AGRIBLOSSOM
ISSN-2582-8258
A monthly peer reviewed e-magazine for Agriculture & allied Sciences

Water use efficiency: Challenges and strategies for improvement

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Abstract

Water plays an important role in the life of plants and humans. It is possible to survive for several weeks without food but without water it is quite impossible to survive even for few days. Every part of body (organs, tissue and even cell) requires water to carry out all important physiological and metabolic activities. Regarding its importance for plants, it helps to transport all nutrients from root to shoot and from one cell to another. It acts as a medium to carry out all metabolic activities and regulate plant body temperature by regulating rate of transpiration. Because of many challenges like climate change, increasing population, increasing scarcity of water etc., it is an estimate that by 2025, half of the world population will live under water stress conditions (WHO, 2019). Only agriculture sector in world consumes 70% of fresh water (UNESCO, 2001). Out of total cropland area only 17% is irrigated and worldwide it is expanding slowly. Although there is an increment in total irrigated area, the irrigated area per capita is decreasing throughout the world (Postel, 1999; Gleick, 2002). As water will be a limiting factor in coming future for agriculture sector, so there is a need to adopt various strategies to improve water use efficiency worldwide.

Water use efficiency (WUE)

Water use efficiency (WUE) is the ability of a crop plant to utilize the water efficiently. It is also defined as the ratio of amount of biomass produced by plant to the amount of water lost during the process of transpiration.

Water productivity and interaction with fertilizers

Dry matter production and transpiration are dependent on plant's physiological processes like entry of carbon and release of water through stomatal pore. In order to produce more grain yield per unit of transpired water plant breeder's most effective approaches is to create crop varieties with improved harvest index (a ratio of grain yield to total dry matter produced by plant). Over the last four decades,

the above-mentioned strategy adopted by plant breeders has significantly enhanced the potential of several crops to produce more grains per unit of water applied than any other agricultural management practices. Plant growth, development and production of grains are affected by water availability in soil, utilization of water by crop plants and supply of nutrients. All these factors are interrelated with each other. Application of fertilizers along with proper water management practices improves the water utilization efficiency. Boosting soil nutrient levels can improve evapotranspirational and transpirational water use efficiency. Increased nutrient content of soil appear to have an additive impact on water utilization efficiency of crops or enhancing yields through appropriate fertilizer application will also improve crop plant transpiration efficiency.

Factors affecting water use efficiency

Genetic factors

Genetic makeup of a crop plant and presence of a specific type of gene within its genome comes under genetic factor. Growth and yield attributes of a crop species is influenced by the interaction between its genetic makeup and various environmental factors. Because of difference in genetic makeup and variations in interactions with environmental factors, crop species are differed in their various traits (yield, morphology, and other physiological processes). Similarly, crops also differ in WUE. Water use efficiency vary with plant type (C3, C4 and CAM) and C_4 crop species (maize, sorghum, sugarcane, pearl millet, finger miller etc. are more efficient in water utilization when compared to C_3 species (pulses, oilseed crops, wheat, barley, oats etc). Genetically modified varieties, hybrids and high yielding varieties etc. shows better response against applied fertilizers and water because of their dwarf nature while traditional varieties show poor response against applied resources thus results in low yield, susceptible to biotic and abiotic stresses.

Climatic factors

Climatic conditions affect plant growth, development and ultimately crop yield. The intensity of sunlight regulate functioning of stomata aperture thus affects rate of transpiration and photosynthesis thereby an important factor to determine WUE. Other factors like temperature, day length and rainfall also have a significant influence on vital morphological, metabolic and physiological processes of plants; thereby contribute towards determination of crop yield. Humidity in air and wind velocity also affects rate of transpiration and have a direct effect on WUE and dry matter production.

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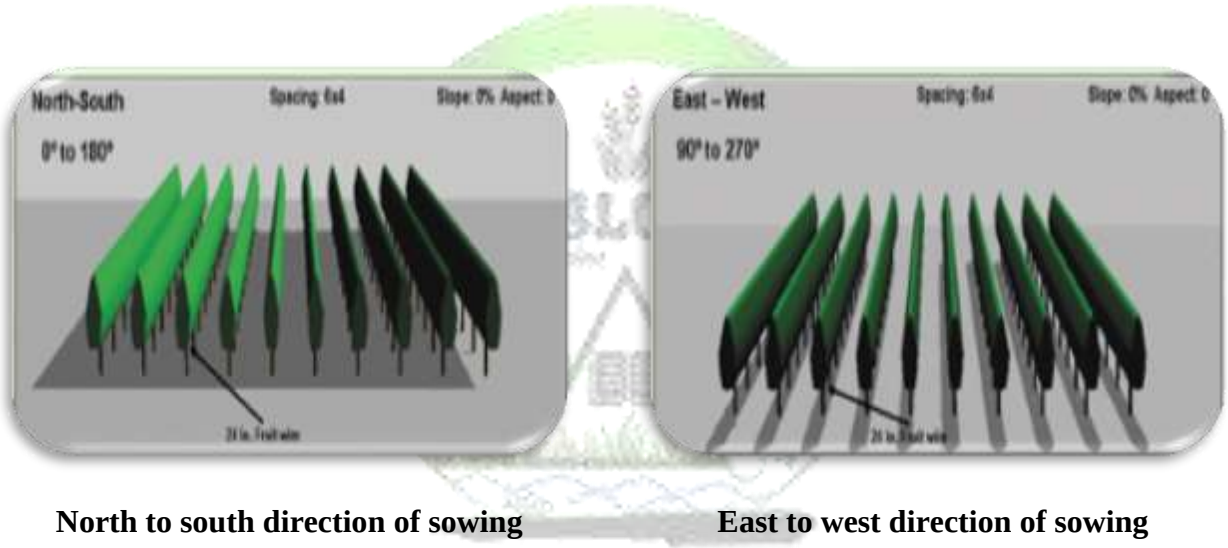
Crop management factors:

Time of sowing: In order to provide optimum temperature range, soil moisture content and better soil conditions for proper nutrition sowing of crop at appropriate time is very essential. It is also very helpful to improve nutrient use efficiency (NUE), WUE and make crop to combat against various biotic and abiotic stresses.

Depth of sowing: Sowing of seed at appropriate soil depth will ensures seedling emergence, seedling vigour and ultimately yield, therefore improves WUE and NUE.

Direction of sowing: Direction of crop sowing influences utilization of water. North to south or south to north orientation of crop rows has been found to be better for WUE as compared to east to west or west to east row orientation.



North to south direction of sowing **East to west direction of sowing**

Plant population: Maintenance of optimum plant density is very essential for proper utilization of resources like light, applied fertilizers, water etc. thus improves WUE.

Insect pests & diseases: Various biotic stresses viz., attack of insects and pests, disease caused by bacteria, viruses and fungus significantly reduce WUE and overall yield of crop (depending upon the degree of infestation). Growing plants in favourable conditions and by the use of genetically modified crop varieties WUE, efficiency of utilization of other resources and crop yield can be improved.

Impact of insects & pests on water use efficiency

Irrigation method: Management of irrigation in crop field is very important factor to improve WUE. Use of micro irrigation techniques like overhead sprinkler, micro sprinkler and drip irrigation methods are more efficient than surface irrigation (furrow, border strip, check basin) methods.

Drip irrigation method **Sprinkler irrigation method**

Strategies to reduce evapotranspiration: Evapotranspiration is an important factor to influence WUE. Mulching (organic mulch and plastic mulch), use of anti-transpirant compounds, shelterbelts and timely weeding etc. reduce loss of water from soil as well as plants without having any negative impact on crop yield.

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Organic mulching

Plastic mulching

Anti-transpirant

Shelter belts

Development of improved varieties: Superior varieties can be selected on the basis of physiological traits (root growth, uptake efficiency, canopy photosynthesis etc.) and incorporated in crop improvement programme for the development of new varieties.

Conclusion

As most of the agricultural land is under rainfed condition and it is continuously increasing. Therefore, it is a necessity to improve water use efficiency by adopting strategies like conservation of soil moisture, soil management practices, development of new crop varieties with improved water absorption and overall utilization capabilities, fertilizer management practices and plant protection measures, etc.

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