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Innovative Technologies for Enhancing Water Productivity

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Introduction

Water is a vital component of plant life, comprising approximately 90% of cytoplasm, 35–95% of leaf tissue, 60–90% of root tissue, and 70–90% of fleshy fruits. It plays a critical role in plant physiology, acting as a nutrient carrier, facilitating photosynthesis, and supporting thermoregulation, which is essential for plant growth and survival.

Water scarcity is a major limiting factor in crop production, exacerbated by climate change and increasing competition for resources. Since agriculture is the largest consumer of freshwater (blue water footprint), efficient irrigation practices must prioritize maximizing yield per unit of water used rather than just per unit of land.

With india's population projected to reach 1.4 billion by 2025, the demand for food, fiber, feed, and fuel is growing rapidly. To meet this demand, india must produce 380 million tonnes of food grains annually, despite having only 2.3% of the world's land and 4% of its freshwater resources. Per capita arable land and water availability are shrinking—from 0.34 ha (1950-51) to a projected 0.08 ha (2025), and from 5300 m^3 (1951) to under 1500 m^3 (2025)—below the global threshold for water stress.

Therefore, water productivity (WP), defined as crop output per unit of water used (Molden, 2010), has become a critical concept. Promoted through slogans like "More Crop per Drop" or "Per Drop More Crop," improving WP is essential for sustainable agriculture in water-scarce regions like india.

Types of Water productivity:

a) Physical water productivity is defined as the ratio of agricultural output to the amount of water consumed from all available sources including irrigation, rainfall etc. (kg of produce per cubic metre of water consumed (through evapo-transpiration) during crop growth, kg/m^3).

b) irrigation water productivity is defined as ratio of the crop output to the irrigation water applied by the farmer/ irrigation system either through surface canals, tank, pond or the well and tube

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well during the crop growth. Thus irrigation is an economic activity and the farmer has to incur certain expenditure to apply the water (kg/m^3).

c) Economic water productivity is defined as the ratio of value of crop output to the amount of water consumed or to the amount of irrigation water applied by the farmer (expressed as Rs /m^3).

Factors affecting WP:

The factors which affect or influence crop yield (numerator of the productivity equation), and water applied or need to be applied (denominator of the same equation), obviously influence the water productivity.

The factors are:

A. Crop Cultivar Type

- Stomatal behavior influences how efficiently plants use water during CO_2 uptake.
- C_4 plants (e.g., maize, sorghum) generally exhibit higher WP than C_3 plants (e.g., wheat, rice).
- in C_3 plants, genotypes with lower carbon isotope discrimination tend to have better WP due to efficient internal CO_2 concentration regulation.

B. Applied Water & irrigation Practices

- Techniques like partial root-zone irrigation, deficit irrigation, and drip systems enhance WP by optimizing water use (Ali et al., 1997).
- Trade-off: Slight reduction in yield for improved WP.
- During drought stress, pre-anthesis stem reserves (sugars, starch) play a crucial role in maintaining grain filling and final yield.

C. Soil Factors

- Soil texture and organic matter influence water retention and release.
- Soils that dry quickly reduce osmotic adjustment and affect plant growth and WP.
- Nitrogen nutrition promotes early leaf development, affecting water use and evaporation.
- Organic matter also supports beneficial microbial activity.

D. Agronomic Practices

- Timely sowing, even plant establishment, optimal fertilization, and adequate plant population significantly affect WP.
- Early canopy development helps reduce soil evaporation and weed competition.
- Mulching and stubble management improve soil water balance, reduce runoff, and increase infiltration.
- Sowing winter crops early (in warm soils) improves canopy cover and reduces evaporative losses.

E. Climate Change

- Rising CO_2 levels, fluctuating temperature, and precipitation changes alter crop water use.
- in some regions, shortened growing periods may decrease yield and WP.
- High water-holding soils may buffer negative climate impacts.
- Expanded irrigation can increase yields but may compromise environmental quality.

F. Economic Factors

- improving WP often requires investment in irrigation infrastructure (drip, sprinkler systems), which includes high fixed and operational costs.
- in developing countries, these costs may be prohibitive.
- Farmers choose cropping patterns based on profitability per unit of land or water, responding to market dynamics and resource availability.

Technologies for enhancing water productivity.

1. **Genetics**
2. **irrigation methods**
   - micro sprinkler
   - drip irrigation
   - deficit irrigation : RDi and PRD
3. **Management practices**
   - seed priming
   - seedling age
   - choice of crop
   - sowing method (use lesser land leveler)
   - Nutrient management

- weed management

4. **Mulches and anti-transparent**
5. **Water harvesting**
6. **Crop Genetics**

Genetic approaches to improving water use efficiency (WUE) focus on selecting crop varieties with traits such as tolerance to heat, cold, salinity, pests, and drought, as well as shorter growing seasons, earlier flowering, and better nutrient use efficiency, suited to specific regional conditions. Crop breeding is most effective when it aligns growth cycles and harvest times with local rainfall patterns at key growth stages. Efforts also target reducing the base water requirement for yield, especially in dryland crops. However, due to genetic-environmental interactions, genetic gains alone may not dramatically improve WUE. instead, combining these advances with efficient cultural and management practices is more likely to deliver substantial and immediate benefits in reducing water use.

7. **irrigation methods**

Efficient water use is vital, especially in arid and semi-arid regions. Traditional surface irrigation methods like check basin lead to significant water losses through seepage, evaporation, and nutrient leaching. in contrast, drip irrigation applies water slowly and directly to the root zone, wetting only 15–60% of the soil surface and minimizing losses (Rao et al., 2016). This method enhances crop survival, yield, and quality while saving 18–42% water and improving irrigation water use efficiency (iWUE) by 35–75%. Drip irrigation, a key tool in precision farming, is now widely used for both wide- and close-space crops. Paired row planting further reduces system costs and water use without affecting plant population.

8. **Anti-transparent and mulches**

Anti-transpirants, once explored in the 1960s–70s, reduce water loss by closing stomata or reflecting sunlight. They can lower evapotranspiration by **5–10%** for about **two weeks**, but often hinder photosynthesis more than water loss. Due to limited effectiveness and short duration, they are not widely practical for large-scale farming.

9. **Conservation Agriculture**

Conservation agriculture will increase the water productivity through reduce tillage, mulches, selection of crop and cropping systems. Zero tillage conserving soil moisture by leaving old root holes to facilitate internal drainage, averts the pulverization of soil aggregates and formation of pans, reduces draft power for planting and gives shelter, winter food and nesting sites for fauna. Crop residues on the surface practically eliminate wind and water erosion, reduce soil moisture loss through the mulch effect, slow spring warm-up.

Mulches conserve water through reduce evaporation losses from soil surface, maintain soil temperature, check weed growth improve the efficiency of irrigation.

10. Water harvesting

in the dry areas water not land is the most limiting resources for improved agricultural production maximizing WP and not yield per unit of land, is therefore a better strategy for dry farming system. Under such conditions more efficient water management techniques must be adopted. Supplement irrigation is a highly efficient agricultural production and improving livelihoods in the dry rainfed area. in dry areas most of rainwater is lost by ET. Therefore, the rainwater productivity is extremely low. Water Harvesting can improve agriculture by directing and concentrating rainwater through runoff to the plant and other beneficial use. it was found that over 50 % of lost water can be recovered at a very little cost.

Conclusion:

We need to concentrate much regarding higher production, higher quality production with the use of limited water. After gone through the literature and seeing the day-by-day reduction of fresh water it can be concluded that water productivity is a basic need of agriculture.it can be concluded that different improved irrigation tech. agronomic management practices and conservation agriculture increase water productivity.

References

Ali, M. H., Hoque, M. R., Hassan, A. A., & Khair, A. (1997). Effects of deficit irrigation on yield, water productivity and economic returns of wheat. *Agricultural Water Management*, **92**(3), 151–161.

Ali, M. H., Talukder, M. S. U., & Sanjey, M. (2005). increasing water productivity in crop production—A synthesis. *Agricultural Water Management*, **95**(11), 1201–1213.

Brar, S. K., Mahal, S. S., Brar, A. S., Vashist, K. K., Sharma, N., & Buttar, G. S. (2012). Transplanting time and seedling age affect water productivity, rice yield and quality in north-west india. *Agricultural Water Management*, **115**(3), 217–222.

Jat, H. S., Datta, A., Choudhary, M., Yadav, A. K., Choudhary, V., & Sharma, P. C. (2019). Effects of tillage, crop establishment and diversification on soil organic carbon, aggregation, aggregate associated carbon and productivity in cereal systems of semi-arid Northwest india. *Soil and Tillage Research*, **190**(2), 128–138.

Kumari, A. (2018). Effect of moisture regimes and weed management on weeds, yields and economics of direct seeded rice. *Journal of Pharmacognosy and Phytochemistry*, **7**(2), 2415–2418.

Molden, D., Oweis, T., Steduto, P., Bindraban, P., Hanjra, M. A., & Kijne, J. (2010). improving agricultural water productivity: Between optimism and caution. *Agricultural Water Management*, **97**(4), 528–535.

Neelakanth, P., Kadasiddappa, M., & Sanjey, M. (2013). Enhancing water productivity through micro-irrigation technologies in indian agriculture. *Annals of Plant and Soil Research*, **15**(2), 601.

Praharaj, C. S., Singh, U., Singh, S. S., & Kumar, N. (2017). Micro irrigation in rainfed pigeonpea—Upscaling productivity under Eastern Gangetic Plains with suitable land configuration, population management and supplementary fertigation at critical stages. *Current Science*, **112**(1), 95–107.

Rao, S. S., Tanwar, S. P. S., & Regar, P. L. (2016). Effect of deficit irrigation, phosphorus inoculation and cycocel spray on root growth, seed cotton yield and water productivity of drip irrigated cotton in arid environment. *Agricultural Water Management*, **169**(2), 14–25.

Suryanasi, S. K., Mahal, S. S., Brar, A. S., Vashist, K. K., Sharma, N., & Buttar, G. S. (2012). Transplanting time and seedling age affect water productivity, rice yield and quality in north-west india. *Agricultural Water Management*, **115**(3), 217–222.