

Influence of flat and bed sowing methods on growth and yield parameters of wheat in rice-wheat cropping system

*Azhar Mahmood¹, Anwar Javaid Wahla¹, Rashid Mahmood² and Liaquat Ali¹

¹Adaptive Research Farm, Sheikhpura, ²Institute of Agricultural Sciences, University of the Punjab, Lahore, Pakistan.

*Corresponding author's email: drazharskp@gmail.com

Abstract

A field experiment was conducted to compare the response of wheat crop in rice-wheat cropping system to flat and bed sowing methods. The experiment was comprised of triple-row and double-row bed planting with bed planter and a single row flat sowing with Rabi drill. Maximum germination count, number of productive tillers, grains per spike, 1000-grains weight and grain yield (kg ha^{-1}) were observed in triple-row bed planting followed by double-row bed planting and drill sowing. The grain yield obtained in triple-row (3953 kg ha^{-1}) and double-row (3728 kg ha^{-1}) bed planting methods, was 17% and 11%, respectively more than that of flat sowing (3364 kg ha^{-1}). It is thus concluded that triple-row bed planting is the most appropriate method of wheat sowing after rice.

Key words: Double-row bed, triple-row bed, drill sowing, wheat grain yield.

Introduction

Wheat (*Triticum aestivum* L.) is the staple food of Pakistan and the most important cereal crop of the country. It contributes 14.4 percent to the value added in agriculture and 2.8 percent to GDP. Wheat is cultivated on an area of 9042 thousand hectares with the annual estimated production of 23864 thousand tones and an average yield under irrigated conditions as 2639 kg ha^{-1} (Anonymous, 2010). The average grain yield of wheat in Pakistan is very low as compared to other leading wheat-growing countries of the world. Several reasons of low production are poor soil fertility, lack of irrigation water, weed infestation, late planting and, the most important and less noticeable is the traditional sowing method.

The selection of suitable sowing method plays an important role in the placement of seed at proper depth, which in turn ensures the better emergence and the subsequent growth. In Pakistan wheat is sown through broadcast method on a large area after harvesting rice. Broadcasting not only requires higher seed rate but also results in poor plant population (Collins and Fowler, 1992). Drill sowing is recommended method because of its uniform seed distribution at desired depth, which results in better germination and uniform crop stand (Tariq *et al.*, 2001; Riffkin *et al.*, 2003).

Sowing of cereals on raised beds was introduced initially for wheat after inspiring by the success of irrigated maize-wheat on permanent

raised beds in Mexico (Sayre and Hobbs, 2004). Since then, many advantages of growing wheat on beds have been reported including opportunities for mechanical weeding, relay intercropping and improved fertilizer placement (Sayre and Hobbs, 2004), irrigation water savings of about 30% and reduced water logging (Talukdar *et al.*, 2002; Sayre and Hobbs, 2004). Raised beds are widely used in agriculture in developed countries and have proven to be an excellent option for wheat (Singh *et al.*, 2009). In field experimentation, Humphreys *et al.* (2005) reported irrigation water savings of 12–60% for direct-seeded and transplanted rice on beds, but with variable effects on yield and water productivity. Balasubramanian *et al.* (2003) described that transplanting or direct drill sowing of rice on beds is more efficient in irrigation water use than traditional transplanting of rice in puddle soil. As a result of better physical environment (loose soil) under bed planting, higher root length density in upper 0-50 cm soil layer was observed than that of conventional system (Aggarwal and Goswami, 2003).

Although effectiveness of raised bed sowing is well studied in various cropping systems but detailed information is not available with reference to wheat by considering the number of rows per bed as a factor. Therefore the present study was planned to compare the conventional flat sowing of wheat with double-row and triple-row bed sowing.

Materials and Methods

A field experiment was conducted at Adaptive Research Farm, Sheikhpura, Pakistan (31.0°-32.5° N; 73.5°-74.42° E) during Rabi 2009-10 in a silt loam soil. The experiment was laid out in randomized complete block design with three replications in plots measuring 8 m × 10 m. The experiment comprised of three treatments viz. triple-row bed planting, double-row bed planting with bed planter and single row sowing on flat with Rabi drill. After the harvest of rice crop, seed bed was prepared by traditional methods. The bed (70 cm wide) formation and wheat cv. Sehar-2006 seeds sowing were done in a single operation by using bed planter on 15th of November, 2009. The seed was used @ 125 kg ha⁻¹. To the bed and flat plots fertilizers were applied at 100 kg N, 60 kg P₂O₅ and 60 kg K₂O ha⁻¹ in the form of urea, diammonium phosphate (DAP) and sulphate of potash (SOP), respectively. The whole P, K, and one third of N were applied at time of sowing. Remaining two third of the N was applied with first irrigation. Four irrigations excluding rauni (irrigation applied before seed bed preparation) were applied at crown root initiation, booting, anthesis and grain development stages. All other agronomic practices except those under study were kept normal and uniform for all the treatments. The meteorological data for the growth period of wheat crop was collected from weather station of Plant Protection Department located in the vicinity of experimental area (Table 1).

An area of one square meter was taken at random at 3 places in an experimental unit to record observations and averages were used in statistical analysis. Germinated seeds and fertile tillers were counted from the selected area. Wheat leaf area was measured periodically (40, 80 and 120 days after sowing with leaf area meter (Licor Model 3100) by randomly selecting a 20 cm crop row segment in each plot at three places. For recording number of grains spike⁻¹ and plant height, ten tillers were randomly selected from each plot. The crop was harvested on April 15, 2010 and threshed mechanically with a mini thresher. A random grain sample from each experimental unit was obtained to record 1000-grains weight (g). The data collected were analyzed statistically by using Mstat-C Fisher's analysis of variance was used to test the significance of variance sources and treatment means were compared by using LSD test at $P \leq 0.05$ (Steel *et al.*, 1997).

Results and Discussion

Effect of planting methods on germination count

Planting methods significantly affected the number of wheat seedlings emerged per square meter (Table 2). Among the three treatments, minimum number of seedlings (172 m⁻²) was observed in flat sowing with Rabi drill. Maximum (208 m⁻²) number of seedlings was noted in treatments where crop was sown on triple-row beds. It was statistically ($P \leq 0.05$) at par with that of double-row beds (Table 2). The better germination of wheat seeds in bed sowing compared to that of flat sowing might be attributed to the availability of more volume of loose soil and almost uniform moisture conditions to all seeds sown on beds. These results are contrary to Tanveer *et al.* (2003), who reported that drill sowing on flat or on beds promoted emergence of wheat seedlings. These contradictions seem to be due to differences in soil physicochemical properties in both studies.

Effect of planting methods on leaf area, spike bearing tillers and grains per spike

All three sowing methods significantly affected leaf area (m²) of wheat crop and it was increased from 40 DAS to 80 DAS and then declined at 120 DAS. Maximum leaf area was noted in plots where crop was sown on double-row bed followed by triple-row bed planting technique. However, in both cases, leaf area was statistically similar when noted at 40 and 80 DAS (Table 2).

The magnitude of the sink capacity of wheat spike is determined by the number of grains it produces, which are often affected by the growing conditions. The sowing method not only influenced the number of spike bearing tillers but also significantly affected the number of grains per spike. Triple-row bed planting produced significantly higher number of productive tillers m⁻² (354.31) which was statistically ($P \leq 0.05$) at par with that of double-row bed planting. The least number of productive tillers m⁻² (341.25) was recorded in plots of Rabi drill sowing on flat (Table 2). In the same way, grains per spike were found maximum (42.23) when sowing was done according to triple-row bed planting which was statistically ($P \leq 0.05$) at par with that of double-row bed planting. The least number of grains spike⁻¹ (38.10) was noted in plots sown by Rabi drill (Table 2).

More leaf area, number of spikes per square meter and grains per spike, in case of wheat sown on beds, seems to be due to more nutrient and water use efficiency owing to better root growth in low bulk density soil of beds than that of flat. Better nutrient uptake by plants sown on beds than those on flat is reported previously (Syre and Ramos, 1997).

Effect of planting methods on plant height

Plant height is a function of both genetic constitution as well as the environmental factors. The data regarding plant height as affected by different planting methods is presented in Table 2. There was a significant difference ($P \leq 0.05$) among the height of wheat plants sown under different planting geometry. The tallest plants (85.10 cm) were found in plots where sowing was done with automatic Rabi drill which was statistically ($P \leq 0.05$) at par with that of double-row bed planting. Wheat plant height was found minimum (81.71 cm) in plots where sowing was done on triple-row beds.

The decrease in plant height of bed sown wheat than that of drilled on flat might be attributed to the moderate availability of water in beds. In case of wheat sown on flat flooding at regular intervals and rains gave a more dip of roots to water than that of bed sowing. This impact is further increased when irrigation was followed by rain at different growth stages particularly vegetative ones (Table 1). Increase in plant height with surplus amount of water is already reported by researchers (Baher *et al.*, 2002).

Effect of planting methods on 1000-grains weight and grain yield

Grain weight is an important yield component and makes a major contribution to grain yield of wheat. Significantly ($P \leq 0.05$) higher 1000-grains weight (40.34 g) was observed in triple-row bed planting and it was followed by

double-row bed planting method. The wheat 1000-grains weight was minimum (35.52) in plots sown by Rabi drill on flat (Table 2).

The efficiency and effectiveness of a sowing method is ultimately determined by grain yield per hectare, which in turn is a function of the interplay of the various yield components. The data pertaining to grain yield depicted that there was highly significant difference among the wheat grain yield under various sowing methods. Triple-row bed planting produced significantly ($P \leq 0.05$) higher grain yield (3953 kg ha⁻¹) which was 17% more than that of flat sowing and it was statistically at par with double-row bed planting method. The minimum grain yield (3364 kg ha⁻¹) was obtained from plots sown by Rabi drill on flat (Table 2)

In conventional tillage system ploughing soil more than 4 inches depth provide very little loose space in soil for the growth and development of plant roots. Raising the soil to form beds possibly increase the volume of low bulk density soil for better and easy root proliferation. Therefore, more volume of soil would be explored for nutrient uptake with healthy crop stand. It was due to the same reason that bed sowing improved growth and yield parameters of wheat compared to that which was sown flat. The better grain yield of wheat on beds was due to more germination count, number of productive tillers, grains per spike and 1000-grains weight. A number of researchers reported more crop yields by sowing on beds than that of flat (Rath *et al.*, 2000; Pratik *et al.*, 2002; Tripathi *et al.*, 2002); however, reversal is also possible under some specific soil and environmental conditions (Riffkin *et al.*, 2003).

It is concluded from the results of the experiment that triple-row bed planting is a better method of sowing of wheat after rice. Further investigations are required to understand principles behind the scene by taking root growth and nutrient uptake as parameters.

Table 1: Meteorological data during growth period of wheat for the year 2009-10.

Month	Mean Temperature (°C)		Relative humidity (%)	Rainfall (mm)
	Minimum	Maximum		
November 2009	12.0	25.3	55	0.0
December 2009	5.2	23.1	50	2.0
January 2010	4.6	17.4	68	0.0
February 2010	8.7	23.6	78	1.0
March 2010	17.0	32.1	70	3.0
April 2010	20.7	34.6	58	4.0

Source: Assistant Director of Agriculture (Pest Warning and Quality Control), Sheikhpura, Pakistan.

Table 2: Growth and yield parameters of wheat as affected by different planting methods.

Treatments	Leaf area (m ²)			Germination count (m ⁻²)	Plant height (cm)	Number of spike bearing tillers (m ⁻²)	Number of grains spike ⁻¹	1000-grains weight (g)	Grain yield (kg ha ⁻¹)
	40 DAS	80 DAS	120 DAS						
Triple-row bed planting	2.09 a †	4.28 a	1.99 a	208 a	82 b	354 a	42 a	40.3 a	3953 a (17)
Double-row bed planting	2.08 a	4.38 a	2.07 a	186 ab	83 ab	353 ab	41 a	37.7 b	3728 ab (11)
Single row flat sowing (Control)	1.94 b	3.87 b	1.78 b	172 b	85 a	341 b	38 b	35.5 c	3364 b
LSD $P \leq 0.05$	0.85	0.15	0.11	32.02	2.58	10.41	1.53	0.76	554.0

†Means not sharing a letter in common in a column differ significantly at $P \leq 0.05$ by using LSD test.

Figures given in parenthesis indicate percent increase over control. DAS = days after sowing.

References

- Aggarwal P, Goswami B, 2003. Bed planting system for increasing water use efficiency of wheat grown on Inceptisol (typic ustochrept). *Indian J. Agric. Sci.*, **73**: 422-425.
- Anonymous, 2010. Pakistan Economic Survey 2009-10. Finance Division, Economic Advisor's Wing, Islamabad. Government of Pakistan. pp.19-20.
- Baher ZF, Mirza M, Ghorbanli M, Bagher RM, 2002. The influence of water stress on plant height, herbal and essential oil yield and composition in *Satureja hortensis* L. *Flavour Fragr. J.*, **17**: 275-277.
- Balasubramanian V, Ladha JK, Gupta RK, Naresh RK, Mahela RS, Singh B, Singh Y, 2003. Technology options for rice in rice-wheat system in south Asia. In: Ladha JK (Eds.), *Improving the productivity and sustainability of rice-wheat systems: Issues and impact*. Madison, pp. 115-118.
- Collins BA, Fowler DB, 1992. A comparison of broadcast and drill methods for no till seeding winter wheat. *Can. J. Plant Sci.*, **72**: 1001-1008.
- Humphreys E, Meisner C, Gupta RK, Timsina J, Beecher HG, Tang Y, Singh L, Yadvinder, Gill MA, Masih I, Guo, Zheng J, Thompson JA, 2005. Water saving in rice-wheat systems. *J. Plant Prod. Sci.*, **8**: 242-258.
- Pratik S, Saradindu C, Tomar SM, Sataya P, Chowdhury S, 2002. Path coefficient analysis of agronomic characters affecting grain yield in wheat (*Triticum aestivum* L.) under furrow irrigated rice raised bed planting system. *Ann. Agric. Res.*, **23**: 248-255.
- Rath BS, Misra RD, Pandey DS, Singh VP, 2000. Effect of sowing methods on growth, productivity and nutrient uptake of wheat (*Triticum aestivum* L.) at various levels of puddling in rice (*Oryza sativa* L.). *Indian J. Agron.*, **45**: 463-469.
- Riffkin P, Evans P, Unkopich M, Leary G, 2003. Successful high rainfall cropping in Southern Australia using raised beds. Proceedings of the 11th Australian Agronomy Conference, 2-6 February, Geelong Victoria.
- Sayre KD, Hobbs PR, 2004. The raised-bed system of cultivation for irrigated production conditions. In: Lal R, Hobbs PR, Uphoff N, Hansen DO (Eds.), *Sustainable Agriculture and the International Rice-Wheat System*. Marcel Dekker, Inc., New York, USA, pp. 337-355.
- Sayre KD, Ramos MOH, 1997. Applications of raised-bed planting systems to wheat. Wheat Special Report No. 31 (free PDF download available at Google books).
- Singh Y, Humphreys E, Kukal SS, Singh B, Kaur A, Thaman S, Prashar A, Yadav S, Timsina J, Dhillon S, Kaur N, Smith DJ, Gajri PR, 2009. Crop performance in permanent raised bed rice-wheat cropping system in Punjab, India. *Field Crops Res.*, **110**: 1-20.
- Steel RGD, Torrie JH, Dickey D, 1997. Principles and procedures of statistics: A biometrical approach (3rd ed.) McGraw Hill Book Co. Inc. New York, USA. pp. 172-177.
- Talukdar AA, Sufian MA, Meisner CA, Duxbury JM, Lauren JG, Hossain ABS, 2002. Enhancing food security in warmer areas through permanent raised-bed in wheat: save water and reduce global warming. In: Poster Paper at 2nd International Group Meeting on 'Wheat Technologies for Warmer Areas'. Agharkar Research Institute, Pune, India, 23-26 September. Available at www.cimmyt.org/bangladesh/.
- Tanveer SK, Hussain I, Sohail M, Kissana NS, Abbas SG, 2003. Effects of different planting methods on yield and yield components of wheat. *Asian J. Plant Sci.*, **2**: 811-813.

- Tariq M, Ali H, Jan A, 2001. Influence of sowing methods and mulching on yield and yield components of wheat. *Pak. J. Biol. Sci.*, **4**: 657-659.
- Tripathi SC, Sayre KD, Kaul JN, Narang RS, 2002. Effect of planting methods and N rates on lodging, morphological characters and yield in spring wheat varieties. *Cereal Res. Commun.*, **30**: 431-438.