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Super Absorbent Polymer (SAP) and Irrigation Water Conservation

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Human activities require more and more resources- among them water is certainly the most precious. Modern agriculture consumes almost two thirds of the water pumped in United States. For this reason, more and more people are seeking ways to conserve it. In the quest for improving water conservation in soils during irrigation, the United States Department of Agriculture (USDA) conducted studies on various materials in the early 1960s. As a result, a resin based on the grafting of acrylonitrile polymer onto the backbone of starch molecules (starch-grafting) was developed, which was known as "Super Slurper". At the time, the USDA gave the basic technology to several USA companies for further development. As the Japanese companies were excluded from participating, they started independent research using starch, carboxy methyl cellulose (CMC), acrylic acid, polyvinyl alcohol (PVA) and isobutylene maleic anhydride (IMA). The hydrolyzed product of the hydrolysis of this starch-acrylonitrile co-polymer gave water absorption greater than 400 times its weight and did not release water as fiber-based absorbents do. *Could super absorbent polymer (SAP) be the future of irrigation water conservation?*

In the early 1970s, SAP was used commercially for the first time – not for soil amendment applications as originally intended – but for disposable hygienic products. Sodium acrylate and starch-graft polymers accounted for virtually all of the commercial volume of SAP and have remained the commercially preferred SAP material during the period. While significantly lower cost is attained by the starch-grafted SAPs, they are not preferred by end-users due to inferior performance characteristics. These polyacrylate polymers had the disadvantage of salt instability and difficulty in achieving high absorption under load at moderate pressures, as the materials would dissolve partially. However, this problem was solved by partly cross-linking the polyacrylate to provide a more stable networked structure.

Early global participants in developing SAPs based on cross-linked acrylic homo-polymers, usually sodium neutralized include Dow Chemical, Hercules, General Mills Chemical, DuPont, National Starch & Chemical, Enka (Akzo), Union Carbide, Sanyo Chemical, Sumitomo Chemical, Kao, Nihon Starch and Japan Exlan. However, over the years, technology improved SAPs used in soil amendments applications, were cross-linked acrylic-acrylamide co-polymers with potassium neutralization. Though toxic intermediates are sometimes used in the manufacturer of these polymers, cross-linked SAPs used for soil amendments are non-toxic, inert with increased shelf life and last for years in the ground.

Earlier efforts using SAPs for soil amendments, predominantly in greenhouse, proved unsuccessful due of its low swell and high cost per unit water held. However, further research helped, developed SAP that improved soil water availability and holding capacity, soil infiltration and aeration thus reducing soil compaction, and enhancing soil water management practices. As aeration provides the exhaust of carbon dioxide expelled by growing roots and other microorganisms in the soil, it also enables the intake of oxygen into the soil, which is necessary to support root development and growth. It is important to note that aeration in planting mix is much more difficult to manage than moisture, because if moisture deficiency exists, frequent irrigation can be employed, however, if aeration deficiency exists, the plant must be removed and the growing environment (root zone) modified with larger particles to improve drainage and porosity.

The amount of water retained in the soil is determined by soil particle size, as the larger the particle size, the less the ability to attract and retain water, and conversely, the smaller the particle the greater the ability to attract and retain water. Because aeration and retained available water are directly associated to larger soil particles and water retention and lack of aeration are directly associated with smaller soil particles, growing medium for plants has perplexed growers and makers of potting mixes for years. Using more stable SAP mix components is a major step toward improving production and controlling problems associated with traditional management of a growing media. A major advantage of using SAP is its ability to make use of moisture present in soil such as clay, and make it available to the roots. SAP amended soils have better nutrient release, high nitrification, reduced microflora and bacterial content. The plant response to the amended soil include but not limited to, reduced iron chlorosis, increased yield due to the available water in the SAP amended soil due to its ability to absorb water hundreds of times its weight.

Studies have shown that SAP is sensitive to the action of ultraviolet rays, which by breaking bonds; degrade the polymer into oligomers (molecules of much smaller size). These polyacrylates thus becomes much more sensitive to the aerobic and anaerobic processess of microbiological degradation, therefore degrade naturally in soils (up to 10% to 15% per year), in water, carbon dioxide, and nitrogen compounds. The polyacrylates is too voluminous to be absorbed into the tissues and walls of plants that it has no potential for bioaccumulation. It is ideal solution for containers, hanging plants, and houseplants, and it has also shown its effectiveness in large-scale farming, especially at the time of germination and development of the root network due to good aeration of the soil.

The overall benefit includes improved soil drainage, reduced pesticide use, improved fertilizer usage, and reduced irrigation watering by 30% to 50% as well as labor costs, as plants are watered on a schedule between field capacity and wilting. Studies have shown that over 90%

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of moisture held by SAP as it expands and contracts is available to the plant, therefore suggesting that no other component used in growing mixes provides this much retained water to the plant. United States and Europe, with a combined share of 58% in 2007, represent the largest markets for SAPs. In the United States alone, the market for SAP was projected to reach 419,000 tons by 2010. It was also suggested that Asia-Pacific, Middle East and Latin America represent the markets with enormous potential. Asia-Pacific market was projected to reach 207,000 metric tons for 2010. Though disposable diapers continue to remain the largest end user for SAP, accounting for over 76% of global sales for 2007, agricultural uses for seed coatings/potting compounds and water retention in arid planting areas rely on SAP's hydrogel properties.