0038-075X/94/1584-233$03.00/0
SOIL SCIENCE

October 1994
Vol. 158, No. 4
Printed in U.S.A.

TIME FOR YET ANOTHER LOOK AT SOIL CONDITIONERS

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As the Allied forces fought to crush the backbone of the Axis powers in World War II, they built scores of airfields and temporary roads, seemingly overnight and frequently in marginal locations under adverse weather conditions. The job might have been impossible, and the war might have been prolonged, had chemical soil conditioners not been developed (Wilson and Crisp 1975). With chemical soil conditioners to stabilize soil structure and prevent the hastily constructed landing fields from returning to mud wallows, trucks kept rolling and Allied planes were able to land and take off to push the offensive.

The technology came home from the war with the troops and made its way to the agricultural arena in the early 1950s. From then through the 1970s, organically derived materials, such as polysaccharides, guar extracts, and starch copolymers, and numerous synthetic materials, including various formulations or copolymers of hydrolyzed polyacrylonitile (HPAN), vinylacetate maleic acid (VAMA), polyvinyl alcohol (PVA), polyacrylamide (PAM), and others have been studied extensively. Their uses have been primarily for soil structure stabilization in horticultural, agronomic, and construction applications (Azzam 1980; De Boodt 1993; Gabriels 1990). The techniques for stabilizing soil plow layers, complete soil volumes in containers, seed rows using banded concentrates, and soil for other high-application rate, high-value uses have been heavily researched and reviewed.

Interest in stabilizers has advanced and receded several times in the last 40 years as new classes of stabilizers or new uses for them have been identified. However, each interest cycle has ended in relative disappointment because high polymer cost, coupled with high application rate strategies, consistently limited use in general agriculture. These setbacks and disappointments have handicapped continued development and promotion of the technology for agriculture. Many soil scientists have become disillusioned and have essentially dismissed this technology for practical agricultural use.

Why, then, are we publishing yet another proceedings on the topic? The answer is at least fourfold. New polymers (very high molecular weight anionic PAMs) have again created new possibilities. We are focusing narrowly on a new low-rate irrigation water treatment strategy. Together, these may finally achieve economic feasibility for PAM in a general agricultural niche. Finally, and perhaps most importantly, this use could have important environmental, soil conservation, and irrigation efficiency benefits. The potential environmental windfall could provide an entirely new motivation for soil conditioner use. You will learn many of the important details on the pages that follow.

We have attempted to broaden treatment of the topic beyond the boundaries of soil science by including engineers, a polymer physical chemist, a biochemist/microbiologist, and an industrial polymer chemist in addition to several soil scientists. All are recognized experts in various aspects of the new PAM technology. They have assembled a fresh body of coordinated information crucial to continued development of this newest opportunity for PAM to provide problem solutions and environmental benefits.

Our attention is directed to PAM use in irrigation water. Specifically, new very high molecular weight anionic polyacrylamides are now commercially available that, when added to irrigation water (approximately 3–7 kg/ha/year, typically 10 ppm applied only in the initial phase of certain irrigations), nearly eliminate irrigation-induced soil erosion and tailwater degradation while significantly increasing infiltration efficiency.

Because environmental aspects of irrigation are increasingly scrutinized, new technologies that reduce its negative impacts are very important. Irrigation accounts for 17% of the world's crop-agriculture land use, but produces twice the per acre yield of rainfed agriculture and accounts for more than twice the harvest value. If we

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Received June 3, 1994; accepted June 9, 1994.

could no longer use irrigation on the 250 million hectares of irrigated farmland worldwide, we would have to plow under over half a billion rain fed hectares to replace them.

These PAMs are manufactured to stringent standards. They are low in monomer contamination and are already FDA and EPA approved for sensitive uses such as food processing and potable water treatment (<5 ppm). PAMs approved for these uses must maintain monomer levels below 0.05%. They should not be compared with inefficiently benchtop-synthesized PAMs such as those prepared for electrophoresis. Nor are they cationic PAMs, a class of PAMs known to have higher irritant and toxicity problems. Although minute amounts of monomer are applied to soil with PAM, the monomer degrades rapidly (a few days) in warm (30°C) soil. Similarly, PAM does not seem likely to breakdown to the monomer since microorganisms utilize amide functional groups as nitrogen sources, preempting acrylamide formation. All these issues are confronted in detail on the pages within.

We feel it is legitimate to embrace the promise of this new technology with a good deal of enthusiasm. At this writing the baseline "technology" for controlling furrow irrigation-induced erosion with PAM is rather well worked out. As with most agricultural technology, it will require some adjustments for field, soil, and water quality variation. The development of what we have been calling "the bag to furrow" methodology is the next significant hurdle for acceptance and use of the technology. PAM use in sprinkler systems is less well understood and researched. It will likely require greater PAM application rates. Finally, increases in net infiltration require changes in irrigation water management, but farmers are used to altering their water management in response to agricultural practices that change infiltration.

Poised at the brink of what could turn out to be PAM's first significant penetration of general agriculture, this symposium offers a chance to ask new questions important to adoption of the new PAM technology. What are the pressing current and future research needs? Our experience suggests the following: determine and be able to quantifiably predict the influence of field soil factors and conditions on PAM efficacy; determine and be able to quantifiably predict how various PAM application practices affect PAM loss in runoff and its fate in specific soils; quantify the effect of these new PAMs and the new application strategies on crop performance, yield, and quality for the new range of applications expected; perform the basic science needed to conclusively explain PAM's mode of action using the new technology; quantify the impact of PAM on the fate and management of the agrichemicals likely to interact with PAM, develop cheap biopolymers from renewable agriculturally derived organic materials that match or exceed PAM's field performance.

Finally, we would like to express our thanks. First, thanks to CYTEC Industries for their gift toward the publication expense of the symposium. Thanks also to the Soil Science Society of America who supported travel of invited international contributors. And thanks to our symposium participants who gave so generously of their time and talent.

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