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G98-1356 Polyacrylamide – A Method to Reduce Soil Erosion

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Polyacrylamide – A Method to Reduce Soil Erosion

This NebGuide describes polyacrylamide, what it is, how it can be used to reduce soil erosion due to, irrigation and what water management changes must be considered.

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Soil erosion due to irrigation can range from none, on many center pivot irrigated fields, to over 30 tons per acre per year on intensely farmed furrow irrigated fields. High soil erosion rates occur either from furrow irrigated fields with slopes greater than 3 percent or on soil prone to erosion. Although the rate of soil loss is greatest on fields with slopes greater than 3 percent, cumulative annual soil loss is greater on furrow irrigated fields having 1-3 percent slopes, due to total acres involved. Approximately 10 percent of the furrow irrigated acres in Nebraska are on slopes greater than 3 percent, while 40 percent, or nearly 1.4 million acres, are on fields with slopes of 1-3 percent. Fields with slopes of 1 percent, or less, makeup the balance of the total furrow irrigated acres. To reduce the total amount of soil lost due to furrow irrigation, sediment loss on any potentially erodible field must also be reduced.

Topsoil loss can mean a long-term reduction in soil productivity, crop yield and the life expectancy of downstream storage reservoirs. In the short term, producers are faced with reuse pits to clean or a buildup of soil at the lower ends of fields which must be redistributed. Measures must be taken to reduce or eliminate soil erosion and sustain Nebraska's soil resource.

Where Does Soil Loss Occur?

Center pivot irrigation accounts for a small portion of the total soil eroded. The majority of soil lost under pivots is due to runoff from precipitation that comes faster than the soil can take in. Runoff, and associated soil loss, is minimal for most center pivots, as properly designed center pivots apply water at or below the soil's infiltration rate. Little water should move from the point of application if center pivots are properly designed. If you're experiencing runoff and subsequent soil erosion during center pivot irrigation, address the question of correct system design first.

Furrow irrigation, however, is a major contributor to soil loss. With nearly half of the irrigated acres in Nebraska under furrow irrigation, reducing soil erosion on these acres could help maintain topsoil for future generations. Furrow irrigation results in greater loss because unlike a center pivot that uses a pipe to transport the water prior to distribution, furrow irrigation uses the soil as the transmission line and distributes the water along the irrigation furrow. Runoff is necessary with furrow irrigation to provide reasonably uniform irrigation. Unfortunately, with runoff water comes soil; in some areas, lots of soil.

The furrow erosion process is slow. Just looking at some of the concrete irrigation ditches installed 30-40 years ago, however, shows how much sediment is being lost from furrow irrigated fields. Some of these ditches are now far above field level. Another way to gauge soil loss is to consider the number of times soil has been removed from the downstream end of the field so water can flow to the end of the furrow. Even though the process is slow, the top soil is gradually removed and fields become less productive. For example, a field that has lost 1 foot of top soil in the last 40 years, lost only about 1/3 inch each year. Such losses would go unnoticed without a permanent structure, like a concrete ditch, to compare to.

On steep slopes, soil erosion can occur in furrows even when small streams are used. As the season progresses, the furrows can become narrow, deep-cut channels. In some cases, these channels can be 12-18 inches deep, which means water is being applied 12-18 inches below the most active portion of the root zone. It is difficult to move water up in the soil profile without a constant water source. The result can be plant water stress for any crop, especially for shallow-rooted crops like dry beans, soybeans and potatoes.

Methods to Control Soil Erosion

Center pivots should not cause runoff and soil erosion unless there are design problems. For low pressure systems, it may be necessary to either use a different sprinkler type or increase pressure. These changes will allow water to be applied over a larger area, reducing the application rate. For more information on controlling irrigation runoff from center pivots and water loss associated with different sprinkler packages, see: *Water Loss from Above-Canopy and In-Canopy Sprinklers*, NebGuide G97-1328;*Application Uniformity of In-Canopy Sprinklers*, NebGuide G97-1337; and *Water Runoff Control Practices for Sprinkler Irrigation Systems*, NebGuide G91-1043.

If system design is found to be acceptable and intake rate is concerning, some type of tillage may be necessary to increase the water infiltration rate. If infiltration cannot be increased, tillage can be used to create surface storage, as water that is stored or puddled on the soil surface can infiltrate later.

Another practice, conservation tillage, leaves residue on the soil surface. During irrigation or rainfall the residue acts as a shock absorber, neutralizing energy that otherwise would break down soil structure and reduce infiltration. Soil infiltration also increases by having residue mixed in the surface soil, as the residue helps maintain open pores for water to infiltrate. Residue, as tillage, can increase surface storage capacity by stopping the flow of water.

Vegetative filter strips on the edge of a pivot do nothing to control soil erosion on the field. Although filter strips prevent soil from moving off a field, erosion may continue within the main portion of the field. The results would be similar to furrow irrigation where soil is deposited at the end of a field. See NebFact NF97-352, *Vegetative Filter Strips for Agriculture*, for more information on using filter strips.

Furrow irrigation systems have been tried to help reduce the amount of sediment lost. Research has involved putting straw or growing grass in the furrows to slow the water and keep sediment on the field. Conservation tillage, as with center pivots, slows the water in the furrow and can reduce soil loss. Although for many irrigators, slowing water advance, especially during the first irrigation, is not advantageous. While these procedures can help reduce sediment loss, they also impact the irrigation's efficiency and uniformity.

What is Polyacrylamide?

Polyacrylamide (PAM) is a long-chain synthetic polymer that acts as a strengthening agent, binding soil particles together. It is harder for water to move these larger, heavier particles of soil. USDA researchers in Kimberley, Idaho began working with PAM in the early 1990's as a method to reduce erosion in furrow irrigation. Their tests indicated PAM applied in the irrigation water reduced soil erosion in furrows by over 95 percent, when compared to irrigation without the polymer.

What are the Benefits of PAM?

Benefits of using polyacrylamide may go beyond erosion control. For example, getting water to the end of the field can be difficult. The ability to put more water in the furrow without causing erosion can reduce furrow advance time and improve irrigation performance. If the soil in the furrow can be held in place, more water can be put down each furrow without causing erosion.

Soil erosion, with furrow irrigation, is generally greater at the top of the field where stream size is the greatest. As water advances down the field, water infiltrates the soil, resulting in a progressively smaller stream size. With a smaller stream size, the ability of water to move sediment is reduced and soil begins being deposited in the furrows. In another example, a field may have a steeper top slope than bottom. The faster moving water at the top of the field erodes the soil and as the water reaches the flatter portion of the field, sediment settles out. In these cases the furrow shallows as sediment is deposited. This can sometimes occur within one irrigation; in other cases it may take several irrigations. Either way, the result is a furrow full of soil and water flooding adjacent rows. This flooding adversely impacts irrigation performance and yield. The use of PAM can reduce this problem by keeping soil in place.

In addition, polyacrylamide has increased the intake rate of some soils. Without polyacrylamide, soil particles come into suspension or bounce along the bottom of the furrow. Shortly after irrigation begins, the bottom of the furrow appears smooth. The small particles eventually find their way into the larger pore spaces on the bottom of the furrow. The larger pore spaces are filled with finely packed smaller soil particles. This process reduces the infiltration rate of the soil. Binding particles with polyacrylamide lessens this effect by maintaining soil structure.

Normally, soil intake rate is high during the first irrigation. If PAM application increases the intake rate of the soil, changes in water management must be made. For example, a producer could increase furrow stream size to account for the intake increase so water advance remains acceptable. For more information on advance time and stream size selection for furrow irrigation, see *Managing Furrow Irrigation Systems*, NebGuide G97-1338.

Application of Polyacrylamide

Polyacrylamide can be purchased as a dry granular, as a liquid or a solid. The dry formulation is easy to handle, but must be kept dry. The dry material is primarily used for open ditch application due to the difficulty of getting the material into a pipeline. For best results, place the applicators used to dispense the bulk material upstream of the irrigation set and away from any splashing water droplets. Creating some type of turbulence, if possible, will help to dissolve the PAM.

With a closed pipe system, the liquid formulation is normally recommended. Using an injector pump, the liquid can be pumped directly into the irrigation pipeline. Turbulence in the pipeline, such as an elbow, helps mix the PAM with the water. The natural turbulence in a pipeline 100 feet long or greater is likely sufficient for mixing. The liquid material is, however, difficult to handle outside of the container. To clean up anything that has come in contact with liquid PAM, "wash" the PAM off with soil. The PAM will adhere to the soil particles making cleanup with water possible.

The liquid formulation also can be used for open ditch applications; however, if you are not using a pump, and simply letting the liquid dribble into the water, watch for changes in air temperature. The viscosity of the liquid can change with temperature changing the calibrated delivery rate. Keeping the containers out of direct sunlight will reduce, but not eliminate, this problem.

The solid formulation of PAM is placed in an area where turbulence is occurring. The action of the water slowly dissolves the polyacrylamide into the flowing water. The only way to control the amount added into the water is to control where the solid PAM is placed and how long it is left in the water. Calibration for dispersion rate has not yet been determined, so trial and error is the current method used.

In 1998, cost of polyacrylamide was expected to run approximately $3/pound for dry, $25/gallon for liquid and $6/pound for the solid. While the recommended application rate is 10 parts per million (ppm), actual application rate will vary depending on irrigation system, soil type and water source. Application rate should be calculated for each location and periodically checked due to the unreliable nature of many of the application devices.

Adding polyacrylamide to water is much different than adding most other materials. For example, if a cup of salt is added to a gallon of water and stirred, the salt will, in a short period of time, dissolve. However, when polyacrylamide is added to water, turbulence is necessary to ensure adequate mixing. Without adequate mixing, the polyacrylamide will not immediately dissolve and PAM globules will form. In time, these globules will find their way to the field and can be seen floating down the furrow. Although not as likely, globules do still occur with injector system use. If PAM is being applied with a center pivot, sprinkler nozzle plugging may occur if the PAM solution is not well-mixed.

Application method depends on the material selected. Granular PAM requires some form of augured metering system. Solid blocks should be placed in a wire basket and secured to the side of the ditch to avoid washing the block downstream. Liquid PAM can be metered directly from the container into an open ditch or through an injector pump into a pipe line.

If adding either liquid or dry PAM to an open ditch, try to keep the discharge point at least 2 feet away from the flowing water. Small droplets of water can cause the PAM to clog at the outlet and stop flow. If turbulence in the water is causing splashing, move the applicator away so that water does not contact the container or try to move the turbulent flow downstream.

Another concern: the type of water used for irrigation. Because polyacrylamide attaches to the soil particles and binds them together, water containing a lot of sediment may result in sediment settling out before water is diverted into the furrows. In general, this does not affect PAM's effectiveness, but with extremely sediment-laden ditch water, sediment may buildup and restrict flow in the supply ditch. This is also a concern for underground transport pipes. If the water velocity in the pipe is insufficient to lift the accumulated sediment, pipe flow may be restricted. Though the flow rate is reduced, the pipe is not likely to plug completely, since as the sediment decreases the pipe's inside diameter, water velocity increases.

Meter polyacrylamide into irrigation water to achieve to a concentration of 10 ppm, the recommended starting application rate for furrow and sprinkler systems. The product label should give, however, application rates based on water flow rate. Be aware: different soil textures and field slopes can give different results when receiving equal quantities of PAM. Therefore, it may be possible to get good erosion control using a lower application rate. In other cases: higher rates may be needed. Start with the 10 ppm rate and increase or decrease the concentration based on the clarity of the runoff leaving your field.

For maximum effectiveness, thoroughly mix PAM with the irrigation water before application. In an open ditch, let the water pass over at least one drop structure or some ditch obstruction to cause turbulence before water is diverted into the furrows. In an earthen ditch, a drop dam will suffice; in a concrete ditch, boards can be used to create the turbulence. In some cases you may have to create a drop in order to adequately mix the material in the water. In gated pipe, the pipes swirling action will generally cause enough mixing within the first 2-3 pipe joints. If pressure in gated pipe is relatively low, 3 feet or less, a Krause Box[1] can be used to create a drop structure in the pipeline.

The furrow is considered treated once the water reaches the end of the field, and additional polymer is normally not required for that irrigation. In many cases, producers are finding that, rather than applying PAM until water advances to the end of the field, protection is adequate by applying PAM only until water advances 50 percent or less of the field length. The advantages are erosion control in the top portion of a field, reduction of sediment deposits in the bottom portion of the field and reduced application costs.

Because polyacrylamide attaches itself to the soil near the surface, cultivation or ditching after PAM application results in loss of effectiveness. PAM should be reapplied after cultivation or ditching disturbs the soil surface. Once applied, PAM is not effective all season long. However, after the initial application, PAM does continue to offer some erosion control during subsequent irrigations. Factors, such as soil type, field slope and irrigation furrow stream size, will determine the long-term effectiveness of a single PAM application.

[1]Mention of trade name is for information only and does not imply endorsement.

Research Results

Research was conducted at the Panhandle Research and Extension Center in Scottsbluff, Nebraska in 1996 and 1997. Furrow stream size was approximately 12 g.p.m. Field slope was 0.2 percent and field length was 1,000 feet. The soil was a Tripp, very fine sandy loam. The crop grown was dry beans in 30-inch rows with every other row irrigated. Furrow advance time to 1,000 feet and sediment loss (tons/acre) were measured and given in *Figures 1-4*.

In 1996, the three treatments were: 1) PAM; 2) no PAM; and 3) patch PAM. *Figures 1* and *2* show the results for three irrigations during the growing season. The patch PAM treatment was done by sprinkling PAM in the dry furrow before water was started. Advance time was similar for all treatments. The amount of soil loss was greatest for the no PAM treatment and the least for the PAM treatment. The patch PAM treatment, although providing some reduction in erosion, was not as effective as having the PAM mixed with the water prior to application.

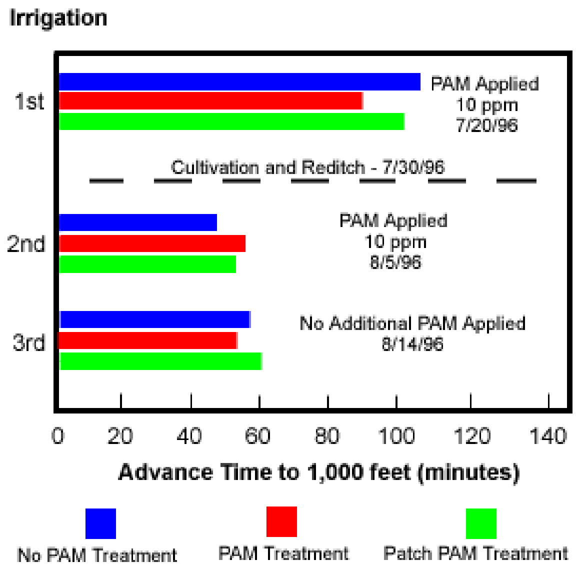

Figure 1. Furrow advance time to 1,000 feet for each irrigation, treatment of no PAM, PAM and patch PAM (1996).

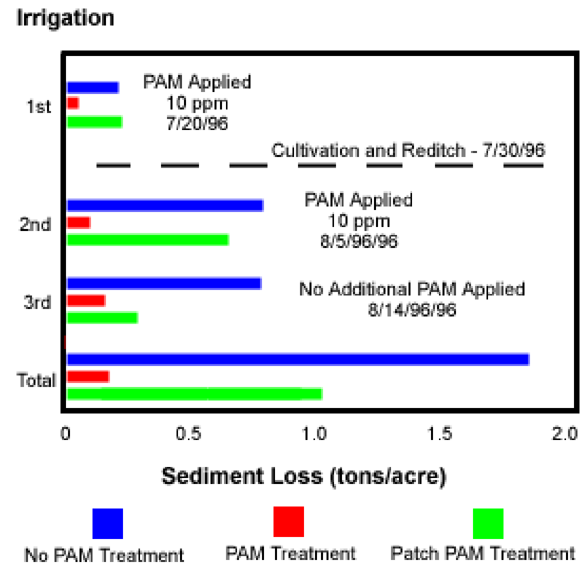

Figure 2. Sediment loss (tons/acre) for each irrigation and total sediment loss (tons/acre) for treatments of no PAM, PAM and patch PAM (1996).

In 1997, four treatments were compared: 1) PAM; 2) no PAM; 3) surge irrigation with PAM; and 4) surge irrigation with no PAM. These results are shown in *Figures 3* and *4*. The advance time to 1,000 feet was similar for all four treatments during the three irrigations. However, the advance times for the treatments using surge irrigation were slightly below the advance times for the conventional irrigation treatments. Soil erosion was consistently less when PAM was mixed with the irrigation water.

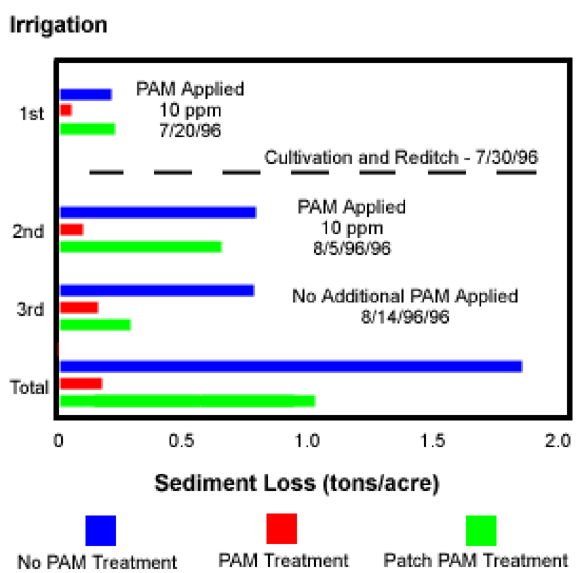

Figure 3. Furrow advance time to 1,000 feet for each irrigation, treatments of no PAM – continuous irrigation, PAM – continuous irrigation, no PAM – surge irrigation and PAM – surge irrigation (1997).

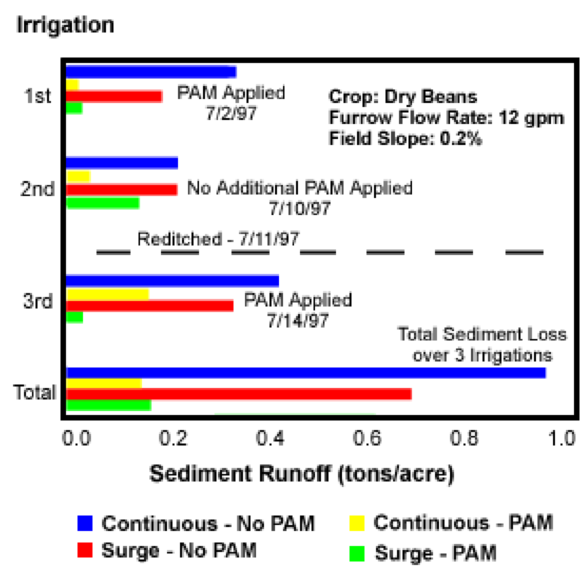

Figure 4. Sediment loss (tons/acre) for each irrigation and total sediment loss (tons/acre) for treatments of no PAM – continuous irrigation, PAM – continuous irrigation, no PAM – surge irrigation and PAM – surge irrigation (1997).

If a producer is using surge and wants to try using PAM, particular attention should be paid to furrow advance time. Surge irrigation, through its wetting and drying process, tends to seal the surface of the soil and reduce intake rate. This, in turn, advances water down the field faster. On many soils, PAM tends to increase soil intake rate by maintaining open pores on the soil surface. The result may be slower water advance times. Using polyacrylamide in irrigation water probably means water management strategies must change. For more information on making management changes to furrow irrigation systems, see NebGuide G97-1338, *Managing Furrow Irrigation Systems*.

Environmental Considerations

Polyacrylamide used for erosion control should have a negative (anionic) molecular charge. Historically, similar compounds have been used in other industries like potable water treatment, food processing, paper manufacturing and wastewater treatment. Research conducted in Idaho showed that less than 5 percent of PAM applied during an irrigation left fields in the runoff water. This research also showed that after leaving the field, the PAM concentration in the runoff quickly fell below detectable limits (>1,500 yards). There is no indication of any adverse impact on soil, plant or aquatic systems when anionic PAM is used to control soil erosion. Because PAM limits soil erosion, using it can prevent nonpoint source pollutants from leaving the field. Nonpoint source pollutants include the soil and contaminants that can be attached to the soil – nutrients, herbicides and pesticides.

Conclusions

Polyacrylamide can control soil erosion that occurs with irrigation; however, like many farming practices, its use, effectiveness and economic return varies from field to field. The use of PAM is relatively new and will require individuals to try different things until recommendations can be developed for specific soil textures and field slopes found in Nebraska.

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