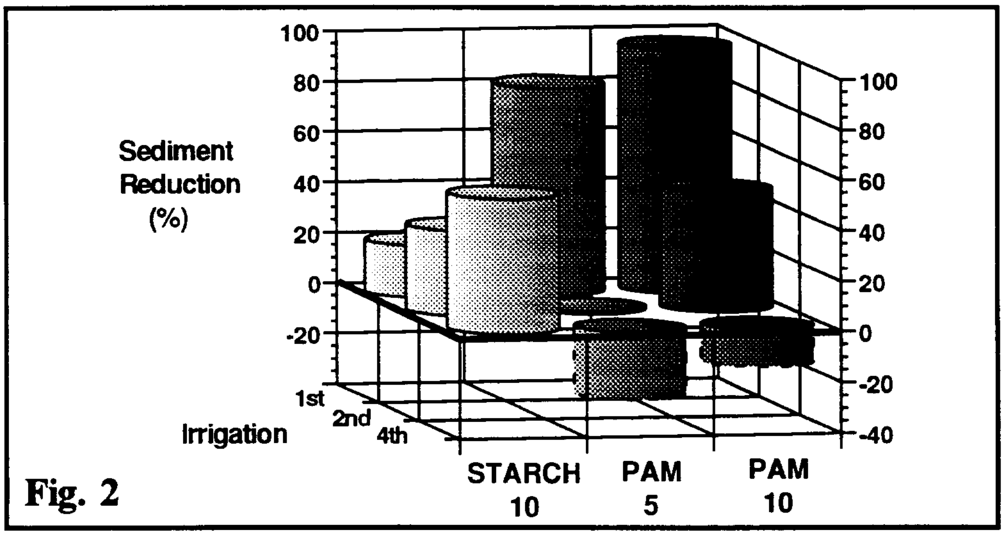


Fig. 2

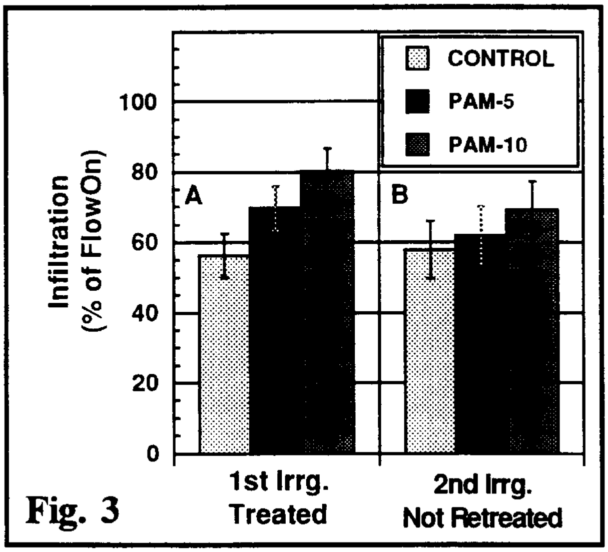


Fig. 3

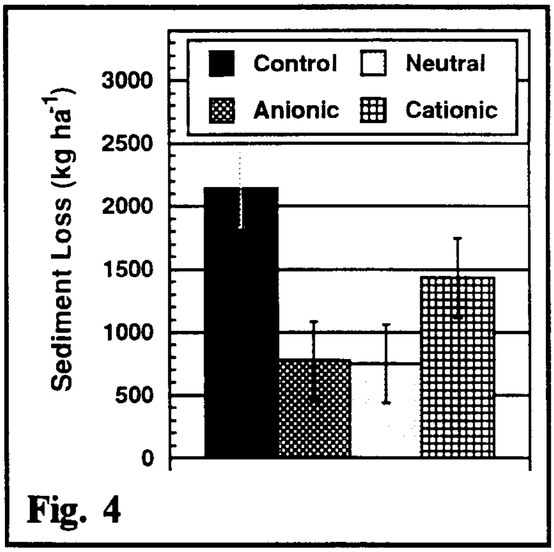


Fig. 4

Figure 1 Sediment Concentration (A) & Accumulation (B) vs. time
Figure 2 Sediment Reduction for 3 polymer treatments over 3 irrigations
Figure 3 Initial (A) and residual (B) effect of polymers on infiltration and
Figure 4 Effect of charge type on furrow sediment loss