ADVANCED IRRIGATION TECHNOLOGY FOR ENHANCING FIELD WATER USE EFFICIENCY AND PRECISION IRRIGATION FOR RICE

(A CASE STUDY-EGYPT)

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ABSTRACT
The limitation of water resources and the remarkable increase in population should be forced research workers to find ways for saving water without significant reduction in yield. The objective of this paper is to explore ways to produce more rice with less water is essential for food security through application of water saving technology for enhancing irrigation precision and water use efficiency for rice. The technology was sprinkler irrigation system with transplanting and drill seed for two successive seasons. Sprinkler irrigation treatments were 100% and 120% of crop evapotranspiration (ET_c) and were daily applied with two methods of planting were drill and transplanting. The second technology was a short duration high yielding rice cultivars with daily irrigation with 120% of ET_c under sprinkler system . Results of the applied first technology revealed that irrigation at 120% of ET_c significantly increased number of tiller m-2, panicle weight and GY by 30.42, 10.37 and 18.88% over the treatment which irrigated with 100% of ET_c. Transplanting method also achieved the highest value of FWUE and proved its superiority over seed drill. Mean values of irrigation water applied amounted 129.7 cm under sprinkler system, whereas it was 174.1 cm in the flooding system. So the saving water was 34.24%. In addition to, value of FWUE under sprinkler irrigation system surpassed flooding method by 14.4%. Transplanting method had high response of grain yield and FWUE to water applied in comparison to drill method. Therefore, technologies of sprinkler irrigation and planting methods could be applied under shortage of irrigation water to save about one third of total amount of irrigation, enhance FWUE and precision irrigation for rice.

Keywords: precision irrigation, field water use efficiency, advanced irrigation technology, planting methods technology and grain yield.

Abbreviations: field water use efficiency (FWUE), irrigation water applied (IWA), grain yield (GY) and crop evapotranspiration (ET_c)

INTRIDUCTION

Rice has an unique place in Egyptian agriculture as a crop of great economic significance. Increasing its production is a national target. It is considered a highly water consumed specially under the conventional irrigation method, thus saving the water is becoming decisive factor for agricultural expansion. Great efforts should be done through improving the agronomic practices, such as planting methods and water management. Recently, shortage of water led to use modern irrigation system such as sprinkler irrigation which assumes great important to increase the water use efficiency. Rice can adopt to flood condition and management is much simplified under flooded conditions. Garry et al. (1985) in Arkansas indicates that sprinkler irrigation is feasible on rice with a 50% saving of irrigation water and yields comparable to flood irrigation. Twice weekly irrigation replacing evapotranspiration is adequate. Rice can be produced on topography unsuited for flood irrigation and plant nutrients and residual herbicides can be supplied through the sprinkler system. Another research for the same investigators in Louisiana indicates that rice yields were reduced 25% by sprinkler irrigation due to fewer tillers/area, fewer florets/panicle and slightly lower specific grain weight. El-Mowelhi et al. (1999) found that under sprinkler irrigation system that the two days irrigation interval with drilled dry rice grains recorded the highest values of rice grain yield and its components. Also, they mentioned that the mean value of irrigation water applied was 12401 m^3 ha^{-1} and flooding method reduced FWUE by 20.4% as compared to sprinkler irrigation system. Mean values of rice consumptive use ranged between 5.9 and 6.3 mm d^{-1} (Abd El-Hafez (1982). A rice crop of about 150 days duration requires water amounting to 64 cm for raising the nursery, 102 cm for growth from planting to flowering and a further amount of 25 cm for repining making the total to 190 cm (El-Refaee, 2002; Ramiah and Vachhani, 1951. Regarding to the effect of planting methods technology, El-Mowelhi et al, (1995) concluded that transplanting method recorded the highest grain yield and proved its superiority over the other methods, broadcasting and seed drill also, saving irrigation water and achieved the highest values of water use efficiency. El-Gibali and Mahrous (1970) indicated that the transplanting method increased rice grain yield (GY) by 23-56%, saved 18.7% of the water requirements and gave the highest water use efficiency. Wissa et al. (1987) reported that hand transplanting gave the highest revenue followed by seed drill and mechanical transplanting. The amount of water saved due to increasing the irrigation intervals compared to continuous flooding (3-day) ranged from 8.32% with 6-day to 27.5% with 12-day. Water use efficiency of irrigation every 6 or 9 days are considered the best WUE for most cultivars compared with other irrigation treatments. Continues saturation saved water by 20.1% with yield reduction about 3.98% when medium duration variety was used, while the water saved by about 31.43% with yield reduction 3.57% when short duration varieties were used. Also, the irrigation every 4 days caused an increase in water use efficiency by about 86% (National Rice Program Workshop, 2005). The maximum of rice yield potential was found to exists when soil is maintained under flooding or saturation conditions (Abd El-Hafez, 1982 and Mahrous et al., 1984).

The present study aimed to manage the advanced irrigation technology for enhancing field water use efficiency, precision irrigation and saving water for rice through technologies of sprinkler irrigation and planting methods.

MATERIALS AND METHODS

Two field experiments were carried out at Sakha Agricultural Research Station, Kafr El-Sheikh Governorate, North Delta, Egypt for two successive seasons. The soil of the experimental site was clayey. The average EC_e of soil salinity over 0-60 cm depth was1.75 dSm^{-1}. EC of irrigation water was 0.45 dSm^{-1}. The preceding crop was clover in both seasons. The system of irrigation used was fixed type with sprinkler spacing of 12 x12 m. The sprinkler discharge was 1.2m^3 h at 3.5 bar average operating pressure. The riser of sprinkler was 150cm in height, 50cm below the ground and 100 cm above ground. Irrigation water was filtered through gravel filters before entering the sprinklers. The experimental treatments consisted of two levels of irrigation (100% and 120% of ET_c) and two methods of planting (drill and transplanting) arranged in a randomized block design with four replications. A split-plot design was used where irrigation levels was the main plot and methods of planting was the sub-plot. Seeds and seedlings of rice cv. Giza 181 were planted in plots consists of thirty rows that were 36 m long and spaced 20 cm apart, using seed drill machine and transplanter. Management of cultural practices were similar to those used in the area. Dates of drilling, transplanting and harvesting were May 12, June 14 and October 10 in summer season of 1999, respectively and were May 15, June 16 and October 18 in summer season of 2000, respectively. Crop data collected were number of tillers m^{-2}, panicle weight g,1000-grain weight g, number of filling grains per panicle and rice GY t ha^{-1} at maturity. Data on number of tillers, panicle weight,1000-grain weight, number of filling grains per panicle were taken on five randomly selected guarded hills from the central four rows of each plot. Aboveground biomass of Giza 181 was sampled from 21 m^2 area. The grain was separated from the straw, and the grain was weighed. GY was calculated based on the adjustment to grain moisture content of 140 g kg^{-1}.

Because the flooding method was traditional and common in the adjacent fields, the rice GY and IWA recorded to calculate FWUE for drill and transplanting methods under flooding irrigation.

The amount of water applied per each irrigation was measured by flow meter and calculated according to the following equation.

$$IWA = \frac{ETo \times Kc}{Ei}$$

Where:

IWA = irrigation water to be applied mm d^{-1}.
ET_o = reference crop evapotranspiration mm d^{-1}.
K_c = crop coefficient
II = irrigation interval d
E_i = irrigation efficiency % = 0.75.

Rice was irrigated every day based on reference (ET_o) and a rice crop coefficient (K_c). ET_o was estimated using modified Penman (Doorenbos and Pruitt, 1977). The data were statistically analyzed using analysis of variance (ANOVA), according to Snedecor and Cochran, (1980). The data for two years were combined (Cochran and Cox, 1957). Means were compared using Duncan's multiple range test at P =0.05 (Duncan 1955). Linear regression coefficient values of GY kg ha^{-1} and FWUE kg grain cm^{-1} of water applied to IWA cm were calculated (Snedecor and Cochran, 1980).

RESULTS AND DISCUSSION

1 Yield and yield attributes:

Data illustrated in Table 1 showed that irrigation at 120% of ET_c significantly increased number of tillers, panicle weight and GY by 30.42, 10.37 and 18.88% over the treatment received 100% of ET_c while the differences between the mean values of 1000-grain weight and number of filling grains per panicle were not significant. This finding can be attributed to the deleterious effect on most physical processes as result of water deficit. These findings coincide with those obtained by Mahrous et. at. (1984) and El-Mowelhi et al. (1999).

Table 1. Average values of number of tillers, panicle weight, 1000-grain weight, number of filling grains and GY as influenced by methods of planting under sprinkler irrigation in combined analysis over two seasons.

Characters	No. of tillers m^{-2}	Panicle weight g	1000-grain weight g	No. of filling grains /panicle	GY t ha^{-1}
Irrigation:					
100% of ET_c	178	3.42	32.47	105	5.935
120% of ET_c	232	3.10	31.72	108	7.056
Methods of planting:					
Drill	227	2.42	34.29	76	5.710
Transplanting	183	4.09	29.90	137	7.282
Interaction:					
Irri. x Yr	n.s	n.s	n.s	n.s	n.s
Methods x Yr	n.s	n.s	n.s	n.s	n.s
Irri. x methods of planting	n.s	* *	n.s	n.s	n.s
Irri. x methods of planting x Yr	n.s	n.s	n.s	n.s	n.s

Means designated by the same letter are not significantly different, at the 5% level according to Duncan's multiple range test.
NS refers to not significant.

1-2 Irrigation water applied (IWA):

Total amount of water applied are 133.55 and 125.77 cm resulted from irrigation at 120% and 100% of ET_c, respectively. In this respect, Garry et al. (1985) concluded that sprinkler irrigation is feasible on rice with a 50% saving of irrigation water and yield comparable to flood irrigation. El-Mowelhi et al. (1999) found that sprinkler irrigation on rice saving 31% of its water as compared to flooding system. Regarding planting methods, it was evident that drill method received the highest amount of irrigation water (133.26 cm) as compared to transplanting method (126.06 cm). While under flooding irrigation the amount of water applied reached (185.25 and 162.86 cm) for seed drill and transplanting methods, respectively,

1-3 Field water use efficiency (FWUE):

Data obtained indicated that sprinkler irrigation at 120% of ET_c increased FWUE by 11.16% more than 100% of ET_c. Moreover, FWUE values under sprinkler irrigation system surpassed flooding irrigation by 14.2%. These findings may be attributed to the higher efficiency of sprinkler irrigation compared to flooding irrigation. Results revealed that transplanting method surpassed seed drill method by 34.7%. This result may be due to superiority of transplanting method in producing higher GY as well as using less amount of water applied. This result is in accordance with that recorded by El-Gibali and Mahrous (1970), Mahrous et al (1984) and El-Mowelhi et al (1995).

Conclusion

Increasing demand on water supplies in Egypt requires that all water have to be managed and used efficiently. Excessive water losses due to leakage and seepage and excessive flows at field outlets should be prevented wherever possible. So, management of water saving irrigation technology for enhancing precision irrigation and water use efficiency for rice can be accomplished by i) reducing the unproductive water outflows and evaporation using sprinkler irrigation system that facilitate a more equitable distribution of water and improving on-farm water management and minimize different irrigation water losses

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