A Study on Super Absorbent Polymers for Water-Efficient Irrigation in Desert Sandy and Drought-Prone Regions for Farming

Rajiv Bharatbhai Dabhi[1]
[1]*Senior Lecturer, Civil Engineering Department, Govt. Polytechnic, Jamnagar, Gujarat, India*

Abstract: *Water scarcity in desert sandy and drought-prone agricultural regions significantly limits crop productivity, especially under conventional irrigation systems where a large portion of water is lost due to evaporation, deep percolation and poor soil water retention. Super Absorbent Polymers (SAP) have emerged as a potential soil amendment for retaining moisture and improving crop performance under limited watering conditions. This research experimentally evaluates the effects of SAP-enriched soil on morphological parameters such as leaf development, plant height, stem diameter, root mass and crop yield under different reduced irrigation intensities (100%, 80%, 60% and 40%) in desert sandy soil. Results indicated that SAP application significantly enhanced soil moisture availability, delayed wilting and improved overall plant growth even at 40% irrigation water compared to control. Yield improvement of approximately 35-55% was observed in SAP-treated plants, confirming its role in water-efficient irrigation under extreme dry climatic conditions. Therefore, SAP offers a sustainable solution for small-scale farmers to reduce irrigation water dependency in drought-prone regions.*

Keywords: Super Absorbent Polymers, Water Efficiency, Sandy Soil, Drought Prone Regions, Plant Morphology, Yield

Introduction

Water scarcity has become a critical challenge in arid and semi-arid agricultural zones of India, Middle-East and African nations, where increasing temperatures, low rainfall and high evaporation drastically reduce crop productivity. Over 70% of freshwater resources are consumed by agriculture (T.B.S. Rajput and Neelam Patel, 2012), but more than 40-60% is lost before reaching the root zone due to seepage and infiltration in desert sandy soils.

Traditional irrigation systems like furrow and flood are inefficient and unsustainable for drought-vulnerable small farming communities who face economic constraints and limited water supply. Therefore, advanced soil-water conservation materials must be adopted to optimize water use efficiency and maintain agricultural sustainability.

Super Absorbent Polymers (SAP) are hydrogel-based biodegradable materials capable of absorbing and storing water up to several hundred times their own weight (Fonteno & Bilderback, 1993; Fidelia N. Nnadi, 2012). SAP releases water gradually to plant roots, reduces irrigation frequency, improves nutrient uptake and increases plant performance under moisture stress. Previous studies demonstrated positive effects of SAP in various horticulture crops such as tomato, cabbage and sunflower (Hossein Nazarli et al., 2010; Anupama et al., 2005; Tripathi et al., 1997).

However, limited research is available on the performance of SAP-based irrigation for desert sandy and extreme drought-prone farming systems, particularly for small-scale farmers.

The present study focuses on evaluating the effectiveness of SAP as a soil amendment to improve crop growth and productivity under reduced irrigation water availability in desert sandy agricultural conditions.

Materials and Methods

The experiment was conducted in an open field under arid conditions in Western India characterized by coarse sandy soil, high evapotranspiration rate, scarce rainfall and extreme temperature variation.

Materials Used

Materials	Details
SAP (Agricultural Grade)	Commercial hydrogel polymer, granular form
Containers	32 plastic pots (25cm × 25cm × 35cm)
Crop Used	Cherry tomato
Soil Type	Coarse desert sandy soil
Water Source	Tap water (400–420 PPM TDS)

Experimental Treatments

Two irrigation methods were evaluated:

Code	Description
CI	Conventional irrigation (Control-No SAP)
SAP	Soil amended with SAP (4% w/w of soil)

Four irrigation intensities: 100%, 80%, 60% and 40% of full water requirement

Total 32 pots: 4 treatments × 4 water levels × 2 replicates

No fertilizer or pesticides were applied.

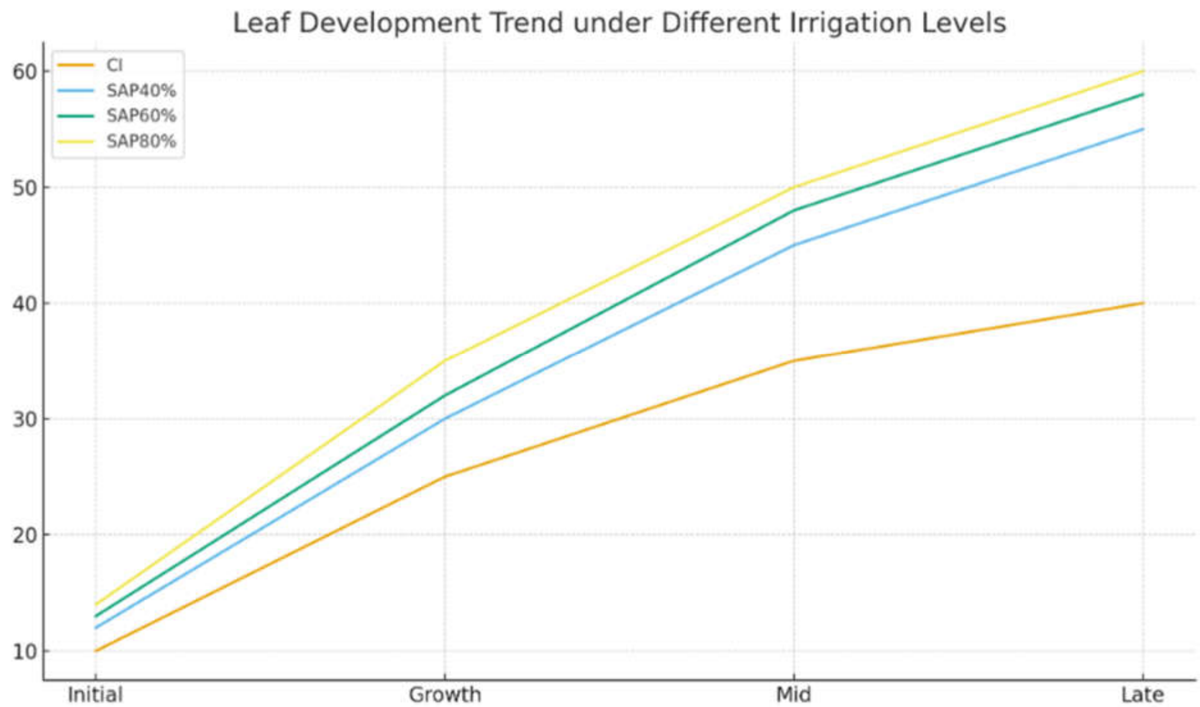
Measurement Parameters

- Number of leaves (counting at intervals)
- Plant height (metal tape measurement)
- Stem diameter (digital vernier scale)
- Root mass (digital weight scale)
- Total yield (fruit weight per plant after harvest)

Results and Discussion

Leaf Development

SAP-treated plants exhibited significantly higher leaf numbers compared to CI at all irrigation levels. Leaf growth for SAP40% was nearly equal to SAP80% and 45–50% higher than CI. The gradual release of water improved cell expansion and photosynthetic activity.



Plant Height

Height increased proportionally with irrigation water, but SAP plants showed superior growth indicating better turgidity and higher nutrient transport. Reduced water stress delayed senescence and maintained metabolic processes.

Stem Development

Stem thickness improved under SAP due to enhanced vascular strength and stable mechanical support. Moisture maintenance improved plant rigidity and stem cell elongation.

Root Development

SAP-treated roots displayed greater depth, branching and weight because of the steady moisture reservoir. Root mass increased by nearly 80% compared to CI at lowest irrigation level.

Yield

SAP80%, SAP60% and SAP40% yielded 55%, 48% and 36% more crop output respectively compared to CI. The highest yield occurred with SAP40%, demonstrating excellent drought tolerance response and irrigation water savings.

Conclusion

The experimental study establishes that Super Absorbent Polymers significantly improve plant growth and productivity under limited irrigation water availability in desert sandy soil. SAP enhanced soil moisture retention, reduced irrigation frequency, promoted nutrient absorption and ultimately improved yield. Even at 40% irrigation, crop yield exceeded that of control without SAP, demonstrating high efficiency.

SAP is therefore recommended as an economically viable technology for sustainable farming in desert and drought-prone regions. Future research should evaluate long-term soil health impacts, crop type suitability and cost-benefit ratio for large-scale adoption.

REFERENCES

[1] *Alessandro Sannino, (2008), Application of Superabsorbent Hydrogels for the Optimization of Water Resources in Agriculture, 3rd International Conference on Water Resources and Arid Environments & 1st Arab Water Forum.*

[2] *Al-Harbi, A. R., Al-Omran, A. M., Choudhary, M. I., Wahdan, H., & Mursi, M. (1996), Influence of Soil Conditioner on Seed Germination and Growth of Cucumber, Arab Gulf Journal of Scientific Research, 14(1), 129-142.*

[3] *Anupama, M. C., Singh, R., Kumar, B. S., & Kumar, P. A. (2005), Performance of New Superabsorbent Polymer on Seedling and Post-Planting Growth and Water Use Pattern of Chrysanthemum under Controlled Environment, Acta Horticulturae, 618: 215-224.*

[4] *CWC (1996; 1998; 2002; 2004), Water and Related Statistics, Ministry of Water Resources, Central Water Commission, Govt. of India, New Delhi.*

[5] *Cookson, W. R. et al. (2001), Root zone soil moisture retention and plant response, Journal of Agricultural Research.*

[6] *Dhumal, K. N. (1993), Effect of Jalshakti on Growth and Yield of Some Vegetables Under Water Stress Conditions, Journal of Maharashtra Agricultural University, 18: 307-311.*

[7] *Fidelia N. Nnadi (2012), Super Absorbent Polymer (SAP) and Irrigation Water Conservation, Irrigation & Drainage Systems Engineering, DOI: 10.4172/2168-9768.1000e102.*

[8] *Fonteno, W. C., & Bilderback, T. E. (1993), Impact of Hydrogel on Physical Properties of Course-Structured Horticultural Substrates, Journal American Society of Horticultural Sciences, 118: 217-222.*

[9] *Francesco Puoci, Francesca Iemma, Umile G. Spizzirri, Giuseppe Cirillo, Manuela Curcio & Nevio Picci (2008), Smart Polymer Systems for Controlled Agricultural Delivery, American Journal of Agricultural and Biological Sciences, 3(1): 299-314.*

[10] *Hossein Nazarli, Mohammad Reza Zardashti, Reza Darvishzadeh & Solmaz Najafi (2010), Effect of Water Stress and Polymer on Water Use Efficiency, Yield and Several Morphological Traits of Sunflower, Notulae Scientia Biologicae, 2(4), 53-58.*

[11] *Janardhan Singh (1999), Effect of Stockosorb and Potassic Levels on Potato and Onion, Journal of Potassium Research, 14(1-4), 78-82.*

[12] *Patil Appa Ananda (2009), Influence of Superabsorbent polymer on Plant Growth & Productivity in Cabbage, Thesis, University of Agricultural Science, Dharwad, India, pp. 56-57.*

[13] *Rajiv Dabhi, Neelkanth Bhatt & Bipin Pandit (2013), Effect of Irrigation Water Quality on the Rate of Water Absorption by Super Absorbent Polymers, IJETAE, ISSN 2250-2459, 496-500.*

[14] *Rajiv Dabhi, Neelkanth Bhatt & Bipin Pandit (2014), Effect on the Absorption Rate of Agricultural SAP under Mixed Soil and Varying Water Quality, IJERT, ISSN 2278-0181, 1402-1406.*

[15] *S. Shooshtarian, J. Abedi-Kupai, & A. TehraniFar (2011), Application Evaluation of SAPs in Green Spaces of Arid Regions, Journal of Biodiversity & Ecological Sciences, Issue 4.*

[16] *Sivalapan, S. (2001), Effect of Polymer on Growth & Yield of Soybean in Coarse Soil, Proceedings of Irrigation Conference, Queensland, Australia, pp. 93-99.*

[17] *Sendur Kumaran, S., Natrajan, S., Muthvel, I., & Sathiayamurthy, V. A. (2001), Standardization of Hydrophilic Polymers on Growth and Yield of Tomato, Journal of Madras Agricultural, 88(1-3): 103-105.*

[18] *T.B.S. Rajput & Neelam Patel (2012), Micro Irrigation in India – Present Status & Future Scope, India Water Week – Water, Energy & Food Security Conference.*

[19] *Taylor, K. C. & Halfacre, R. G. (1986), The Effect of Hydrophilic Polymer on Water Retention and Nutrient Availability, HortScience, 21(5): 1159-1161.*

[20] *Tripathi, M. L., Kurmavanshi, S. M., & Namdeo, K. N. (1997), Effect of Starch Polymer & N-Triacontanol on Growth & Yield of Indian Mustard, Indian Journal of Agronomy, 42(1): 194-195.*

[21] *Yang, X., Chen, X., Ge, Q., Li, B., Tong, Y., et al. (2006), Tolerance of Photosynthesis to Photo-Inhibition, High Temperature & Drought Stress in Wheat Leaves, Plant Science, 171: 389-397.*