NEWS - 08.09.2024

Polyacrylamides for Improving Soil Structure and Water Conservation

By Ridha Bergaoui - In Tunisia, agriculture is primarily rain-fed, and agricultural production is closely tied to precipitation in terms of both quantity and temporal and spatial distribution. Aside from water, the main factor for plant development, production also depends on many other factors such as soil quality, fertilization, farmer expertise, and pest management.

The Importance of Soil Quality

Soil quality is crucial for plant development and performance. Fertile, healthy soil ensures good yields and high-quality produce. According to a report titled "Strategic Review of Food Security and Nutrition in Tunisia," the Tunisian Institute of Strategic Studies reveals that 96% of Tunisia is at risk of desertification. Water erosion removes 10,000 to 30,000 hectares

of land annually. Wind erosion affects the southern and central parts of the country. The area affected by moderate to high salinization is estimated at 12 million hectares, removing 3,000 hectares of productive (irrigated) land each year.

The organic matter content in Tunisian soils is generally low, rarely exceeding 1%, whereas it is recommended to have at least 2-3% for optimal plant development and soil health. Organic matter provides essential nutrients to plants and plays a central role in soil structure, stability, and erosion control. It also contributes to soil aeration, permeability, and water retention. Our soils retain little water, and our crops rely heavily on mineral fertilization, which, if overused, represents a significant financial loss and has severe consequences on soil and groundwater.

Many agricultural lands are on slopes and are highly susceptible to erosion. Torrential rains often lead to runoff, as the soil cannot absorb all the water, causing erosion. This runoff leads to sedimentation in dams, reducing their lifespan, especially in the absence of trees that stabilize the soil.

Climate change is likely to worsen the situation, with increasing desertification and soil salinization due to declining groundwater levels and deteriorating water quality in irrigation areas. Water scarcity, high risks of water and wind erosion, and soil salinization are significant barriers to agricultural development.

Possible Solutions

In addition to correct agricultural practices such as avoiding monoculture, practicing crop rotation with legumes or rapeseed, and implementing erosion control measures (both water and wind erosion), soil quality can be improved through appropriate amendments to address permeability issues, compaction, poor drainage, or deficiencies. Amendments can be organic, inorganic (such as gypsum and lime), or increasingly, synthetic.

Organic amendments are the ideal solution. Adding large quantities of manure or compost, applying green manure from legumes, and incorporating crop residues to increase soil organic matter content should be a constant concern for farmers. These practices improve soil structure, permeability, water retention, and fertility. Mineral amendments (calcium carbonate, various minerals) balance soil pH, enhance structure, and stimulate microorganisms. These amendments are recommended in case of deficiencies. Unfortunately, both organic and mineral amendments are very costly due to transport, purchase, and application. Manure is becoming rare, difficult to handle, and poses transport issues.

Synthetic conditioners, due to their proven efficiency, required low quantities, and favorable prices, are increasingly used to combat erosion and improve soil structure and water retention. Polyacrylamides (PAMs) are particularly noted for their effectiveness.

Use of Polyacrylamides in Agriculture

Polyacrylamides (PAMs) are high molecular weight polymers of acrylamide, soluble in water. Depending on their ionic characteristics, PAMs can be non-ionic, anionic, cationic, or amphoteric. PAMs are used in various fields, including water treatment, paper manufacturing, textile industry, and oil and gas industries.

In agriculture, PAMs are primarily used to improve soil structure, reduce erosion, and increase water retention. Anionic PAMs are most commonly used. These PAMs bind to fine particles and form aggregates in the upper soil layer where plant roots develop. They increase soil porosity, infiltration, water retention, and reduce stagnation. PAMs also reduce runoff, compaction, and soil erosion.

PAMs facilitate root penetration, aeration, and improve plant growth and crop productivity. In dry conditions, they enhance rainwater efficiency. In irrigated conditions, they reduce water usage while improving crop productivity, leading to significant water and labor savings. Nutrients in the soil or solution are retained and not leached away, resulting in better efficiency and reduced pollution risks. The effectiveness of PAMs depends on soil type and condition. They are particularly useful in poorly structured soils but do not provide nutrients for soil microorganisms or plants like organic amendments. Their use should be complemented with appropriate fertilization for optimal crop yields.

PAMs have been used in the US since 1991, in Australia since 1997, and in Canada. They are also employed in many other countries in Europe and Africa. In the US, approximately 800,000 hectares of irrigated land are treated with PAMs annually for soil and water management.

Application of PAMs in Agriculture

PAMs are easy to use. They come in tablet, powder, or liquid form. They can be dissolved, added to irrigation water, and used in all irrigation systems: drip, sprinkler, furrow, etc. Their effectiveness lasts from 4 to 8 weeks depending on environmental conditions. They are usually applied at 5 to 6 liters per hectare, with repeat applications during the last 4 or 5 weeks of the crop cycle, as the effect is cumulative and related to the plants' growing needs. Manufacturers guarantee a 30% reduction in irrigation water. PAMs can be used for all crops, both dry and irrigated, especially for high-value crops such as fruit trees or vegetables.

Since the 1990s, PAMs have been considered safe and environmentally friendly. In the soil, PAMs degrade after a few weeks due to UV rays and microorganisms, producing water, CO_2, and ammonium nitrate. They do not pose danger or cause residue pollution. However, PAMs may contain some acrylate molecules that are harmful, so precautions such as masks, gloves, and lab coats are necessary during handling. Various international health authorities approve these products.

In Tunisia, PAMs are becoming known and used by some farmers. They have observed improvements in soil quality, soil moisture levels, and water savings. There is also an increase in production compared to control plots without PAMs.

Some PAMs are designed to trap salts and are recommended for treating saline soils or irrigation with saline water. They enhance salt solubilization and leaching, thus protecting soil from salt accumulation even with highly saline water.

PAMs differ from superabsorbent polymers (SAPs) or water retainers. SAPs can absorb large amounts of water (from irrigation or rain) and store it in the soil for plant use as needed. SAPs are much more expensive than PAMs, have a longer lifespan, and must be amortized over 5 or 6 years before degradation. SAPs are better suited for arboriculture, nurseries, or forestry.

Conclusion

Poor soil quality and water scarcity are two critical factors limiting plant development and agricultural production. Erosion and soil salinization pose serious threats to agriculture and food security. PAMs can fix fine soil particles, improving soil structure and water retention, leading to significant water savings and enhanced efficiency. In Tunisia, where agriculture is predominantly rain-fed, a significant portion of this water is not utilized by plants. PAMs offer a valuable solution, and their low cost, ease of use, limited application dose, and favorable effects on soil, plants, and yields make them important auxiliaries that deserve attention from farmers, alongside the use of fertilizers. They offer promising prospects for better water management and soil conservation.

Chemistry can be an ally to farmers, providing solutions to enhance and preserve agricultural production. However, improper use of chemicals can harm farmers, the environment, and consumer health. Proper training and awareness for safe handling of these products are essential. As with cars, which are excellent inventions that bring people closer but can also be dangerous if misused, so too must chemicals be handled responsibly.

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