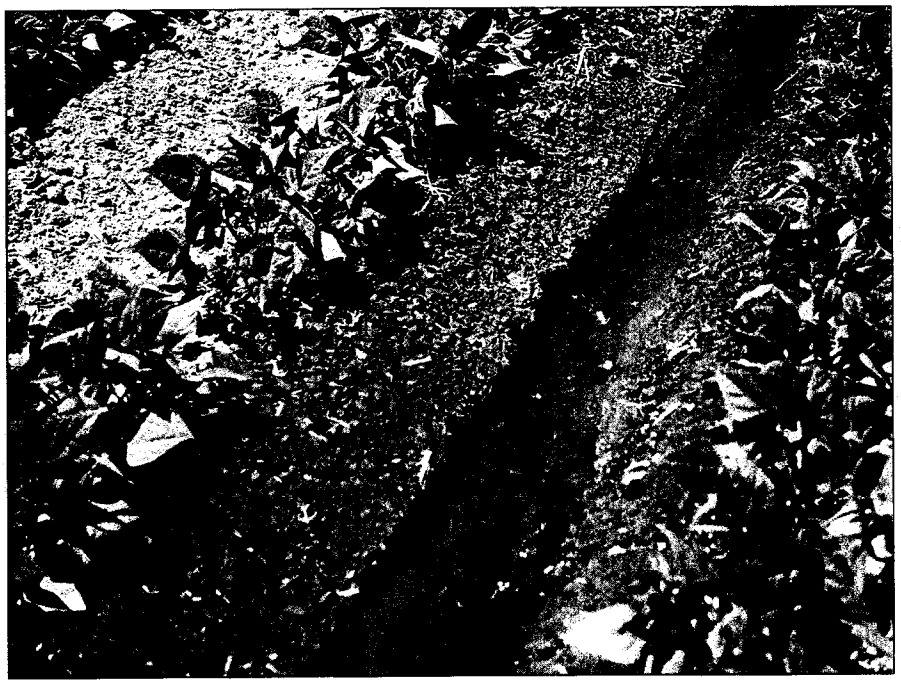
Fighting Erosion in Furrow Irrigation

By Dave Bjorneberg, P.E., Ph.D.

Despite the trend towards center pivot and drip irrigation, furrow irrigation is still used on almost half of the irrigated land in the US. However, soil erosion is an inherent problem when water flows over soil. Erosion causes problems within the field and off the field. Within a field, soil tends to erode from the upper end making furrows deeper. Erosion deposits soil on the bottom end, filling furrows and causing water to flood across rows. Severe erosion can expose plant roots. Fortunately, applying a small amount of polyacrylamide (PAM) to the furrow soil or with irrigation water almost eliminates erosion in irrigation furrows.

During the last 10 years, research at the USDA-ARS Northwest Irrigation and Soils Research Laboratory (NWISRL) in Kimberly, ID, has shown that PAM can reduce erosion in furrow irrigation by more than 90 percent. Erosion reductions with PAM are sometimes less, but this typically occurs on fields with little erosion. In some cases PAM may not be effective if the water has very few soluble salts or a high concentration of sodium salts. The negatively charged PAM molecule works best to flocculate solids and stabilize soil when calcium ions are present in the water to bridge between the soil and PAM.

In fine to medium textured soils, PAM improves infiltration by reducing seal formation on the soil surface. This can result in slower advance times and



All photos courtesy of David Bjorneberg, USDA-AR, Kimberly, ID.

An untreated irrigation furrow in a dry bean field that has been cut along the edge from erosion.

A PAM-treated irrigation furrow on the same dry bean field.

poorer irrigation uniformity if inflow rates on treated furrows are similar to untreated furrows. To alleviate these problems, inflow rate can be increased when PAM is used without causing erosion. However, PAM does not affect infiltration as consistently as erosion, and the effects are soil dependent.

asked about PAM use is an indication of its importance. The four states with the greatest PAM usage were Idaho, Washington, Wyoming, and Colorado (Table 1). PAM was used on 9 percent, 25 percent, 4 percent and 3 percent of the surface irrigated land in these four states, respectively. These percentages would probably be greater if pasture, hay, and small grain acres (crops that usually have little erosion problems) were removed from the total irrigated acreage.

Applying PAM

One of the most important aspects of using PAM is purchasing a polyacrylamide product labeled for erosion control. There are many types of polyacry-

Many irrigators have found that using PAM makes furrow irrigation easier.

Accepted practice

Using PAM to control soil erosion is an approved conservation practice by the Natural Resources Conservation Service (NRCS). PAM industry representatives estimate that about one million irrigated acres in the US are being treated with PAM, based on current product sales. They also report increasing interest internationally. According to the USDA National Agricultural Statistics Service's Farm and Ranch Irrigation Survey, PAM was used on almost 350,000 surface irrigated acres in 1998. This was 1.4 percent of the total surface irrigated acres or 2.7 percent of the furrow irrigated acres, assuming PAM was not used on basin or border irrigation. Just the fact that the 1998 survey

lamides produced. PAMs labeled for erosion control are anionic, high molecular weight, linear products. Do not use gel-forming, super-water absorbent or crosslinked (non-linear) PAMs for erosion control. The PAM should also have less than a 0.05 percent acrylamide monomer (AMD) by weight.

PAM needs to be applied whenever soil is disturbed. It can be applied either with the irrigation water or directly to the irrigation furrow. The original NRCS standard method was to apply PAM at 10 ppm with irrigation water only while water advanced across the field. Applying PAM with the water is the best way to be sure the entire furrow is treated. Recently the original NRCS standard was modified to include applying PAM directly to the soil within the first five feet of the furrow. Applying a "patch" of PAM (about one to two tablespoons) to the soil is an easy way for irrigators to experiment with PAM. For the greatest benefit, PAM should be applied before inflow is started. Then PAM slowly dissolves in the irrigation water, continuously treating the soil during the entire irrigation. The patch method may not be as precise as metering material into irrigation water, but NWISRL tests show it is equally or more effective. The patch method also is preferable when inflow water contains high sediment concentrations because PAM flocculates sediment, potentially causing sediment to fill ditches and pipes. The downside of using the patch is that it can be covered with sediment or washed away with high inflow rates (for example 25 gpm).

A conservation tillage plot with crop residue that has been treated with PAM.

Table 1. Top Ten States Using PAM with Surface Irrigation According to 1998 Farm and Ranch Irrigation Survey

State	PAM Use (acres)	Surface Irrigation (acres)	Percent PAM Treated
Idaho	87,497	991,613	8.8
Washington	63,262	252,312	25.1
Wyoming	51,220	1,295,332	4.0
Colorado	46,892	1,663,571	2.8
California	25,719	5,819,660	0.4
Arkansas	14,220	3,495,198	0.4
Missouri	13,563	495,250	2.7
Oregon	13,530	745,083	1.8
Nebraska	11,670	2,020,438	0.6
Arizona	5,500	792,806	0.7

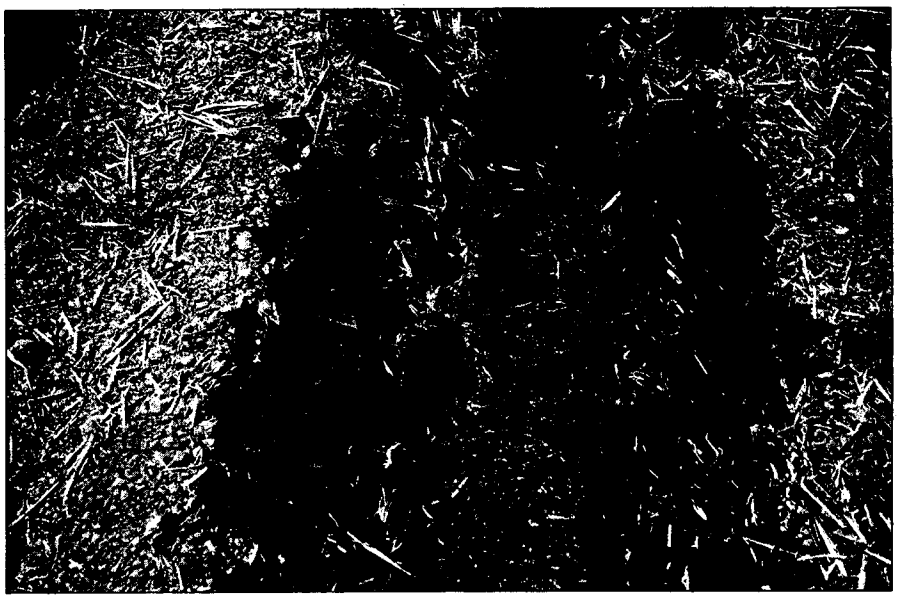
PAM makes irrigating easier

Controlling erosion is a good idea, but farmers tend to choose practices that improve net income or make life easier. Many irrigators have found that using PAM makes furrow irrigation easier. Reducing erosion reduces side-cutting in furrows. Severe side-cutting can cause irrigation water to cross over to an adjacent furrow leaving part of a furrow dry while the adjacent furrow receives too much water, causing excessive erosion in that furrow. Crop residue bridging across a furrow catches eroded sediment, causing a dam in the furrow. PAM can reduce damming by reducing sediment transport. Reducing side-cuts and damming result in fewer trips through the field with a shovel to keep water flowing down a furrow. A Nebraska farmer once reported that PAM allowed him to use conservation tillage because residue no longer plugged his furrows. Conservation tillage, in turn, reduced wind erosion on his farm.

Using PAM can also make filter strips a manageable practice with surface irrigation. Grassed filter strips on the bottom end of

the field can protect return flow ditches from eroding as water leaves the field. In the past, some farmers tried using filter strips to reduce sediment in irrigation return flow only to remove them after excessive sediment smothered the grass. Using PAM on the field keeps filter strips from being overloaded with sediment.

Reducing soil erosion obviously helps maintain the long-term productivity of the soil, but side-by-side comparisons have yet to prove that using PAM consistently increases crop yields in the short term. Some brief studies on research plots and farmers' fields showed no significant difference in dry bean yield between PAM-treated areas and untreated areas. These comparisons, however, were conducted on fields with uniform slopes. Using PAM could impact crop yields on fields with varying slope where eroded soil from steep areas, which are deeply eroded and under-irrigated, is deposited in lower, flat areas of the field, causing flooding and excessive infiltration.



The same conservation tillage plot that was untreated. The additional sediment from the residue and the flowing water is cutting into the side of the furrow.

More than stops erosion

Using PAM with furrow irrigation does more than reduce erosion. Nutrient and pesticide losses are also reduced, primarily because runoff water contains less sediment. Recent research by Bob Sojka, NWISRL soil scientist, and Don Morishita, Univ. of Idaho weed scientist, has shown that PAM also reduces weed seeds transported in furrow irrigation runoff. On a particular field however, more weed seeds remain in the soil where they can germinate. However, if your upstream neighbor uses PAM, you should have fewer weed seeds moving unto your field with irrigation water. Sojka and Jim Entry, NWISRL soil microbiologist, have found similar results with microorganisms - fewer microorganisms are transported in PAM-treated furrows. This suggests that wide spread use of PAM could reduce weed seed and disease migration among fields within surface irrigated watersheds.

Other PAM Research

Several PAM research projects are continuing at the NWISRL. They involve using PAM with surge irrigation, improving irrigation uniformity with PAM and surface active ingredients, and applying PAM with sprinkler irrigation. For more information about PAM research, check out the NWISRL's PAM research page at http://kimberly.ars.usda.gov/pampage.shtml.

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Widespread use of PAM could reduce weed seed and disease migration among fields within surface irrigated watersheds.