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# Polymers in Agriculture: A short review

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## ABSTRACT

The integration of polymer science into agriculture has transformed conventional farming practices by improving water use efficiency, nutrient management, and environmental sustainability. This paper reviews the types, functions, and impacts of polymers used in agriculture - from superabsorbent hydrogels and mulch films to controlled-release fertilizer carriers and biodegradable alternatives. Recent advances emphasize eco-friendly and biodegradable systems that minimize plastic accumulation in soils. Challenges remain in cost, scalability, and field degradation dynamics. Future research must bridge polymer engineering and soil ecology to ensure polymers contribute to sustainable agricultural intensification.

**Key Words -** Polymers, Agriculture, Soil management, Biodegradability

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## INTRODUCTION

Global agriculture faces increasing pressure from climate variability, water scarcity, and soil degradation. As the demand for food continues to rise, materials science innovations are being explored to enhance crop productivity and environmental resilience. Among these, polymers-both synthetic and natural-have gained considerable attention for their multifunctional roles in water retention, nutrient management, and crop protection (Kumar *et al*., 2020). Polymers provide controlled release properties, improve soil structure, and reduce irrigation needs. However, their environmental implications, especially concerning persistence and microplastic formation, have also raised concerns (Mansoor *et al*., 2022). This paper examines the roles of polymers in agriculture, categorizing them into key application domains, reviewing their benefits and drawbacks, and identifying emerging trends toward biodegradable and sustainable polymer systems.

### Classification of Polymers in Agricultural Use

Polymers applied in agriculture can be broadly categorized into synthetic non-biodegradable, biodegradable/biopolymeric, and functional composites. Synthetic polymers like PE and PP dominate due to their low cost and strength, but their persistence creates long-term ecological burdens (Kumar *et al*., 2025). In contrast, biodegradable polymers degrade under soil microbial activity, offering a more sustainable path (Malik *et al*., 2023).

## APPLICATIONS OF POLYMERS IN AGRICULTURE

### Water Management and Soil Conditioning

Superabsorbent polymers (SAPs) can absorb hundreds of times their weight in water, releasing it gradually to plant roots during dry conditions. Hydrogels made of polyacrylamide, polyacrylate, or starch-based composites significantly improve soil moisture retention and reduce irrigation frequency (Omar *et al*., 2025). Malik *et al.,* 2023 demonstrated that SAP-treated soils reduced evaporation losses by up to 30% and improved crop yield under water stress.

### Mulching and Microclimate Regulation

Mulch films regulate soil temperature, suppress weeds, and conserve moisture. Polyethylene films are widely used but generate persistent residues that contribute to soil microplastic pollution (De *et al*., 2024). Recent studies highlight biodegradable mulch films made from PLA and starch blends that degrade after harvest without harmful residues (Seddighi *et al*., 2025).

### Controlled Release of Fertilizers and Agrochemicals

Polymers are engineered into coating materials for fertilizers and pesticides to ensure controlled release, minimizing leaching and volatilization losses. Polymer-coated urea (PCU) and polymer-encapsulated pesticides have shown enhanced nutrient use efficiency and reduced environmental contamination (Kaur *et al*., 2025).

### Seed ting and Plant Growth Enhancement

Polymers serve as seed coating agents that deliver micronutrients, growth regulators, and protective agents directly to germinating seeds. Polyvinyl alcohol (PVA) and starch-based coatings improve germination rates and provide controlled hydration (Zhao *et al*., 2025).

### Environmental Implications

While polymers enhance efficiency and productivity, their environmental impact cannot be overlooked. Persistent polymers accumulate as microplastics in soil, potentially altering microbial activity and soil porosity (Chen *et al*., 2025). Studies show microplastic fragments can affect nutrient cycling and root growth, particularly in sandy soils (Yang *et al*., 2025). Biodegradable polymers mitigate these issues but may degrade inconsistently under field conditions (Yao *et al*., 2024).

### Emerging Trends and Future Directions

Recent research trends highlight a shift toward eco-designed polymers integrating renewable feedstocks and smart release mechanisms. Bio-based hydrogels, stimuli-responsive systems, hybrid nanocomposites, and circular economy approaches all represent next-generation innovations in agricultural polymers.

## CONCLUSION

Polymers have become indispensable tools in modern agriculture, driving innovations in water conservation, nutrient delivery, and soil management. However, the dual challenge of performance and environmental safety persists. Continued development of biodegradable and bio-based polymers is essential to ensure polymers support long-term agricultural sustainability.

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