

Smart technologies

for increasing crop water productivity

Suryakanta Kashyap, Bisworanjita Biswal, Hardev Ram* and Rakesh Kumar

ICAR-National Dairy Research Institute, Karnal, Haryana 132 001

By reducing the amount of water required for crop production through integrating breeding/genetic engineering and agronomic approaches along with resource management; water productivity can be increased at field and basin level is a key strategy for achieving food security and water sustainability in a world with growing demands for the both. Also greater awareness of these options among growers and policymakers can encourage more cost-effective water management strategies that can free up water for other uses. However, appropriate management strategies to increase crop water productivity will vary regionally.

Keywords: Food securing, Water management, Water productivity, Water sustainability

WORLD is facing twin challenges of water scarcity and food insecurity. And both will be increasing in future as crop production/agriculture is the largest global consumer of water. Hence, producing more food per drop of water is a key strategy to address both challenges. Water crisis is one of the key factors in influencing water management issues in the agricultural sector. Two basic factors are critical. Firstly, the agricultural sector is by far the largest user of freshwater which is about 90% and second, water use in agriculture tends to have lower net returns as compared to other competing uses. It has been suggested that in the next three decades, the global food systems will demand 40-50% more freshwater than current scenario. Municipal and industrial demand for freshwater will increase by 50-70% during this period, while demand for energy sector will increase by 85%. India is facing high water stress and the country is amongst those with the most delicate and uncertain water resources in the world. So, water productivity (WP) is the single and most important leeway for managing

water demand in agriculture. Measurement and improvement of WP is thus an important answer to growing water and land scarcity, optimization of other production inputs and improved incomes and environment.

What is water productivity?

Water productivity (WP) is the ratio of the net benefits from crop, forestry, fishery, livestock and mixed agricultural systems to the amount of water used to produce those benefits. In broader sense, the main objective is getting more benefits in terms of food production, income, livelihood and ecology at less social and environmental cost per unit of water consumed. WP can also defined in following ways:

Physical water productivity (Kg/m³): Ratio of agricultural output to the amount of water consumed from all available sources including irrigation, rainfall etc.

Irrigation water productivity (Kg/m³): 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 tubewell during the crop

growth.

Economic water productivity (kg/m³): Ratio of value of crop output to the amount of water consumed or to the amount of irrigation water applied by the farmer.

So, depending upon the professional interest and expected outcome, WP is expressed differently in its concept and measurement.

Factors affecting water productivity

For estimating WP, one should have knowledge about the factors that are influencing it. Besides the quantity of water applied or depleted, WP also depends on many factors such as cropping pattern, irrigation technology, field water management, land configuration and infrastructure for storage of water, climatic pattern, virtual water footprint and economy and policies etc. Also, a general misperception is that irrigation is wasteful due to incompetent practices. So, by saving, water released from irrigated agriculture it can be made available to other, higher value uses in cities, industries, ecosystems or more agriculture. When all water users are taken into account and the concept of recycling

and reuse of water is considered collectively in a system of agricultural production, then output per unit total water use is known as agricultural water productivity. Since it considers multiple use of water, its value represents higher value than crop water productivity.

Key principles to improving WP

There are three principles for improving WP under rainfed as well as irrigated condition:

- Boost the marketable yield of a crop for each unit of water transpired,
- Cut down all outflow (drainage, seepage, percolation, evaporative excluding stomatal transpiration), and
- Effective use of rainfall, stored water and poor-quality water.

First principle aims at boosting the crop yield or the value of produce. Second principle aims at decreasing all losses except the transpiration losses which does not mean that improving WP is impossible job by reducing stomatal transpiration. This drawback can be beaten by various breeding approaches. Third principle aims at alternate resources of water and their use in agriculture. All these three principles apply at all levels i.e. plant to field and agroecological levels. However, these principles require various approaches and technologies to formulate it in practice.

Enhancing WP at plant level

This plant level option can be mainly dealt by breeder by improvement of germplasm. These include improving seedling vigour, increasing of rooting depth, increasing harvest index and enhancing photosynthetic efficiency. By various breeding programmes significant improvement in yield stability can be achieved. The maximum crop growth period can be achieved as planting, flowering and maturation dates are crucial in matching the maximum crop growth with time when the saturation vapour pressure deficit is minimum. Development of varieties of short duration with deeper rooting system for dry areas (drought avoidance

mechanism) is needed. Introduction of drought tolerance mechanism in cultivar has also proved to be an important strategy to increasing WP. There are several morphological and physiological traits that determine drought tolerance of plants such as resistance to wilting, short anthesis-silking (maize) interval, early flowering, waxy cuticle, dense pubescence, stay green characteristics, osmotic adjustment, cellular membrane stability and high harvest index. Photo-insensitive short to medium duration varieties of some crops like wheat, rice and maize also result in increasing WP by escaping late season drought during flowering and grain development stage. Genetic engineering integrated with breeding programmes can further contribute to development of variety which will ultimately contribute in enhancing WP.

Enhancing WP at field level

At field level by adopting improved practices by changing crop management, soil management and water management one can enhance WP. These are given here.

1. Selection of crop and cultivars as per the availability of resources. Crop like pearl millet having crop duration of about 60 days perform better under water scarce condition.
2. Planting methods (Raised bed, broad bed and furrow)- Growing maize, vegetables and other less water requiring crops in raised bed and rice furrow bed where excess water is collected can be an effective planting method under low land area and increasing crop production per unit area and WP. Broad bed and furrow (105 cm

width and 45 cm depth) is most suitable under black soil along with dry sowing of crops.

3. Minimum/conservation tillage with residue retention which will act as mulch material for reducing evaporation of stored soil moisture. Also avoid residue burning.
4. Irrigation at critical stage of crop growth- Irrigation should be applied at most sensitive stage of crop growth to maximize productivity resulting in higher WP.
5. *Nutrient management*: Management of plant nutrient is one of the key strategies to increase the productive transpiration and improve WP of crop plants under limited water supply condition. Nitrogen deficit reduces yield per unit ET by reducing biomass per unit transpiration. N fertilization increase soil water use and decrease unproductive loss of water. Similarly, P fertilization has positive impact on WP under moisture stress condition.
6. *Micro-irrigation (drip, sprinkler)*: These have conveyance efficiency of 100%, application efficiency 70-90% than that of basin irrigation are 40-70% and 60-70%, respectively. It has been reported that WP is improved in crops like wheat, maize, sorghum, sugarcane and cotton under sprinkler irrigation than that of basin irrigation system. Drip irrigation reduces irrigation requirement by 20-70% with boost in crop yield by about 20-90%.
7. *Timely plant protection*: This implies timely management of

Critical stage of crop growth for irrigation of some important crops

Crop	Most sensitive stage of irrigation
Rice	Transplanting to tillering, panicle initiation to flowering
Wheat	CRI, tillering, booting, milking and grain formation
Maize (<i>kharif</i>)	Silking
Sorghum (<i>kharif</i>)	Booting
Pearl millet	Flowering
Groundnut	Pegging and pod development
Soybean	Blooming and seed formation
Pigeon pea	Flowering initiation, pod development

Source: Yadav *et al.* (2000)

weed, insect pest and pathogen will boost crop production and the WP also. Weeds compete with crops for soil moisture, nutrient and light. It has also been observed that WP is higher in wheat with weed control than that of weedy check because of reduction in water loss by the weeds and more grain yield.

Besides these, precise land leveling by use of laser land leveler about 20% of irrigation water can be saved under surface irrigation system. This helps in reducing evaporation and percolation losses by facilitating faster irrigation times and by eliminating the land depressions.

One of the field level approach for increasing WP is practicing deficit irrigation. This deficit irrigation (DI) is an optimization strategy in which irrigation is applied during drought sensitive stages of crop growth. This aims at stabilizing yields and at obtaining maximum crop water productivity rather than maximum yield. Another form of DI is partial root drying (PRD) which increases WP by improving crop yield under

limited water supply condition. Alternate furrow irrigation is also considered as PRD and it is found to be increasing WP in many crops. However, providing supplementary irrigation during prolonged dry spell can stabilize the yield and WP compared to irrigation at critical stage of crop growth.

Less WP per unit water supply in case of rice results from standing water layer on the rice field. By recycling this water, rice WP can be compared with that of other dry cereals. Various water saving techniques like alternate wetting drying, direct seeded rice cultivation, SRI, saturated soil culture rather than flooding and aerobic rice system can help in enhancing WP in rice.

Enhancing WP at basin level/agro ecological level

At basin level, relative importance of various water management processes changes. Here, the effect of agriculture on other users of water, human health and environment becomes as important as production issues. Various options for improving

WP at basin level are

- Efficient land use planning such as watershed.
- Efficient use of medium term weather forecasting- Sowing, water management, fertilization and other agronomic practices based on forecasted weather and soil moisture will enhance crop yield and water productivity.
- Improved irrigation scheduling should be done by accounting the rainfall variability of that location to improve WP.
- Conjunctive use of water from various sources (rain/canal) including poor quality water along with ground water through pressurized irrigation system is effective in enhancing crop yield, profitability and WP. In upland areas of Odisha, efficient management of ground water helps in bringing crop diversification and increasing WP.

*Corresponding author e-mail:
devagron@gmail.com

Innovative Agri-Solutions During COVID-19

Drought Management by Methylootrophs in Small Cardamom

Intervention

- KVK Idukki assumed the responsibility and advised the planters (owner) to provide initial irrigation, preparation of Pink Pigmented Facultative Methylootrophs (PPFM) and spraying to mitigate the stress.
- Spraying of PPFM @ 5L / ha helped to ensure water stress upto 45 days, withering of plants reduced more than 30% and yield increased to 20%.
- KVK produced 695L of PPFM, supplied to 178 farmers and realized Rs. 1.39 lakhs.
- 300 farmers benefited by online training of mass multiplication of PPFM and covered 700 ha area. Family members could cover 1.85 acres per day and saved 32% of labour requirement.
- 7 WhatsApp group created by KVK which covers 610 farmers.

Contribution: KVK, IDUKKI, Kerala

Source: www.icar.org.in