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TECHNIQUES AND STRATEGIES FOR MAXIMIZATION OF WATER USE EFFICIENCY IN AGRICULTURE

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Abstract

Shortage and scarcity of water and as well as the increasing global demand for water in many sectors including agriculture, has become an important global concern. The rapid growing population of the world and adverse effects of climate change has led to increasing competition for water use by industrial and urban uses for agricultural to secure enough food production. Increasing water use efficiency in agricultural will require an increase in crop water productivity and reduction in water losses from the crop root zone. At present there are many ways of enhancing water use efficiency and productivity of agricultural produce by maximum utilization of water. These include mainly agronomic practices *viz.*, Crop selection, Selection of variety, Sowing time, Sowing and planting method, seed rate, intercultural operations, use of improved irrigation methods (Sprinkler and drip), Adoption of Intercropping, soil moisture conservation practices such as spraying of antitranspirants, mulching, use of vegetative barriers and New concepts such as Integrated Farming System, Agro forestry.

Introduction

Water is the most crucial input for agricultural production. Globally, agriculture accounts for more than 80% of all freshwater used by humans, most of that is for crop production (Morison *et al.*, 2008). The Food and Agriculture Organization has predicted a net expansion of irrigated land of about 45 million hectares in 93 developing countries (for a total of 242 million hectares in 2030) and projected that water withdrawals by the agriculture sector will increase by about 14% during 2000 – 2030 to meet food demand (FAO, 2006). Agriculture sector in India has been and is likely to remain the major consumer of water but the share of water allocated to irrigation is likely to decrease by 10-15 per cent in the next two decades. Current use efficiency or productivity of irrigation water is so low that most, if not all, of our future water needs could be met by increased productivity or efficiency alone, without development of additional water resources. Improving water use efficiency by 40% on rainfed and irrigated lands would be required to counter- balance the need for additional withdrawals for irrigation over the next 25 years to meet the additional demand for food. Growing more crop per drop of water use is the key to mitigating the water crisis, and this is a big challenge to many countries. Vagaries of monsoon and declining water table due to over exploitation have resulted in shortage of fresh water supplies for agricultural use, which calls for an efficient use of this resource. Strategies for efficient management of water for agricultural use involves conservation of water, integrated water use, optimal allocation of water and enhancing water use efficiency by crops.

Crop and varietal Selection:

The prime most important strategy under the water scarce condition is the proper crop selection and its varieties to be cultivated in the season. The amount of rainfall (Rainy season) and crop growing season should be matched, so as the crop selected would be able to utilize the maximum amount of water received in that particular time. Escaping drought, in this plant completes its life cycle and matures before the shortage of water ceases in is termed as ephemerals. For major field crops, there are many examples where the use of early maturing (or early flowering) cultivars increased and stabilized grain yield, especially in conditions of 521 terminal drought (Fereres *et al.,* 1998). Improved varieties well adapted to specific conditions can improve soil water use and increase yield. These varieties should be tolerant to abiotic stresses such as cold, drought and heat, and biotic stresses such as diseases and insects (Dakheel *et al.,* 1993). Verma *et al.* (2003) reported that wheat cultivars HUW 234 and Lok 1 had higher water use efficiency.

Sowing/ Planting time and method:

Sowing time is the non-monetary input in factors of production which not only ensures higher yields but also the maximum utilization of the applied inputs and resources. Sowing and Planting time is a vital factor for achieving higher yield and maximum utilization of available resources. As an example, attempts made to persuade farmers to move from spring to winter sowing of chickpea gave 30-70% yield increases (Erskine and Malhotra, 1997). Grain yield increase of 20-25% was obtained by sowing lentil in mid-November instead of early January (Pala and Mazid, 1992b). Planting pattern has a direct effect on yield, solar energy capture and soil water evaporation and thus an indirect effect on water use efficiency. The correct method of planting according to the site moisture availability or other factors can help to increase the yield or reduce the total irrigation water to be applied to crop without affecting the yield of crop. Gill *et al.,* (2006) reported that better water use efficiency and water productivity were observed in direct seeded rice.

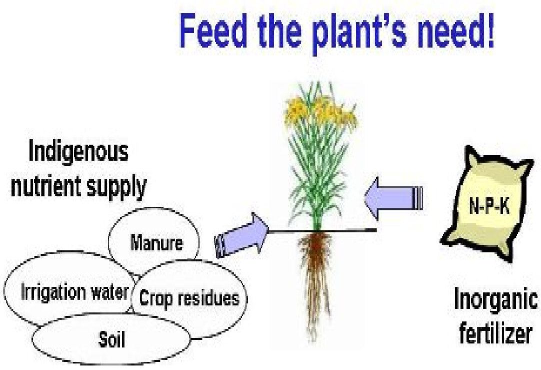
Plant density:

Establishment of an optimum plant density per unit area is a non-monetary input factor for getting higher production. There is a considerable scope for increasing yield by proper adjustment of spacing (Balyan and Mehta, 1985). This can be done by adjusting both inter row as well as intra row spacing. Plant population and yield of crop are the important factors which are interdependent to each other. The number of plants per unit area forms a base of yield triangle. More than optimum plants ha^{-1} tends to enhance total yield, but $plant^{-1}$ yield reduces substantially. On the contrary, lesser plants $unit^{-1}$ area than the optimum, tend to produce higher $plant^{-1}$ yield, but plants number being suboptimal which reduce the yield ha^{-1}. Soil water evaporation is reduced with higher planting density. In humid regions where rainfall exceeds evapotranspiration, plant densities can be increased with a concomitant increase in yield. However, in semi-arid areas where soil moisture is deficit the thicker stand are avoided. The desirable plant density which could be supported by available moisture up-

-to production of economic part and not initial biomass only is recommended for these situations. Karrou (1998) observed that the lower seed rate of 200 kernals/m2 gave the highest grain yield and WUE of durum wheat, which was statistically at par with 300 kernals/m 2 but significantly better than 400 kernals/m2.

Nutrient management:

Good yield can be achieved by balanced nutrition along with nitrogen and adequate supply of phosphate and potash is highly important. Fertilizer is an important input for successful crop production. Fertilizer use can also have a very marked effect on crop yield and water use efficiency. Nitrogen, phosphorus, combination of chemical fertilizer with organic fertilizer or chemical fertilizer with biofertilizer has been both dry and irrigated areas. Patil and Sheelavantar (2000) reported that application of nitrogen increased the yield, water use efficiency and yield component of sorghum. Ghosh *et al.* (2003) reported that application of 75% NPK and poultry manure 1.5 t/ha recorded the highest water useefficiency of rainfed sorghum.



Irrigation:

The artificial supplementation of water to the crop during water deficit and critical growth stages is known as irrigation. Irrigation scheduling can be used to improve WUE, and various strategies may be adopted depending on the crop response to water stress, water holding capacity of the soil, the availability of irrigation water and the irrigation system used. Nadeem *et al.* (2007) reported that maximum water use efficiency of wheat was recorded at IW: CPE ratio 1.25, which was statistically on a par with that at IW: CPE ratio 1.0. Ghadage *et al.* (2005) reported that the water use efficiency of cotton was higher due to each row and alternate row irrigation. This might be due to the significantly same seed cotton yield produced by irrigation techniques. However, Nalayini *et al.* (2006) reported that water use efficiency of cotton was highest with drip irrigation as than conventional irrigation during winter season.

Intercropping:

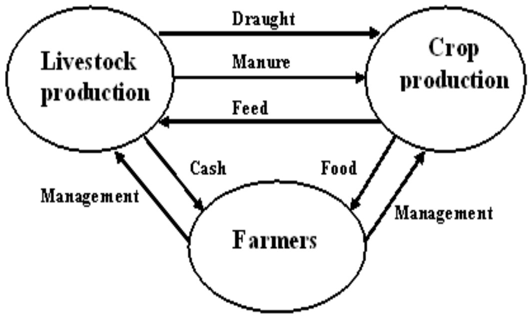
Growing two or more crops simultaneously on the same piece of land with a definite row arrangement is called as intercropping. The main objective of intercropping is to get higher productivity per unit area in addition to stability production. Intercropping utilizes resources efficiently. Efficient intercrops are cowpea, greengram, blackgram, soybean, etc. Inter and mixed cropping is a practice to have an opportunity to diversify cropping system by making the multiple land use possible utilizes water and other resources more effectively and also provides a cover against the failure of one crop particularly under the rainfed situations. Any factor that increases yield will increase water use efficiency. Higher water use efficiency has been reported for Maize + potato (Bharati *et al.,* 2007), pearlmillet + greengramand pearlmillet + cowpea (Goswami *et al.,* 2002) intercrops in relation to their respective monocrops.

Soil moisture conservation practices:

Soil moisture is the most limiting factor in dryland agriculture. About 60-75% of the rainfall is lost through evaporation. Such losses can be reduced by mulches, antitransoirants, wind breaks. Agronomic measures of soil moisture conservation include strip cropping, vegetative barriers. These measures help in greater intake rate of water by the soil due to imporove in organic matter and soil structure. There is better interception of rain water and hence reduction in splash erosion. Antitranspirants are the materials which are applied to transpiring plant surfaces to reduce water loss from the plant. E.g.:Stomata closing type (Phenyl mercuric acetate), Film forimg type (Mobileaf), Reflecting type (Kaolin). Moisture conservation practices have been widely practiced as a mean of improving yields in water limited environment. Continuous cover crops can reduce on- farm erosion nutrient leaching and grain losses due to pest attacks and build soil organic matter and improve the water balance, leading to higher yields (Oliver *et al.,* 2010). Awasthi *et al.* (2007) reported that water use efficiency of Indian mustard was highest with the weeding, hoeing and paddy straw mulch at 20 days after sowing followed by weeding, hoeing and grass mulch at 20 days after sowing, weeding and hoeing at 20 days after sowing and control. Vegetative barriers; dense vegetation is raised across the slope for making the live bunds. The vegetative barier helps to reduce the length of field slope, check the run off velocity, improve the soil moisture. Chand and Bhan, 2002 reported that water use efficiency of sorghum was appreciably improved due to different vegetative barriers over control. The maximum water use efficiency was recorded under *Sesbaniasesban* followed by *Leucaenaleucocephala* and *Cajanuscajan* barriers.

Minimizing water use efficiency was observed under the control crop. The increase in the water use efficiency may be attributed to appreciable increase in grain yieldwhich was in much greater proportion than the water use under different vegetative barriers.

Integrated farming systems:



An integrated farming system is a holistic production system which combines the sectors such as agriculture, horticulture, dairy, fishery, sericulture etc which ensures growth and stability in overall productivity and profititability. Comparing the different combination of farm enterprises, crop + fishery system gives more profit per unit of water followed by crop + dairy combination. The water productivity has increased considerably where allied enterprises involved along with crops. Among the allied enterprises, dairy component requires minimum water which in turn produced maximum water productivity per unit of water (Palanisami and Ramesh, 2009).

Conclusion and Remark:

Water is utmost requirement of any living being around the globe. As far as plants are concerned water use efficiency is an important physiological characteristics which is related to ability of crop to cope with the water stress condition. It can be manipulated and enhanced by selection of proper crops in a respective season, timely sowing, maintaining an optimum population, supply of optimal nutrition and irrigation, adoption of intercropping, use of newer techniques such as mulching, spray of antitranspirants, vegetative barriers and last but certainly not the least integrated farming system.

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