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Effect of irrigation techniques on wheat production and water saving in soils

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Abstract

The studies were carried out on farmer's field to evaluate different irrigation techniques (border/flat, bed and furrow method) for their effects on water saving and crop yield in saline soils at four sites. The results revealed that bed furrow method consumed about 35.6% less water as compared to flat border irrigation method .The germination count m^{-2} and yield components were considerably improved under bed and furrow irrigation technique. The grain yield was 13.4% higher in bed and furrow method than that in flat border method. Under heavy rains where the crop could be endangered by-submergence and poor surface drainage, the bed and furrow planting technique for wheat proved more useful for germination and subsequent plant growth.

Keywords: Irrigation technique, bed and furrow, problem soil

Introduction

Wheat is an important cereal crop of Pakistan. But, its production potential is restricted by limited farm resources, non-availability of fertilizers at appropriate time, costly inputs, waterlogging, salinity the shortage of irrigation water and its inefficient use. Unwise use of irrigation water through traditional irrigation method has further constrained the cropping intensities and crop yields (Hamdy *et al.,* 2003). Thus, without judicious use of irrigation water and other farm resources, the production potential of wheat crop cannot be obtained.

The On Farm Water Management Project during last three decade has improved the water availability at the farm through minimizing conveyance losses. However, the system is still constrained to provide water for the suggested water requirement of 2.7 acre-feet acre[1] (Gill, 1994). The present situation of acute shortage of irrigation water and problem soils in many parts of the country has further emphasized the need to utilize the available canal water more efficiently. It is important to note that inefficient irrigation is the major cause of salinity and shallow water table in most of the irrigation projects of the world and that the need for artificial drainage can substantially be reduced through improvement in irrigation management (ASCE, 1990).

The Forth Drainage Project (tile drainage) comprises gross area of 0.345 m acre (354000 acres) in district Faisalabad. In the project area, 79 sumps were constructed which are not in full operation due to lack of operation and maintenance (WAPDA, 1997). The underground water is unfit for irrigating the crops. The scarcities, inequity and unreliability of canal water supplies have reduced the cropped area. The existence of salinity hazard in the project area further aggravated the situation. Therefore, it required prior consideration for implementing water management practices. Generally, wheat crop is sown on flat, which often endangers the crop by excess irrigation/rainwater. Under bed and furrow irrigation system, the plants are grown on raised beds which not only use irrigation water more efficiently but also ensure better crop growth under heavy rains (Berkhout *el al.,* 1997). Among the gravity irrigation methods, furrow bed irrigation method permits more efficient use of irrigation water as compared to basin or border irrigation (Hassan *et al.,* 2005). Moreover, furrow method of irrigation is well suited to crop which are adversely affected by prolonged submerged condition (Chaudhry *et al.,* 1994). The present study was, therefore, conducted to determine feasibility of bed and furrow irrigation under the prevailing conditions of salinity, water logging and scarcity of irrigation water at the forth drainage project area, and to assess its effect on yield of crop and water saving.

Materials and Methods

The study was conducted on farmer's field at the 4th drainage project area, Faisalabad. The irrigation technique consisted of bed and furrow irrigation including traditional method of flat or border irrigation. The experimental soil

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was saline. Four sites in two villages were selected to test the said technologies. The bed (48 cm wide) as well as sowing of wheat on beds was accomplished by using a bed furrow planter provided by the department of On Farm Water Management, Punjab. Sowing of wheat on flat was accomplished by conventional method of line sowing. Wheat (Inqalab 91) was used at all sites as a test crop. Irrigation was applied according to the farmer's irrigation turn replenishing each time the depleted moisture and bringing the soil to field's capacity. The time/duration of irrigation was based on farmers' judgment so as to fill the furrows just below the tops and irrigate the flat to reach water closer to downstream end of the field. Fertilizer doses, pesticides, and intercultural practices were the same for all the irrigation treatments at each location. To evaluate salt movement as influenced by irrigation treatments, soil samples were collected from 0-30 cm depth while in beds samples were collected from the center as well as from the sides and then analyzed for pH, $Ca^{++} + Mg^{++}$, Na^{+} and SAR. Observations on the desired parameters were recorded using standard procedures. The data was collected and analyzed using two factor factorial embedded in RCBD with three replications. The analysis of variance was carried out using PROG GLM (General Linear Model) procedure of the SAS Institute, 2009.

Results and Discussion

Water saving

The statistically analyzed data on average time taken to irrigate (min/ha/irrigation) under various treatments of irrigation are presented in Table 1. The table indicates significant difference in irrigation time for both the methods. There was substantial saving of irrigation water in bed and furrow methods of irrigation as compared to flat/border. Based on individual irrigation, the average water saving with bed and furrow was 35.6 % compared to flat irrigation. Similar results have been reported by Chaudhry and Qureshi (1991), Chaudhry *et al.* (1994), Ahmad and Mahmood (2005) and Hassan *et al.* (2005). Similarly, the average irrigation duration decreased by35.6 % in case of bed and furrow irrigation method, hence more area can be irrigated with the same available water (Hassan, 2005). Kalwij *el al.* (1999) reported 30.6 % decrease in time spent on irrigation water application in bed and furrow irrigation method for cotton crop. Directorate on Farm Water Management (1997) recorded water saving in bed and furrow as a result of compacting the furrows with tractor wheel which resulted in minimum deep percolation and increased lateral movement of irrigation water. Hadda and Arora (2006) reported an increase of 45 % in soil moisture storage with raised bed technology. The application of water with reference to different sites was same for B1 and B3 but different than site B2 and B4 (Table 2).

Germination count (m^{-2})

Germination plays an important role in the ultimate stand density and yield of crop. Statistically analyzed data pertaining to germination count m^{-2}as affected by different irrigation techniques are presented in Table 1. The results revealed that bed and furrow irrigation method resulted in

Table 1. Effect of sowing methods (Flat and bed and furrow) on irrigation time, yield and yield components (Data for flat and bed & furrow is average of 4 sites)

Treatments	Irrigation time Min/ha/irrig	Germination m^{-2}	Fertile tillers m^{-2}	No. of grains/spike	1000 grain weight (g)	Yield (t ha^{-1})
Flat/border	338.25[a]	162.7[a]	217.4[a]	40.8[a]	42.4[a]	2.607[a]
Bed and furrow	218.44[b]	182.2[b]	278.9[b]	46.1[b]	47.6[b]	2.955[b]
Means	278.3	172.42	248	43.46	44.95	2.781
LSD	6.23	4.5	6.24	2.79	2.81	0.0626

Significance at alpha = 0.05

Table 2. Effect of sowing methods (Flat and bed and furrow) on irrigation time, yield and yield components

Sites/Block	Irrigation time Min/ha/irrig	Germination m^{-2}	Fertile tillers m^{-2}	No. of grains/spike	1000 grain weight (g)	Yield (t ha^{-1})
B1	278.8[a]	179.9[a]	167.1[a]	47.1[a]	44.6[a]	2.665[a]
B2	267.5[b]	167.5[b]	231.9[b]	43.2[b]	44.2[a]	2.665[a]
B3	290.0[a]	170.0[b]	291.5[c]	41.1[b]	46.5[a]	2.925[b]
B4	269.5[b]	172.0[b]	302.0[d]	42.7[b]	44.5[a]	2.870[b]
Means	278.3	172.4[2]	248	43.46	44.95	2.781
LSD	8.81	6.36	8.823	3.96	3.98	.0885

Significance at alpha = 0.05, Means are average of 4 sites

significantly higher germination count al all sites than flat method. Germination count was 12.17 % higher in bed and furrow irrigation method as compared to flat irrigation method. Kalwij (1999) reported 80-95 % germination count for bed and furrow and 70-80 % for flat irrigation method in cotton crop. The higher germination count in bed and furrow method was attributed to more favorable soil environment developed as a result of bed and furrow preparation and irrigation method in saline submerged soil. Results (Table 2) also indicated that at site B1, germination was higher than other three sites.

Yield and yield components

The fertile tillers, number of grain per spike, weight of 1000 grains and yield of crop were significantly higher on bed and furrow sowing method as compared to flat sowing method (Table 1). It is evident from the results that wheat sown on beds and irrigated by furrows method, yielded significantly higher (13.4 %) than flat irrigation method. However, at one site, the crop yield under bed and furrow irrigation decreased by 7 %, which was associated with higher SAR level. These results are in accordance with those of Chaudhry and Qureshi (1991). By contrast, on the basis of average yield for the whole study, the yield obtained from bed and furrow method of irrigation was 13.4 % higher than flat border method. Ahmad and Mahmood (2005) reported 11.2 % increase in wheat yield, whereas Hassan *et al*. (2005) mentioned an increase of 30 % in maize yield. The higher yield in bed furrow irrigation method was ascribed to increased seedling density (Bhatti *el al.,* 1990; Hadda and Arora, 2006). Higher germination, more fertile tillers and higher 1000-grain weight as compared to flat method, where as reduction in fertile tillers, 1000-grain weight might be due to deficiency of available plant nutrients, and poor soil aeration for plant growth because of poorly drained soils that in turn suppressed tillering. The yield enhancement by bed and furrow method has also been reported by Berkhout *et al*. (1997) who attributed higher yield in bed and furrow method to better seed germination and root growth. The response of site B1 and B2 was same but significantly different from B3 and B4 (Table 2)

Salt movement

The results of chemical analysis of the soil under flat border and bed and furrow method of irrigation are presented in Table 3 and 4. The results indicated that EC (dS m^{-1}) tended to increase in the central space between the plant rows. Decrease in salt concentration at bed side (at plant rows) justifies the increase in crop yield on beds. The SAR also varied in the same fashion. The salt movement through the beds improved the soil plant environment for better seed germination and plant growth leading to higher crop yield. These results are quite in line with that of Kalwij *et al.* (1999).

Table 3. Salt movement as affected by irrigation technique (Flat and bed furrow)

Treatment	Soil pH	EC (dS m^{-1})	$Ca^{++} + Mg^{++}$ (me L^{-1})	Na^{+} (me L^{-1})	SAR (mmol $L^{-1})^{1/2}$
Flat/border	8.64[a]	2.86[a]	3.92[a]	18.89[a]	13.49[a]
Bed and furrow	8.63[a]	2.22[b]	2.69[b]	17.77[b]	15.35[b]
Means	8.633	2.43	3.30	18.33b	14.32
LSD	0.217	0.073	0.069	0.575	0.465

Significance at alpha = 0.05, Means are average of 4 sites

Table 4. Salt movement as affected by treatments (Flat, Bed side and Bed centre)

Treatment	Soil pH	EC (dS m^{-1})	$Ca^{++} + Mg^{++}$ (me $L^{-1)}$	Na^{+} (me L^{-1})	SAR (mmol $L^{-1})^{1/2}$
Flat/Border	8.64[a]	2.86[a]	3.92[a]	19.1[a]	13.62[a]
Bed side	8.50[a]	1.62[b]	1.96_{b}	12.2[b]	12.23[b]
Bed Centre	8.76[a]	2.82[a]	3.43[c]	24.1[c]	18.46[c]
Means	8.633	2.434	3.10	18.33	14.66
LSD	.251	.086	.081	.663	.537

Significance at alpha = 0.05, Means are average of 4 sites

Conclusion

Bed and furrow irrigation method not only provided better drainage under heavy rains but also saved more than 35% of irrigation water as compared to flat methods and experienced more crop yield. Saving of irrigation water accompanied by improvement in yield is a breakthrough for the farmers having shortage of good quality water. It is therefore, recommended that the bed furrow irrigation method should be encouraged particularly for efficient utilization of water resources and improving wheat productivity in soils.

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