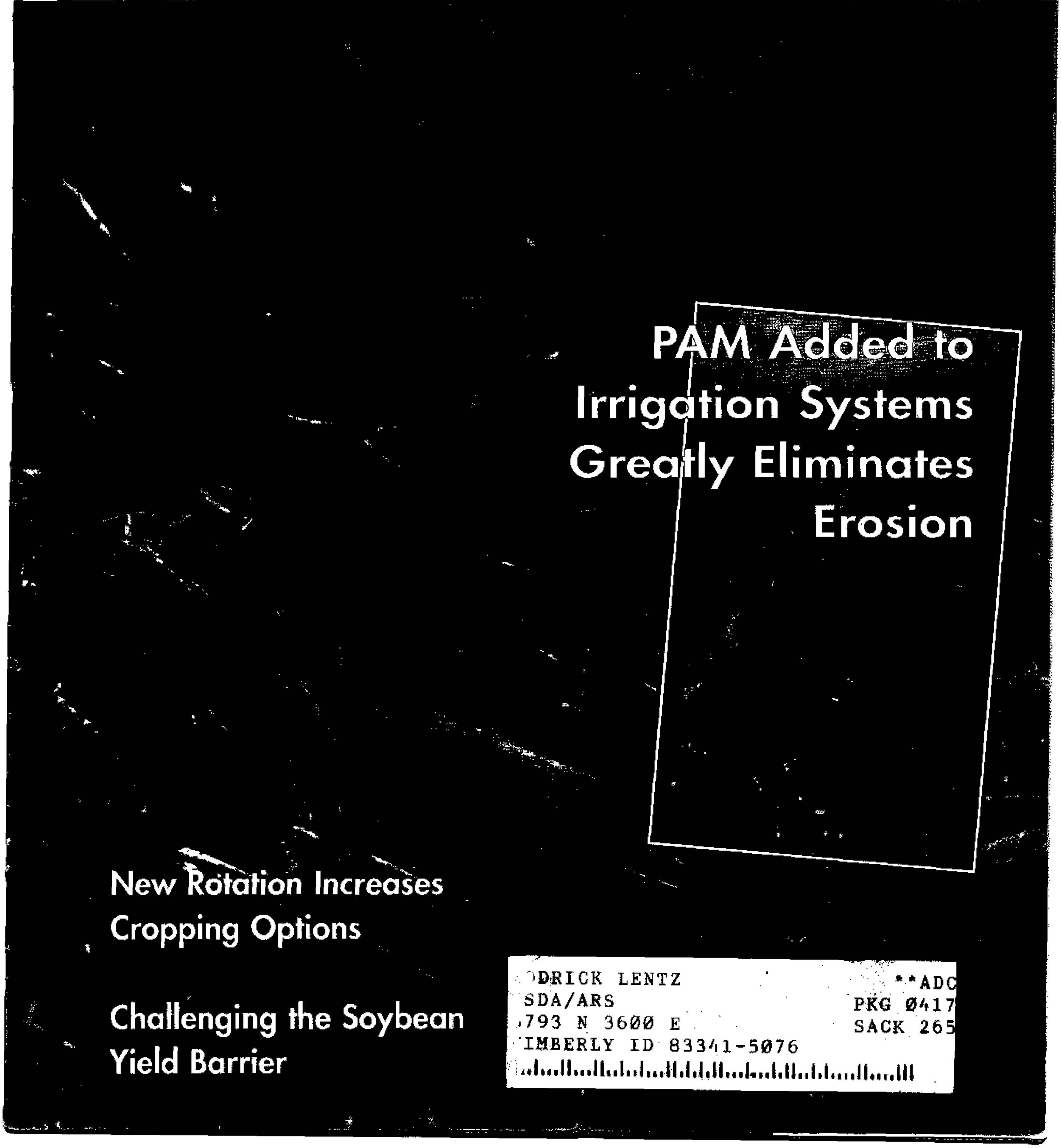
Conservation Tillage

FEBRUARY 1997

Official Publication for State Conservation Tillage Associations and Districts



PAM Added to Irrigation Systems Greatly Eliminates Erosion

New Rotation Increases Cropping Options

Challenging the Soybean Yield Barrier

Polyacrylamide (PAM) For Erosion Control

By Rick Lentz and Bob Sojka

ARS technician holding cones showing a control sample and a treated sample.

Erosion is one of the banes of agriculture; it just won't go away. Its curse has hunkered over tillers of the soil for thousands of years, stealing soil, nutrients and productivity. Soil erosion is highly detrimental, both on and off site. It has been blamed for the loss of peoples and the collapse of civilizations. Now, a technology that uses an off-the-shelf chemical flocculent provides a convenient and economical means of fighting back. The chemical flocculent is PAM, short for polyacrylamide. Field studies conducted since 1991 by the USDA's Northwest Irrigation and Soils Research Laboratory (Kimberly, Idaho) demonstrated PAM's ability to practically eliminate water erosion on furrow irrigated fields. These findings have stimulated the imaginations of other scientists and farmers, who are exploring PAM's potential for controlling erosion and increasing infiltration under sprinkler irrigation and on construction sites and improving emergence of row crops.

"... PAM may eventually be economically useful in rainfed agriculture."

PAM belongs to a class of materials called polymers. Polymers are very large molecules made from smaller identical building blocks that are chemically linked together. The PAM used in erosion control is made from two types of building-block units. Several hundred thousand of these units are linked together into a long chain to produce a water-soluble, "linear" copolymer. It is this linear PAM that is used to control erosion. Unfortunately, the linear PAM is often confused with a related "cross-linked" form that has very different properties. The "cross-linked" PAM is produced when many individual linear copolymer chains bond together. The resulting massive and complex molecule is not water soluble. The "cross-linked" polymer is a highly absorbent material with a large water-holding capacity. It is often used as a soil conditioner to increase plant available soil water or as an absorbent in disposable diapers. However, it is the water soluble, linear PAM that is used in this erosion control technology and discussed in the remainder of this article.

The PAM molecule's size and charge characteristics are important because they determine how PAM reacts with soil. The linear PAM used in erosion control has a very high molecular weight of 12-15 million grams per mole. When dissolved in water, about 18% of the PAM's building-block subunits ionize, giving the molecule a negative (anionic) charge. This PAM stabilizes and strengthens soils and acts as a settling agent. A settling

Continued on p. 24

Polyacrylamide (PAM) For Erosion Control

Continued from p. 21
agent causes individual soil particles suspended in the flowing water to stick together, forming larger and heavier soil clumps that settle to the furrow bottom. PAM was tested in a three-year ARS study conducted in Idaho. Applying about one pound PAM per acre in irrigation water cut field soil losses by 94% and increased net infiltration into furrows by 15%. The combined effect of reduced furrow down cutting and greater infiltration, increased lateral water movement toward the planted row by 25%. PAM treatment greatly improved runoff water quality. Treated furrow runoff was clear, having little sediment and markedly lower concentrations of phosphorus, nitrate and organic materials.

PAM works most effectively when it is dissolved in the irrigation water that first flows down the furrows and wets the soil. PAM concentration in irrigation water should be 10 ppm (i.e. 10 parts PAM for every million parts water). Typically, PAM-treated water is used only during the furrow advance phase, that period in the early part of the irrigation when water first overruns and wets (treats) the dry soil. Then untreated irrigation water is used for the remainder of the irrigation. During initial wetting, PAM in infiltrating water contacts and becomes bound to a thin layer of soil on the surface of furrow clods and along the wetted furrow. The treated soil is more cohesive and stable, and is less likely to rupture, disintegrate, or move downstream in flowing water. Any fine soil particles in the furrow stream adhere to one another and form larger particles that settle out of the flow. Compared to untreated furrows, PAM-treated soils have a coarser structure, furrow surfaces are rougher, and the depositional layer that forms along the furrow bottom, is more porous. This allows infiltration rates to remain high, maintains lower runoff rates and helps prevent erosion and soil loss. Not all irrigations need be treated, but we recommend that irrigations done early in the season, and those on disturbed soils be treated with PAM.

PAM use for preventing furrow irrigation-induced erosion is growing rapidly in the irrigated West. Most farmers buy granular PAM from local farm suppliers in 55 lb. bags at a cost that ranges from $3.50 to $5.00 per pound. The PAM is applied to the water supply using home-built or purchased devices that include a storage bin and a battery-powered Gandy© applicator or auger-screw system that drops PAM crystals into the water flow at a uniform rate. Turbulence is introduced in the water just downstream from the point of application to help dissolve and disperse the PAM. Flow drops or dams placed in the downstream flow produce sufficient turbulence in most cases. PAM is also available in either 30% or 50% inverse oil emulsion concentrates that dissolve more easily when dribbled into flowing water.

PAM is an environmentally safe material. At concentrations used in field application, it has no known toxic effects on humans or other mammals, aquatic vertebrates or invertebrates, or plant life. It has been listed by U.S. EPA as an "Acceptable Drinking Water Additive" and has gained a variety of FDA approvals for food additive applications. In soil, PAM acts like other naturally occurring, persistent forms of organic matter, degrading to H_20 and CO_2 at a rate of approximately 10% per year.

There are a number of different types of polyacrylamides available for sale. Farmers should verify that the PAM they purchase for anti-erosion is the anionic, high molecular weight, water soluble type and contains less than 0.05% of the monomer, acrylamide, which is regulated by law. At these levels, the acrylamide monomer, a manufacturing contaminant, poses no threat to soils or surface waters. Unlike polyacrylamide, the acrylamide monomer rapidly biodegrades in soil or water, decomposing in a matter of hours.

Some farmers have already used PAM in center pivot sprinkler systems to increase infiltration and reduce runoff and erosion. An emulsified PAM concentrate is injected into the sprinkler source flow to obtain a 10 ppm concentration, which is delivered to the field in varying amounts of water. The farmers saw definite improvements using the PAM. Scientists are currently researching this new application method. In addition, engineers have successfully used PAM on disturbed construction-site soils to increase infiltration and reduce erosion from rainfall. More investigation needs to be done, but these successes suggest that PAM may eventually be economically useful in rainfed agriculture. While PAM is not the ultimate solution to agricultural erosion, it is a conveniently applied technology that can be used immediately to dramatically reduce soil losses and nonpoint source pollution. As such, it is one of the most exciting and effective new weapons available in our agricultural arsenal. The final solution to agricultural erosion most likely will rely on a system approach that utilizes conservation tillage techniques and residue management to build up and maintain soil strength and structure. Even then, some rotations that include a low-residue crop will probably require additional protection, like that supplied by PAM. ▲

Rick Lentz and Bob Sojka are soil scientists at the USDA Agricultural Research Service, Northwest Irrigation and Soils Research Labortatory, Kimberly, Idaho.

At Left: Farrow irrigation without PAM treatment.
Below: Farrow irrigation with PAM treatment.