OPTIMIZING irrigation water

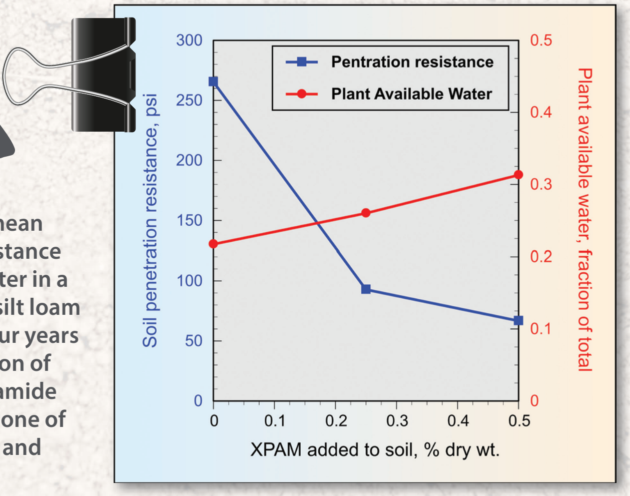
This furrow-irrigated field in southern Idaho has soils with low organic matter and high volcanic ash fractions, which are highly susceptible to erosion. The furrow stream on the left was untreated and shows sediment load and head-cut erosion (lower left). The furrow stream on the right was treated with 10 mg/L water-soluble anionic polyacrylamide (WSPAM) during stream advance.

PAM optimizers are powerful tools for irrigation and are most effective when the application is customized for the circumstances.

By Rodrick (Rick) D. Lentz, PhD

When applied properly, the synthetic organic polymer, polyacrylamide (PAM), can provide substantial water quality, infiltration and water retention benefits to irrigated agriculture. To achieve peak performance, applications may need to be fine-tuned for individual circumstances.

The term PAM refers to a family of polymers, all composed of two components (monomers), acrylamide and acrylic acid, which occur in varying proportions depending on the polymer. Polyacrylic acid polymer, which includes no acrylamide monomer, is sometimes included in the PAM category. The acrylate monomer ionizes in water, giving the PAM a positive charge that helps bind the polymer to soil particles. PAM comes in two forms: 1) The water-soluble form (WSPAM) can be used to stabilize soil structure, increase infiltration and reduce soil erosion, particularly in furrow irrigation, and 2) The nonsoluble form is comprised of WSPAM polymers cross-linked together to form a massive, porous product (XPAM). XPAM can absorb >100+ times its weight in water and is added to soil to increase its water retention, improve structure, reduce water and nutrient leaching losses, and improve root penetration.



The figure shows the mean soil penetrometer resistance and plant available water in a degraded, calcareous silt loam soil (0-6 inch depth) four years after a one-time addition of cross-linked polyacrylamide (XPAM) was applied at one of three rates (0%, 0.25% and 0.5% dry wt.

Water-soluble PAM in furrow irrigation

WSPAM is commonly added to furrow irrigation water, primarily in the irrigations applied to freshly formed or cultivated furrows, which tend to be highly susceptible to erosion. The polymer can be added to irrigation water at 10 ppm during furrow advance only or continuously at 1 to 2 ppm. The latter is often achieved using a special tool to sprinkle about 1 ounce of granular WSPAM at the furrow head near the inflowing water. These approaches are effective for reducing erosion and increasing infiltration over a broad range of conditions; however, a few factors need to be considered to achieve maximum efficacy of the WSPAM treatment:

- **irrigation water quality** – If irrigation water has an unusually low salt concentration such as from an irrigation source that receives a large influx of snowmelt waters, is high in sodium or contains high sediment loads, the application may need to be adjusted to be most effective.
- **soil properties** – Shortly after irrigation begins, infiltration in furrow soils quickly declines due to the breakdown of soil structure and formation of a slowly permeable surface seal. WSPAM increases infiltration in the furrow by stabilizing soils in the channel and delaying or preventing seal development. Therefore, WSPAM may not improve water intake for soils where infiltration already is inhibited by a restrictive subsoil horizon. Similarly, in furrow soils that lack structure entirely, such as in sands, WSPAM applied to water at >2 ppm may reduce infiltration due to viscous effects. This is beneficial since it can increase irrigation uniformity in such soils. Recent research indicates that relative decreases in initial soil water content and increases in water temperature or salt content can increase infiltration benefits derived from WSPAM treatments.

In general, WSPAM has been shown to effectively control furrow erosion for most soils and irrigation waters present in semiarid farmlands. The polymer achieves its greatest reductions in runoff sediment losses in those soils that are most susceptible to erosion. In the few studies that have evaluated WSPAM in regions with wetter climates (i.e., having generally acidic soils and irrigation water), results have been mixed. Soils high in shrinking-swelling clays and organic matter may require greater WSPAM application rates, although research on such soils is also limited.

Increasing soil water retention with XPAM

Cross-linked polymers, including XPAM, have been employed in the horticulture and nursery industries for at least 25 years to increase water retention in potting mixes that are engineered for thorough drainage. XPAM could be a useful amendment for arable lands, where soil productivity potential is generally declining while food demand is rising. A cost-effective means of increasing plant available water would be of great benefit to remediate degraded soils, buffer effects of drought and climate change on rainfall and irrigation water supplies, and bring soils with marginal water potential into production. Though much research has shown that XPAM additions reduce crop stress and increase yields under drought, little XPAM is used at the farm level because initial costs are high and the durability of XPAM properties in soil is poorly understood. Recent research has shown that the mean residence time of XPAM water-retention benefits in a degraded soil was far longer (at least 24 years) than previously estimated (3-5 years), substantially increasing the cost-effectiveness of the practice. Conversely, water retention benefits of the cross-linked polyacrylic acid polymer tested persisted for only one growing season.

The use of XPAM in humid regions may present a challenge, since increased soil water retention during periods of surplus precipitation could create problems associated with excess water: slow soil drying/warming in spring and delayed tillage and planting. XPAM additions to irrigated soils in semiarid lands may provide the most benefits because water deliveries to fields in these areas are intensively managed and can be limited or delayed. However, in such areas, the soil profile still needs to be flushed periodically using an adequate leaching fraction to avoid salt accumulation. The amount of water absorbed by XPAM declines with increasing salt content in soil or irrigation water, though this is partially influenced by the type of cations present.

Rodrick (Rick) D. Lentz, PhD, *is a research soil scientist at the USDA-ARS Northwest Irrigation and Soils Research Laboratory in Kimberly, Idaho.*

THOUGH MUCH RESEARCH HAS SHOWN THAT XPAM ADDITIONS **REDUCE CROP STRESS** AND **INCREASE YIELDS UNDER DROUGHT**, LITTLE XPAM IS USED AT THE FARM LEVEL.