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EFFECT OF SOWING METHODS ON WHEAT PRODUCTION IN POTOHAR, PAKISTAN

M. Asif[*1], G. Akbar[1], S. H. Khan[1], Z. Islam[1] and S. A. Kalwar[2]

[1]Climate, Energy and Water Research Institute, [2]Agricultural and Biological Engineering Institute, National Agricultural Research Centre, Islamabad, Pakistan

ABSTRACT

The water productivity under rainfed condition may be affected by a multitude of factors including soil moisture at sowing time, quality of wheat seed, soil fertility and delayed rainfall, etc. However, this study focused on yield and water productivity effects in different sowing methods of wheat crop under rainfed condition. The study was conducted during two-consecutive wheat growing seasons in 2015-2016 and 2016-2017 at Fath-e-Jang in Potohar region of Pakistan. Three sowing methods 1: flat (involving broadcasting prior to flat cultivation), 2: ridge (65 cm furrow spacing with two rows) and 3: bed (soil piled up and cv. 130 cm flattened on top, having five wheat rows 15 cm apart) were evaluated for winter wheat crop (Ujala) for yield and water productivity. The three treatments were replicated thrice using randomized complete block design. The results indicated substantial saving of irrigation time in bed irrigation and ridge irrigation methods as compared to flat. The results showed that the overall average time to irrigate bed and ridge method of sowing was 24 and 17.5% less as compared to flat sowing method due to less water losses. The germination count (plants m^{-2}) was significantly higher (29% and 20%) in bed and ridge, respectively as compared to flat sowing method. The results indicated a significant difference in grain yield among the treatments. The highest grain yield was achieved in bed sowing (4.95 tons ha^{-1}) which is 16.36% higher than flat sowing method. The results showed water productivity for bed (33%) and ridge sowing (16%) higher when compared with flat sowing method, respectively for season 2015-16. A similar trend was observed in 2016-17, where the water productivity of bed (28%) and ridge sowing (17%) was higher as compared to flat sowing method. This study indicates increasing wheat productivity for bed sowing method than traditional flat sowing method under rainfed area of Potohar.

Keywords: sowing methods, water productivity, wheat, yield

INTRODUCTION

Agriculture plays a key role in the national economy of Pakistan, which is highly dependent on the efficient utilization of natural resources and input management (Abbas *et al.,* 2014). Wheat is an important cereal crop of Pakistan and is grown on large area annually and its production tends to increase but at a very low pace (Abdul, 2012). Wheat accounts for 9.6 percent of the value added in agriculture and 1.9 percent of GDP of Pakistan (Pak Economic Survey, 2012). During 2016-17, wheat was sown on an area of 9052 thousand hectares witnessing a decrease of 1.9 percent compared to 9224 thousand hectares during last year (Pak Economic Survey., 2012). Wheat production was estimated at 25.750 million tons during 2016-17 (GoP, 2016-17). The existing yield shows more than 50% yield gaps (Aslam, 2016) as compared to developed countries production. The main causes of low production may be either obsolete farming methods, inappropriate sowing methods, limited farmers resources, low quality wheat seed, non-availability of fertilizers at appropriate time, costly inputs, waterlogging, salinity, shortage of irrigation water and its inefficient use (Kalwij, 1999). Therefore, efforts need to be more focused on addressing these issues for increasing wheat production, which is essential for food security in Pakistan.

Sowing methods play an important role in germination of wheat crop in rainfed areas by conserving residual soil moisture in root zone (Bodner *et al.,* 2015). The available surface or groundwater, generally in limited quantity, needs to be efficiently utilized for maximizing production. Unwise use of irrigation water

[*]Corresponding author: asifbukhari1@gmail.com

through traditional irrigation method and inappropriate sowing method may reduce the cropping intensities and crop yields (Hamdy *et al.,* 2003). Thus, without a more improved sowing method and judicious use of available irrigation water and other farm resources, the production potential of wheat crop cannot be obtained. Poor water application efficiencies at field level must be improved to overcome the shortage of water. Improvement in application efficiencies will reduce the problem of waterlogging and salinity (Robert *et al.,* 2008). It is, therefore, important to develop techniques to fully utilize the available rainwater, groundwater and surface water resources more efficiently for crop production.

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). Generally, wheat crop is sown on flat land, which often negatively affects the crop by excess irrigation or rainwater (Hassan *et al.,* 2005). 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 due to drainage capabilities (Berkhout *et al.,* 1997). Ghane *et al.* (2009) stated that bed planting systems for cereal crops including wheat have been used in cultivation for centuries and have demonstrated multiple benefits under the irrigated farming conditions in Pakistan (Akbar *et al*., 2016a; Akbar *et al*., 2017). The origin of raised-bed cultivation has traditionally been associated with water management issues, either by providing opportunities to reduce the impact of excess water in rainfed conditions, or to more efficiently deliver irrigation water in high production irrigated systems (Sayre, 2004). Moreover, furrow method of irrigation is well suited to crops including wheat, which are adversely affected by prolonged submerged conditions (Chaudhry *et al.,* 1994).

Wheat crop is generally sown on flat land by broadcast method after cultivating the field which not only results in poor germination but tends to suffer from water stress due to poor rainwater harvesting potential and irrigation performance (Chaudhry *et al.,* 1994). Bed and ridge sowing methods have been practiced in irrigated lands but, production benefits of sowing wheat on ridges or beds supplemented with irrigation were not demonstrated under the rain fed conditions of Potohar. Therefore, this study was conducted to evaluate the effect of different sowing methods including flat (traditional), ridge and bed under the rainfed conditions of Potohar supplemented with limited irrigation water from a rainwater storage dam (Akbar *et al*., 2016a; Akbar *et al*., 2017).

MATERIALS AND METHODS

The experiment was conducted during two consecutive wheat-growing seasons i.e. during 2015-16 in the month of November and 2016-17 in the month of November at Thatti Gujran (Fateh-Jang, district Attock, Punjab).The study area is located at 330N and 730 E at an elevation of 315 m above the mean sea level. The climate is classified as semi arid with hot-dry summer and cold winters. Rainfall ranges from 157 to 310 mm every year during wheat growing season. The agro-meteorological data including rainfall and temperature under wheat growing season 2015-16 and 2016-17 was collected that was obtained from meteorological observatory in the Fatheh Jang experimental field station of NARC and is tabulated in Table 1 and 2. The physical properties of the experimental soil are also tabulated in the Table 3.

Table 1. Rainfall during consecutive wheat growing season at the experimental site

Month-Year	Rainfall (mm)	Month-Year	Rainfall (mm)
	2015-16		2016-17
Nov-15	00.00	Nov-16	000.00
Dec-15	20.52	Dec-16	000.00
Jan-16	27.19	Jan-17	101.78
Feb-16	73.78	Feb-17	031.69
Mar-16	63.08	Mar-17	020.51
Apr-16	09.96	Apr-17	060.86
May-16	04.70	May-17	000.00

Table 2. Ambient temperature during consecutive wheat growing season at the experimental site

Month-Year (2015-16)	Average Temperature, ºC		Month-Year (2016-17)	Average Temperature, ºC	
	Max	Min		Max	Min
Nov-15	23	09	Nov-16	26	08
Dec-15	19	04	Dec-16	23	04
Jan-16	17	04	Jan-17	16	05
Feb-16	21	06	Feb-17	22	07
Mar-16	23	12	Mar-17	25	10
Apr-16	30	14	Apr-17	31	15
May-16	37	20	May-17	37	20

Table 3. Physical properties of the experimental soil

Depth (cm)	Particle size distribution			Texture	Field capacity %	Perma-nent wilting point %	Bulk density (gm cm^3)
	Sand %	Silt %	Clay %				
0-30	48	28	24	Loam	-	-	-
30-60	30	38	32	Clay loam	36	18	1.53
60-90	30	38	32	Clay loam	36	18	1.53

Treatments and experimental design

The winter wheat (cv. Ujala-16) was planted in the month of November and harvested in the 1st week of May under both consecutive wheat-growing seasons. The experimental design consisted of Randomized Complete Block (RCBD) with three replications. Three sowing methods included in the study were: 1 flat basin (broadcasting followed by cultivation) as a control, 2: ridge (65 cm furrow spacing with two rows of wheat) and 3: bed (130 cm furrow spacing with five rows of wheat). Area under research was divided equally into three individual plots/treatments for flat, ridge and bed sowing methods as per layout given in the Figure 1. Three replications were used for each plot. Each individual plot was 12 ft x12.5 ft in size. Furthermore, each treatment was separated by 4 ft buffer zone/area (un-cultivated area) to minimize the chances of seepage flow from one treatment to other treatment at the time of irrigation. The irrigation to the experimental plot was carried out through main line (UPVC 3 inches in dia) running along the experimental area and irrigation is done through an outlet/hydrant provided in front of each experimental treatment (Figure 1). Wheat crop was sown under each treatment at the seeding rate of 50 kg acre^{-1}.

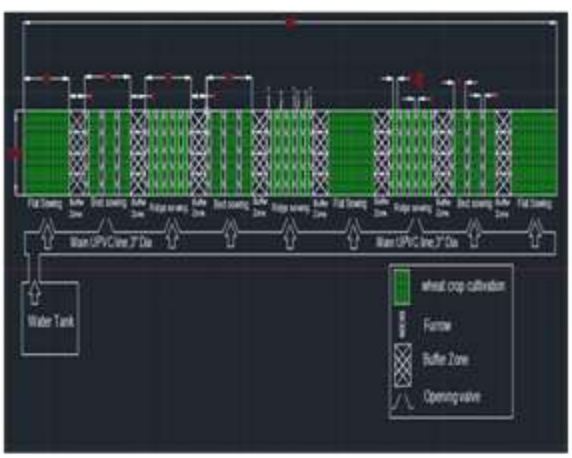

Figure 1. Experimental layout of flat, ridge and bed sowing methods for wheat cultivation

Irrigation

Irrigation was applied to each experimental plot through hydrant connected with outlet/valve. The discharge from the outlet pipe was determined by volumetric method as noted below:

Q= V/t……. (1)

Where:
Q = Discharge from the canvass pipe, Lps
V = Volume of water applied (liters)
t = irrigation time taken (sec)

Time to irrigate under different sowing methods was recorded using stopwatch for each treatment. The volume of water applied under different treatments was determined by using irrigation time and flow rate data. The following noted below relation has been used for the volume of water applied under various treatments.

V= Q x t…………. (2)

Where:
Q = Discharge from the canvas pipe, Lps
V = Volume of water applied (liters)
t = irrigation time taken (sec)

Similarly in case of flat method of sowing, irrigation time was measured for its whole area, whereas for ridge and in bed method sowing techniques, the time to irrigate furrows was recorded. A furrow area was determined from its length and width under each treatment. The depth of water applied under each treatment has also been worked out from the noted below:

QT = 27.78Ad……… (3)

Where:
Q = Discharge (lps)
T = Time (hrs)
A = Area (ha)
d = Depth of water (cm)
T = 27.78Ad/Q
Conversion factor=27.78

Rainfall

Rainfall was measured using a standard rain gauge from automatic weather station of Davis Company USA installed at the experimental site.

Yield and yield components

The crop yield and yield components including number of plants per unit area, plant height, number of tillers plant^{-1}, spike length, number of grains spike^{-1}, 1000-grains weight and grain yield per unit area were recorded under each treatment at the end of the season.

Water productivity

The water productivity (kg m^{3} or kg ha^{-1} mm) for crop grain was calculated by dividing crop yield

by the total water input including both irrigation application and rainfall.
Water productivity for grain = grain yield/water input (Perry *et al.,* 2009).

Statistical analysis

The data collected for irrigation time and yield parameters was put for analysis of variance techniques as described by Steel and Torrie (1997) at 5% alpha level.

RESULTS AND DISCUSSION

Irrigation time measurement

One irrigation was applied during each growing season 2015-16 and 2016-17. The soil moisture deficit before irrigation was determined using gravimetric method. The average time taken to irrigate (min/ha/irrigation) under different treatments was analyzed statistically and the results are illustrated below in Table 4. The results indicated significant difference in irrigation time under different sowing methods and the irrigation time, followed the pattern of flat > ridge > bed. The highest numbers of irrigation time per irrigation per unit area were achieved under flat sowing (5524), followed by ridge (4454.3) and then bed sowing techniques (4162.7) during 2015-16 wheat growing season. Similar trends in irrigation time measurement have been observed during 2016-17 wheat growing season. The results indicated substantial saving of irrigation time in bed and ridge sowing methods as compared to flat method of sowing. In 2015-16 growing wheat season, the time to irrigate bed and ridge method of sowing was 25 and 19% less as compared to flat sowing method. Whereas in 2016-17 wheat growing season, the time to irrigate bed and ridge method of sowing was 23 and 18% less as compared to flat sowing method. Hence, the overall average time to irrigate bed and ridge method of sowing was 24 and 17.5 % less as compared to flat sowing method due to less water losses. Similar results have been reported by Chaudhry and Qureshi (1991). Similarly these findings are also in line with Kalwij (1999) and Akbar *et al.* (2016b) who reported 30% decrease in irrigation time in bed as compared to flat method of sowing. Directorate of Water Management (1997) also reported similar findings for saving in irrigation time under bed and ridge sowing method, they reported, saving in irrigation time was due to compaction of furrow through tractor wheel, which ceased and minimized deep percolation losses and facilitated lateral movement. Moreover, Munir (2010) conducted study on irrigation techniques in the irrigated area of Pakistan and reported 35% saving in irrigation time as compared to flood method of irrigation.

Table 4. Average irrigation time under different sowing techniques

Treatments	2015-16	2016-17
	Irrigation time (Min/ha/ irrigation)	**Irrigation time (Min/ha/ irrigation)**
Flat	5524.4a	5424.3a
Ridge	4454.3b	4435.3b
Bed	4162.7c	4160.7c
LSD (5%)	6.3222	7.8892

Significance at alpha=0.05

Yield and yield components

The wheat yield and its yield components were statistically analyzed for the growing period 2015-16 and 2016-17 and the results for the both growing seasons are placed in Table 5 and 6. The germination count (plants m^{-2}) was significantly different among all three sowing methods. The germination count was 30% and 19% higher in bed and ridge, respectively as compared to flat sowing method in growing season 2015-16. Similarly the same trend was found during growing period 2016-17. The highest number of germination count was achieved under bed sowing (96), followed by ridge sowing (83) and lastly flat sowing (67) for the growing period 2015-16. The similar trend of increase in the germination count was observed for bed (71) as highest, followed by ridge (65) and lastly flat sowing (52) for the growing period 2016-17. The higher germination count in bed and furrow method was attributed to more favorable soil environment developed as a result of bed and furrow preparations and sowing method. These findings are in line with the work of Tanveer *et al.* (2003), who reported that in bed planting methods, the germination was high and significantly different for flat conventional sowing method.

Similarly, there was significant difference for number of tillers m^{-2} among the treatments. The highest numbers (430) were achieved in bed sowing, followed by ridge (319) and flat sowing (306) for the growing season 2015-16, the similar increasing trend was found in the growing season 2016-17. These findings are in line with the results of Kilic (2010) in which a significant difference between bed and flat sowing methods for tillers m^{-2} was observed. Furthermore, there was significant difference for plant height among the treatments. The highest numbers were achieved in bed sowing (104), followed by ridge sowing (103) and then flat sowing (98) in the growing period 2015-16. Similarly, for the growing period 2016-17, the similar trend was observed as 100.90 cm plant height found under bed sowing technique, 99 cm height in case of ridge sowing and 97.57 cm plant height noted for flat method of sowing.

There was a significant difference for number of grains spike^{-1} among the treatments. The highest grain numbers were recorded for bed sowing (63) as compared to flat sowing (56). These findings are compatible to the results of Mollah (2009), who reported significant difference among the treatments for number of grains spike^{-1}. The data also showed significant difference for 1000-grain weight among the treatments. The highest was achieved in bed sowing (38 gm) as compared to flat sowing (33 gm). The results indicated a significant difference in grain yield among the treatments. The highest grain yield was achieved in bed sowing (4.95 ton ha^{-1}) which is 16.36% higher grain yield as compared to flat sowing method. Conclusively, the best results were obtained in bed sowing method as compared to ridge and flat sowing methods.

Water productivity

Water productivity of wheat showed increasing trend from season 1 to season 2. The results showed water productivity of 19.29 and 15.28 kg/ha/mm for bed and ridge sowing method, which is 33% and 16% higher as compared to flat sowing method (Table 7) for season 1 (2015-16). Furthermore, a similar trend was found in 2016-17 wheat growing season, the water productivity of 16.02 and 13.86 kg/ha/mm was attained for bed and ridge sowing method, which is 28% and 17% higher as compared to flat sowing method (Table 8).

Table 5. Effect of sowing method on yield and yield components (2015-16)

Treatments	Number of plants (m^{-2})	Number of tillers (m^{-2})	Plant height (cm)	Spike length (cm)	Number of grains (spike^{-1})	1000-grain weight (g)	Grain yield (t ha^{-1})
Flat	67.333c	306.00b	098.33a	11.267	57.000 b	33.000b	4.1933c
Bed	96.333a	430.33a	104.00b	11.733	67.000a	38.667a	5.2117a
Ridge	83.000b	319.33b	103.33b	11.567	64.000ab	36.333ab	4.5709b
LSD (5%)	12.678	57.934	n.s	n.s	8.1211	5.1529	0.2563

Table 6. Effect of sowing method on yield and yield components (2016-17)

Treatments	Number of plants (m^{-2})	Number of tillers (m^{-2})	Plant height (cm)	Spike length (cm)	Number of grains (spike^{-1})	1000-grain weight (g)	Grain yield (t ha^{-1})
Flat	52.333b	287.00a	097.57b	09.997	55.000	33.333	4.1000b
Bed	71.000a	373.00b	100.90a	10.000	58.333	39.333	5.1111a
Ridge	65.000a	350.33bc	099.10ab	10.443	59.667	36.600	4.6900a
LSD (%)	11.510	n.s	1.9406	n.s	n.s	n.s	1.0605

Table 7. Water input, crop yield and water productivity of wheat crop under different sowing methods at Fateh Jang, district Attock, Punjab during 2015-16

Growing season	Particulars	Sowing method		
		Flat	Bed	Ridge
2015-16	Rainfall (mm)	199	199	199
	Irrigation (mm)	125	71	100
	Total water input (mm)	324	270	299
	Grain Yield (tons ha^{-1})	4.19	5.21	4.57
	Water Productivity (kg/ha/mm)	12.93	19.29	15.28

Table 8. Water input, crop yield and water productivity of wheat crop under different sowing methods at Fateh Jan district Attock, Punjab during 2016-17

Growing season	Particulars	Sowing method		
		Flat	Bed	Ridge
2016-17	Rainfall (mm)	214.84	214.84	214.84
	Irrigation (mm)	141	104	122
	Total water input (mm)	355.84	318.84	336.84
	Grain yield (tons ha^{-1})	4.10	5.11	4.67
	Water productivity (kg/ha/mm)	11.52	16.02	13.86

CONCLUSION

From this study, it is concluded that sowing method also is an important factor, which affects yields and water productivity. In this study the bed method of sowing has shown the prospects of increased yield per unit volume of water (water productivity) as compared to ridge and flat method of sowing. Hence, it is recommended to use bed-sowing method in the rainfed condition to improve yield and water productivity of wheat crop.

AUTHOR'S CONTRIBUTION

M. Asif: Lead the study/data collection/analysis and paper writing.
G. Akbar: Supported/design/management of the study and carried out data analysis.
S. H. Khan Khalil: Collected and compiled field data.
Z. Islam: Literature review and assisted author in paper drafting.
S. A. Kalwar: Supervised the mechanical operations for land preparation and experimental layout.

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