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Effect of sowing methods and seed rates on wheat yield and water productivity

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RESEARCH ARTICLE

Abstract

Wheat yield and water productivity can be improved by sowing on beds with balanced seed rate. The present study was conducted during rabi seasons of 2012-2013 and 2013-2014 at the experimental area of Water Management Research Centre, PARS, University of Agriculture, Faisalabad, to investigate three seed rates (100, 130, and 160 kg/ha) and three sowing methods (broadcasting, drill sowing, bed planting) for better yield and water productivity of wheat. It was concluded that wheat sowing under bed planting showed better results with highest plant height (92.358 cm), numbers of tillers (294.17), numbers of grains per spike (42.5), 1000 grain weight (35.338 g), grain yield (3941.8 kg/ha) and water productivity (2.3028 kg/m^3), while these parameters were observed as the lowest under broadcasting among all treatments. Moreover, wheat on beds produced 13% more yield and saved 35% water in comparison to that under broadcasting. The results regarding seed rate revealed that the highest grain yield (4,117.1 kg/ha), water productivity (1.8361 kg/m^3) and numbers of tillers (297.94), but lowest numbers of grains per spike (38.833) and 1000 grain weight (34.256 g) were obtained with seed rate of 160 kg/ha. Seed rate of 100 kg/ha produced highest numbers of grains per spike (42.167) and 1000 grain weight (35.336 g) but lowest numbers of tillers (264.17), grain yield (3,360.1 kg/ha) and water productivity (1.5272 kg/m^3). The economic analysis also revealed the benefits of bed planting over the other treatments with highest benefit cost ratio as 2.74 with 160 kg/ha seed rate. It is, therefore, recommended that wheat should be sown with seed rate of 160 kg/ha under bed planting for economically better yield and water productivity in the semi-arid area of Faisalabad, Pakistan.

Keywords: benefit cost ratio, grain yield, seed rate, sowing method, water productivity

1. Introduction

The increase in population stipulates additional food requirement despite looming crisis of water shortage. Considering higher demand of food and importance of water, it is need of the time to adapt conservation and water saving technologies for production of wheat. In Pakistan wheat is sown through broadcasting on a large area hence wheat yield in Pakistan is very low as compared with that in many other countries and even the farmer's yield within the country is 30-35% of the potential yield. The wheat yield has been reported to be affected by sowing methods such as broadcasting, line sowing, and bed planting (Carver, 2005; Hobbs *et al.*, 1998; Sayre and Ramos, 1997; Singh and Singh, 1992; Singh *et al.*, 1994). The line sowing generally produces higher yield than sowing under broadcasting (Krezel and Sobkowicz, 1996).

The drill sowing showed better results for wheat crop regarding wheat yield, plant density, 1000 grain weight and number of grains per spike (Fenech and Papy, 1977; Kipps, 1970; Shaalan *et al.*, 1977). Worldwide, bed planting technology is being used for water saving along with other advantages like better crop stand, easy drainage of excess water after raining, easy weed control and increase in yield. Bed planting has been found to show improved fertiliser use efficiency, water distribution efficiency and lodging (Hobbs and Gupta, 2004). Peries *et al.* (2001) reported that improvement in root proliferation under bed planting ensures better crop stand and yield. (Fahong *et al.*, 2003)

reported that furrow irrigation under raised bed technology saved more than 30% of irrigation water against traditional flood irrigation and also needs reduced seed rate without compromising crop yield as compared to that under flat sowing. Hobbs *et al.* (2000) reported that crops grown on raised beds showed reduced weed infestation and lodging.

To determine the crop vigour and ultimate yield, seed rate has been reported to be a major factor besides other agronomic factors (Korres and Williams, 2002). According to Malik *et al.* (2009) the highest yield was obtained by using a seed rate of 125 kg among 125, 150 and 175 kg/ha seed rates, whereas, seed rate of 150 kg/ha for getting maximum yield (4.10 t/ha) among four different seed rates (125, 150, 175 and 200 kg/ha) was suggested by (Iqbal *et al.*, 2010).

Keeping in view the benefits of drill sowing and bed planting and importance of seed rate regarding wheat yield and water productivity, this study was designed to investigate the appropriate sowing method and balanced seed rate for semi-arid climate of Faisalabad with the following objectives:

- to investigate effects of different seed rates on wheat yield, sown under broadcasting, drill sowing and bed planting methods;
- to find the best and economical combination of seed rate and sowing method for better yields and water productivity.

2. Material and methods

The study was conducted at the experimental area of Water Management Research Centre, PARS Jhang road, University of Agriculture, Faisalabad during rabi seasons of 2012-2013 and 2013-2014. The study area has a subtropical climate with mean annual rainfall of 350 mm. The temperature reaches 50 °C to, at times, fall below the freezing point. Soil of the field was sandy loam with bulk density of 1.52 g/cm^3 at a depth of 0.3 m. Three seed rates i.e. 100, 130 and 160 kg/ha and three different sowing methods, i.e. broad cast, drill sowing (rabi drill) and bed planting with 4-row on each bed were evaluated for wheat variety 'Sehar 2008'.

The experiment was laid under a randomised complete block design with three replicates and nine treatments as given below:

1. broadcasting with seed rate of 100 kg/ha;
2. broadcasting with seed rate of 130 kg/ha;
3. broadcasting with seed rate of 160 kg/ha;
4. drill sowing with seed rate of 100 kg/ha;
5. drill sowing with seed rate of 130 kg/ha;
6. drill sowing with seed rate of 160 kg/ha;
7. bed planting with seed rate of 100 kg/ha;
8. bed planting with seed rate of 130 kg/ha;
9. bed planting with seed rate of 160 kg/ha.

The total area of the experiment (76 × 47 m^2) was divided into 27 plots. The net size of each plot was 8 × 15 m^2. The layout of the experiment is shown in Figure 1.

All the required management and agronomic practices were followed uniformly at all plots throughout the growing period in both growing seasons as shown in Table 1.

Total water depth of each irrigation was recorded with the help of cut throat flume of 8' × 3' size. At harvesting numbers of tillers per square meter, Plant height, numbers of grains/spike, 1000-grain weight and grain yield (kg/ha) were measured as plant growth parameters. Water productivity was calculated by dividing grain yield (kg/ha) of each treatment by total volume of water applied per hectare under that treatment.

The data were analysed using analysis of variance technique (Steel *et al.*, 1997) to determine significance level of treatment effects on biomass and comparison of treatment means was made using least significance difference (LSD) test at 5% probability level ($LSD_{0.05}$).

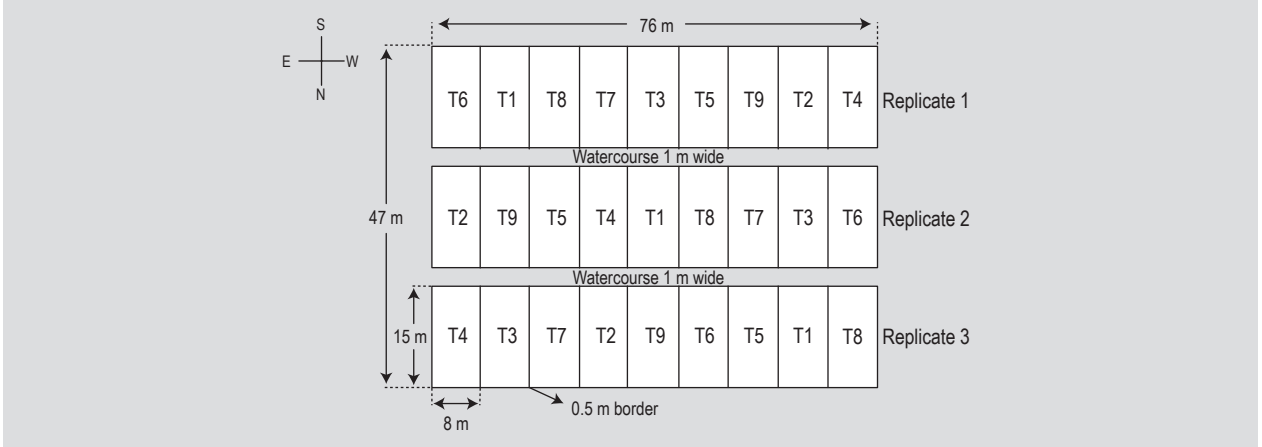

Figure 1. Experimental layout.

Table 1. Summary of management/agronomic practices for wheat crop.[1]

Practice/item		Date/quantity
Rouni		145 mm
Sowing	2012-2013	20-11-2012
	2013-2014	23-11-2013
DAP (basal dose during land preparation)		125 kg/ha
Urea (three split doses with every irrigation, i.e. 1st, 2nd, 3rd)		250 kg/ha
SOP (basal dose during land preparation)		60 kg/ha
Weedicide (spray)	Buctril	1.2 l/ha
	Topic	2.47 l/ha
Harvesting	2012-2013	18-04-2013
	2013-2014	22-04-2014

[1] DAP = diammonium phosphate; SOP = sulphate of potash.

The economic analysis of any agronomic practice is essential from farmer's point of view, as they are often interested in benefits and cost of a certain technology. The benefit cost ratio is an indicator that shows the profitability and adoptability of any new sowing technology. If the benefit cost ratio works out to be less than 1, then the present worth of the costs at this discount rate would have exceeded the present worth of the benefit and we would not have recovered our initial expenditure plus the return on our investment from the farm practice. The benefit cost ratio was calculated regarding each sowing method and seed rate according to procedure explained by Husnain (2011).

3. Results and discussion

Plant height

Variations in plant height in response to sowing methods and seed rates are shown in Table 2. The variations between bed planting and drill sowing was non-significant for all seed rates. In case of broadcasting plant height was lower (90.066 cm) than that of under drill sowing (92.344 cm) and bed planting (92.358 cm). These results are comparable with the work of Soomro *et al.* (2009).

Number of tillers

The data (Table 2) revealed that there was linear increase in number of tillers per square meter with increased seed rate. Among seed rates, 100 kg/ha produced significantly lower number of tillers (264.17) than that under seed rates of 130 kg/ha and 160 kg/ha which produced 283.72 and 297.94 number of tillers per square meter, respectively.

Table 2. Growth parameters of wheat crop under different sowing methods and seed rates.[1]

	Plant height (cm)	No. of tillers/m^2	No. of grain per spike	Weight of 1000 grains (g)
Sowing methods				
M1 = broad casting	90.066b	262.83c	36.833b	33.753c
M2 = drill sowing	92.344a	288.83b	42.167a	35.207b
M3 = bed planting	92.358a	294.17a	42.500a	35.338a
LSD (0.05)	0.1002	0.5784	0.4437	0.0090
Seed rates (kg/ha)				
S1 = 100	91.522a	264.17c	42.167a	35.336a
S2 = 130	91.614a	283.72b	40.500b	34.707b
S3 = 160	91.631a	297.94a	38.833c	34.256c
LSD (0.05)	0.1184	0.6298	0.6077	0.0108
Interaction (M×S)				
M1×S1	89.860c	245.50i	38.500d	34.420g
M1×S2	90.163b	266.17h	36.500e	33.860h
M1×S3	90.173b	276.83e	35.500e	32.980i
M2×S1	92.347a	271.50g	43.500ab	35.650b
M2×S2	92.320a	289.50d	42.500b	35.020d
M2×S3	92.367a	305.50b	40.500c	34.950e
M3×S1	92.360a	275.50f	44.500a	35.937a
M3×S2	92.360a	295.50c	42.500b	35.240c
M3×S3	92.353a	311.50a	40.500c	34.837f
LSD (0.05)	0.2052	1.0908	1.0525	0.0188

[1] Treatment means with different letters are significantly different (P=0.05); LSD = least significant difference.

These findings are in accordance with the work of Iqbal *et al.* (2010) who reported that increasing seed rate increased the fertile tillers and total tillers significantly. The results further revealed that different sowing methods significantly affected the number of tillers, which were 294.17, 288.83 and 262.83 tillers/m^2 under bed planting, drill sowing and broadcasting, respectively.

Number of grains per spike

The seed rate of 100 kg/ha produced significantly more number of grains per spike (42.167). Minimum number of grains were recorded for seed rate of 160 kg/ha (38.833). This trend has also been shown in the work of (Kraft and Spiss, 1988). Bed planting produced significantly more number of grains per spike (42.5) than those under broadcasting (36.833).

Weight of 1000 grains

The heaviest weight of 1000 grains was observed under plants sown at seed rate of 100 kg/ha (35.336 g) and lightest weight under 160 kg/ha (34.256 g). Sowing method also significantly affected the weight in such a way that bed planting produced more weight (35.338 g) and broadcasting produced smallest weight (33.753 g). The results are shown in Table 2. These findings are in accordance with the works of Iqbal *et al.* (2010).

Water applied

The total depth of irrigation water applied throughout growing season was significantly different in case of bed planting (184.67 mm) compared with that under drill sowing (283.39 mm) and broadcasting (284.17 mm). Different seed rates have no effect on water applications. In bed planting the least amount of water was applied and 35% of water was saved than that applied under flat sowing methods (broadcasting and drill sowing). Water saving under bed planting has been observed by Fahong *et al.* (2003) and Ashraf (2014). The average depth of each irrigation for both growing seasons under different sowing methods is given in Tables 3 and 4.

Yield

The highest and lowest yields were observed under sowing method of bed planting (3,941.8 kg/ha) and broadcasting (3,486 kg/ha), respectively. Also the seed rates of 160 kg/ha and 100 kg/ha produced the highest (4,117.1 kg/ha) and the lowest (3,360.1 kg/ha) yield, respectively. The yield increase in bed planting was about 13% than that under broadcasting. These findings for yield increase with balanced seed rate and bed planting are in accordance with the works of Iqbal *et al.* (2010) and Ashraf (2014), respectively. The highest and lowest yields were obtained under seed rates of 160 kg/ha with bed planting (4,327 kg/ha) and 100 kg/ha with broadcasting (3,151.3 kg/ha), respectively (Table 4).

Table 3. Average depth of irrigation under different sowing methods.[1]

Irrigation	Depth of water applied (mm)		
	Broadcasting	Drill sowing	Bed planting
1st	130.20	126.66	84.08
2nd	113.00	122.12	76.11
3rd	117.24	106.00	73.03
Total	284.17a	283.39a	184.67b
Water saving	–	–	35%

[1] Treatment means with different letters are significantly different (P=0.05).

Table 4. Yield and water productivity of wheat crop under different sowing methods and seed rates.[1]

	Water applied (mm)	Yield (kg/ha)	Water productivity (kg/m^3)
Sowing methods			
M1 = broad casting	284.17a	3,486.0c	1.3183c
M2 = drill sowing	283.39a	3,809.7b	1.4406b
M3 = bed planting	184.67b	3,941.8a	2.3028a
LSD (0.05)	7.421	33.462	0.0881
Seed rates (kg/ha)			
S1 = 100	248.89a	3,360.1c	1.5272c
S2 = 130	251.00a	3,760.2b	1.6983b
S3 = 160	252.33a	4,117.1a	1.8361a
LSD (0.05)	10.143	36.532	0.1125
Interaction (M×S)			
M1×S1	282.67a	3,151.3h	1.2067e
M1×S2	284.33a	3,465.0f	1.3150de
M1×S3	285.50a	3,841.7d	1.4333cd
M2×S1	279.00a	3,398.0g	1.3200de
M2×S2	285.83a	3,848.3d	1.4367cd
M2×S3	285.33a	4,182.7b	1.5650c
M3×S1	185.00b	3,531.0e	2.0550b
M3×S2	182.83b	3,967.3c	2.3433a
M3×S3	186.17b	4,327.0a	2.5100a
LSD (0.05)	17.569	63.275	0.1949

[1] Treatment mean with different letters are significantly different (P=0.05).

Water productivity

The results in Table 4 revealed that greater water productivity was obtained under bed planting (2.3028 kg/m^3) than under drill sowing (1.4406 kg/m^3) and broadcasting (1.3183 kg/m^3). The seed rate of 160, 130 and 100 kg/ha obtained water productivity of 1.836, 1.6983 and 1.5272 kg/m^3, respectively. The best results were observed under bed planting with 160 kg/ha (2.51 kg/m^3) and poor results were observed under broadcasting with 100 kg/ha (1.2067 kg/m^3).

Economic analysis

Total production cost of wheat has been calculated and depicted in Table 5. The benefit cost ratio was calculated regarding each combination of sowing method and seed rate and presented in Table 6. The data show a highest benefit cost ratio under bed planting for 160 kg/ha seed rate; so this combination is economically best as compared to other treatments (Table 6). Furthermore, economically

Table 6. Economic analysis of different sowing methods and seed rates.[1]

Treatment	Total income (Rs./ha)	Total production cost (Rs./ha)	Benefit cost ratio
Broadcasting + 100 kg/ha	137,417	60,350	2.28
Broadcasting + 130 kg/ha	147,613	61,850	2.39
Broadcasting + 160 kg/ha	159,855	63,350	2.52
Drill sowing + 100 kg/ha	145,435	61,850	2.35
Drill sowing + 130 kg/ha	160,070	63,350	2.53
Drill sowing + 160 kg/ha	170,938	64,850	2.64
Bed planting + 100 kg/ha	149,758	61,100	2.45
Bed planting + 130 kg/ha	163,937	62,600	2.62
Bed planting + 160 kg/ha	175,628	64,100	2.74

[1] Total income calculated as Rs. 32.5/kg grain yield plus Rs. 35,000/ha dry mater yield. 1 US Dollar = 104.4 Rs. (October 2015).

Table 5. Cost of production of wheat (Pakistani rupee (Rs.)/ha)[1].

Operation/input	Quantity/amount	Unit price (Rs.)	Cost/ha (Rs.)
Tillage practices			
Cultivator + disk harrow + planking	1 + 1 + 1	2,000 + 4,000 + 1,750/ha	7,750
Seed charges	100 kg/ha	50/kg	5,000
	130 kg/ha	50/kg	6,500
	160 kg/ha	50/kg	8,000
Sowing method charges			
Broadcast	–	500/ha	500
Sowing by drill	–	2,000/ha	2,000
Sowing by bed planter	–	2,500/ha	2,500
Fertiliser (bag)			
DAP + urea + SOP[2]	2.5 + 5 + 1.25 bag/ha	3,700 + 1,850 + 4,000/bag	23,500
Irrigation (canal + tubewell)			
Broadcasting	–	–	3,600
Drill sowing	–	–	3,600
Bed planting	–	–	2,350
Interculture			
Spray (Buctril + topic)	–	1,250 + 1,500/application	2,750
Harvesting			
Harvesting charges	–	7.5 mounds/ha	9,750
Threshing charges	–	7,500/ha	7,500

[1] 1 US Dollar = 104.4 Rs. (October 2015).
[2] DAP = diammonium phosphate; SOP = sulphate of potash.

worse results were shown by seed rate of 100 kg/ha through broadcasting because of lowest benefit cost ratio.

4. Conclusions

Based on field experiment conducted under three sowing methods (broadcasting, drill sowing, bed planting) and three seed rates (100, 130, and 160 kg/ha), the following conclusions were drawn:

- The seed rate of 160 kg/ha produced the highest and 100 kg/ha seed rate produced the lowest yield and water productivity.
- Wheat on beds produced 13% more yield and showed better performance regarding water productivity by saving 35% water in comparison to that under broadcasting.
- Wheat sowing with seed rate of 100 kg/ha through broadcasting has lowest and seed rate of 160 kg/ha under bed planting has highest and economically better yield and water productivity.

It is recommended that wheat should be sown with a seed rate of 160 kg/ha under bed planting for economically better yield and water productivity in semi-arid area of Faisalabad, Pakistan.

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