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Improvement of wheat (*Triticum aestivum L.*) yield by different row spacings and varieties

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Abstract

A field experiment was conducted at CCS Haryana Agricultural University, Hisar during *rabi* 2011-12 and 2012-13 to study improvement of wheat (*Triticum aestivum L.*) yield by different row spacing and varieties. Three wheat varieties *viz.* DBW 17, PBW 550 and WH 711 with four row spacings (15.0, 17.5, 20.0 and 22.5 cm) were studied in experimentation split plot design. Results of the experiment revealed that all parameters including growth, yield and yield attributes were significantly influenced by different row spacings. Based on pooled mean data, maximum plant height (90.8 cm) and effective tillers/m^2 (481) were recorded in 15.0 cm row spacing crop, which were significantly higher than wider row spacing whereas, highest 1000 grain weight (42.7 g) and grains/earhead (41.9) were observed in 22.5 cm row spacing. The highest grain yield (54.0 q/ha) and straw yield (84.7 q/ha) were recorded when crop was sown at 15.0 cm row spacing, which was significantly higher than 20.0 and 22.5 cm row spacing crop. Among the cultivars, WH 711 recorded highest 1000 grains weight (43.5 g), whereas maximum grains/earhead were recorded in PBW 550 (41.9). Maximum grain yield (52.7 q/ha) was recorded in PBW 550 though the differences were non significant among different varieties, whereas, maximum straw yield (83.9 q/ha) was found in WH 711. Harvest index of PBW 550 (40.1) was significantly higher than DBW 17 and WH 711.

Keywords: Wheat, row spacing, varieties and grain yield

1. Introduction

Wheat is one of the most important cereal crops of India not only in terms of acreage, but also in terms of its versatility for adoption under wide range of agro climatic conditions and crop growing situations. Our country has witnessed spectacular growth in production and productivity, which has made country not only self sufficient but also for exporting surplus wheat. The area, production and productivity of wheat in India and Haryana during 2015-16 is 30.23 mha, 93.50 mt, 3093 kg ha^{-1} and 2.57 mha, 11.35 mt, 4407 kg ha^{-1}, respectively (Anonymous, 2016). There is need to further increase in production to fulfill requirement of exploding population, maintenance of adequate buffer stock and to meet out demand for processing industries. The development and recommendation of high yielding adaptable varieties considered to be the first step to generate maximum production. In recent past, wheat varieties developed by plant breeders have high yield potential but all the varieties do not perform well in the similar plant spacing. Among various agronomic factors, the inter row spacing of wheat is very important for proper distribution of plants over cultivated area for better utilization of available soil and natural resources (Mali and Choudhary, 2013). Proper row spacing is important for maximizing light interception, penetration, light distribution in crop canopy and average light utilization efficiency of the leaves in the canopy and thus affects yield of a crop (Das and Yaduraju, 2011; Kalpana *et al.*, 2014 and Ali *et al.*, 2016).

The space available to plants is one of important primary determinants for growth, development and yield of the crop plants (Iqbal *et al.*, 2010; Hassan and Arif, 2012 and Hussain *et al.*, 2014).

Row spacing changes the micro-climate inside the canopy for better light and CO_2 utilization in an attempt to enhance crop productivity (Duncan and Schapough, 2000). Proper spacing can help to optimize tillering capacity and improve the yield components of wheat crop (Hussain *et al.*, 2012 and Hussain *et al.*, 2014). The plant population per unit area beyond an optimum limit enhances competition among the plants for natural resources, resulting in weaker plant and severe lodging (Mukhtar *et al.*, 2012).

Wheat sown under narrow-row spacing (15.0cm) produced higher wheat yields due to a significant increase in productive tillers. Narrow-row spacing increased inter row competition while a wider row spacing increased the number of grains per earhead and 1000-grain weight, but did not compensate for the drastic decrease in productive tillers which resulted in decreased grain yields (Hussain *et al.*, 2012). Keeping these points in view the present study was aimed to study the influence of row spacing on grain yield and yield components of wheat varieties in Haryana conditions.

2. Materials and methods

The experiment was conducted during *Rabi* 2011-12 and 2012-13 at Research Farm of Chaudhary Charan Singh Haryana Agricultural University, Hisar (India) located in Indo-Gangetic plains of North-West India with latitude of $29^0 10'$ North and longitude of $75^0 46'$ East at 215.2 meters above mean sea level. The soil of the field was sandy loam in texture, slightly alkaline in pH (7.9), low in organic carbon, poor in available nitrogen and medium in available phosphorus and potassium. The experiment consisting of four row spacings *viz.* 15.0, 17.5, 20.0 and 22.5 cm in main plots and three varieties viz. DBW 17, PBW 550 and WH 711 in sub-plots was laid out in split plot design with three replications. The crop was sown manually with hand plough on 7th November in both the years (2011-12 and 2012-13). N 150 kg + P_2O_5 60 kg ha^{-1} were applied through urea and DAP. Half of N and full dose of P were applied as basal dose. Remaining half of urea was top dressed at 1st irrigation. To control weeds, one hand weeding was done at 30 DAS in all the treatments. Other management practices were adopted as per recommendations for wheat crop. Data on plant height, number of effective tillers, number of grains per earhead, 1000 grain weight, grain yield, straw yield and harvest index were recorded by using standard procedure. The crop was harvested on 7^{th} April, 2012 and 19^{th} April, 2013 during 2011-12 and 2012-13, respectively. The data pertaining to growth, yield attributes and yield were analysed statistically as per the methods suggested by Gomez and Gomez, 1984.

3. Results and discussion

Row spacing describes interplant competition for nutrients, sunlight interception and water thereby; resource use efficiency of cultivars may increase or decrease. In present study, different row spacing significantly influenced the growth, yield and yield components of wheat cultivars.

3.1 Growth: The perusal of the data in Table 1 shows that plant height was influenced significantly by different row spacing. The plant height increased, when the row spacing decreased. Plants at 15.0 cm row spacing recorded significantly higher plant height (95.3 cm) than wider row spacings in 2011-12 but the effect was non-significant in 2012-13. On pooled mean basis, tallest plants were recorded from narrow row spacing. Plants at 15 cm row spacing recorded significantly higher plant height as compared to wider row spacing. This might be due to competition for light at high plant population density and at wider spacing due to less competition for light and other resource. These results are in agreement with the results obtained by Hozayn *et al.* (2012) and Hussain *et al.* (2014). Among the varieties, DBW 17 recorded maximum plant height (91.6 cm), which is significantly higher than PBW 550 and WH 711 during both year of investigation.

3.2 Yield attributes: The number of effective tillers/m^2 differed significantly by different row spacing during both the years (Table 1). The pooled data of two years indicate that effective tillers decreased with increasing row spacing. The number of effective tillers/m^2 was significantly higher (481) in 15.0 cm row spacing and it decreased with increasing row spacing during both the years. The higher tiller numbers at the narrow row spacing was likely due to more uniform spatial distribution and less intra row plant to plant competition compared with the wider row spacing.

Hussain *et al.* (2003), Mali and Choudhary (2013) and Kalpana *et al.* (2014) also reported that narrow row spacing produced significantly more tillers/m^2. Varietal effects on effective tillers were non significant in 2011-12, but in 2012-13, PBW 550 produced the highest number of effective tillers (428), which was significantly higher than WH 711(405), but at par with DBW 17 (415). However, two years pooled means revealed that effective tillers were statistically similar under different varieties.

Table 1. Effect of row spacing and varieties on growth and yield attributes of wheat during 2011-12 and 2012-13

Treatments	Effective tillers/m^2			1000 grain weight (g)			Grains/earhead			Plant height (cm)		
	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled
Spacing (cm)												
15.0	510	452	481	42.7	38.5	40.6	38.7	40.2	39.5	95.3	85.7	90.8
17.5	472	436	454	43.3	39.4	41.4	39.5	40.2	39.9	93.3	84.7	89.0
20.0	454	408	431	43.9	40.1	42.0	40.7	41.4	41.0	93.7	84.1	89.1
22.5	414	368	391	44.3	40.9	42.7	41.6	42.4	41.9	93.2	84.0	89.0
SE (m)±	6.7	5.3	5.5	0.28	0.48	0.23	0.28	0.31	0.19	0.27	0.54	0.32
CD(p=0.05)	23.01	18.45	18.9	0.96	1.64	0.79	0.96	1.08	0.65	0.92	NS	1.09
Varieties												
DBW 17	464	415	440	41.9	38.1	40.0	39.9	41.2	40.5	97.0	85.7	91.6
PBW 550	463	428	446	44.0	38.8	41.4	41.2	42.5	41.9	92.8	84.4	88.8
WH 711	460	405	433	44.8	42.3	43.5	39.3	39.5	39.4	91.8	83.8	88.0
SE (m)±	6.02	4.7	3.9	0.35	0.24	0.23	0.39	0.57	0.36	0.74	0.42	0.36
CD(p=0.05)	NS	14.14	NS	1.06	0.73	0.68	1.17	1.70	1.08	2.23	1.25	1.07

Statistical analysis of the data revealed that row spacing and varieties had a significant effect on number of grains /earhead (Table 1). Number of grains/earhead increased with increased row spacing. The highest number of grains /earhead (41.6 and 42.4) were recorded at row spacing of 22.5 cm as against minimum (38.7 and 40.2) observed at row spacing of 15 cm in 2011-12 and 2012-13, respectively. The higher number of grains/ earhead of wheat in wider row spacing might be due to more space and nutrients utilization by the plants. These results were in accordance with the results of Hussain *et al.* (2003), Ali *et al.* (2010) and Nizamani *et al.* (2014). On pooled mean basis, PBW 550 produced maximum number of grains/earhead (41.9), which was significantly higher than DBW 17 (40.5) and WH 711 (39.4). The differences in number of grains/earhead were probably due to variation in genetic potential from variety to variety. Inamullah *et al.* (2006) and Nizamani *et al.* (2014) also observed significant differences in grains per earhead among different wheat varieties.

Plant spacing has a significant effect on 1000-grain weight (Table 1). On pooled basis, the highest 1000-grain weight was obtained by 22.5 cm row spacing (42.7 g), which is significantly higher than 15.0 cm (40.6 g) and 17.5 cm (41.4 g) row spacing but statistically at par with 20.0 cm (42.0 g) row spacing. These results indicated that wider row spacing increased 1000-grain weight due to vigorous and bold seeds. These results were similar with the findings of Mali and Choudhary (2012) and Nizamani *et al.*, (2014), who observed that 1000 grain weight increased with increasing plant spacing. Among different varieties, maximum 1000- grain weight (43.5 g) was recorded in variety WH 711, which was significantly higher than PBW 550 (41.4 g) and DBW 17 (40.0).

3.3 Grain and straw yield : Grain yield was significantly influenced by different row spacings (Table 2). The highest grain yield of 65.5 and 42.6 q/ha was obtained in 15 cm row spacing during 2011-12 and 2012-13, respectively, which was significantly higher than 22.5 cm row spacing (59.9 and 37.4 q/ha), but was statistically similar with 17.5

cm (64.7 and 42.3 q/ha) row spacing. Row spacing of 15 cm recorded 8.54 and 12.21%, 3.35 and 7.04%, 1.22 and 0.70% higher yield than 22.5, 20.0 and 17.5 cm row spacing during 2011-12 and 2012-13, respectively. The study exhibited that 15 cm row spacing produced more effective tillers/m^2 as compared to wider row spacings resulted in higher gain yield (Table 1). On the other hand 22.5 cm row spacing produced less number of effective tillers/m^2 resulted in low grain yield.

Table 2. Effect of row spacing and varieties on yields and harvest index of wheat during 2011-12 and 2012-13

Treatments	Grain yield (q/ha)			Straw yield (q/ha)			Harvest index (%)		
	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled
Spacing (cm)									
15.0	65.5	42.6	54.0	99.9	69.5	84.7	39.6	38.0	38.9
17.5	64.7	42.3	53.5	98.2	68.2	83.2	39.7	38.3	39.2
20.0	63.3	39.6	51.4	96.7	64.6	80.7	39.6	38.0	39.0
22.5	59.9	37.4	48.6	92.6	62.6	77.6	39.3	37.4	38.5
SE (m)±	1.02	0.58	0.65	1.77	0.91	1.05	0.25	0.12	0.18
CD (p=0.05)	3.51	2.01	2.24	NS	3.16	3.62	NS	0.43	NS
Varieties									
DBW 17	61.4	41.5	51.5	97.6	65.9	81.8	38.6	38.6	38.6
PBW 550	64.5	40.6	52.7	93.6	64.2	78.9	40.8	38.9	40.1
WH 711	64.1	38.9	51.5	99.3	68.6	83.9	39.2	36.2	38.0
SE (m)±	0.70	0.68	0.43	1.25	1.16	0.81	0.26	0.16	0.15
CD(p=0.05)	2.09	2.05	NS	3.76	3.47	2.43	0.65	0.49	0.43

Increasing light capture by a canopy has been reported in wheat with narrow row spacing configurations (Mali and Choudhary, 2013). These results also agree with the findings of Bakht *et al.* (2007) and Kalpana *et al.* (2014), who reported that grain yield decreased with increase in row spacing. Similarly, Zhou *et al.* (2011) found that wheat yields were highest for 14.0 cm row spacing with yields ranked 14 > 17 > 24.5 > 49 cm. However, Pandey *et al.* (2013) reported that wheat cultivated in 20.0 cm rows produced significantly more effective tillers compared to 15 and 25 cm rows. Among the genotypes, on pooled mean basis maximum grain yield (52.7 q/ha) was recorded with PBW 550, followed by WH 711 (51.5 q/ha) and DBW 17 (51.5 q/ha), but difference was non significant among the varieties. The highest grain yield in PBW 550 might be due to higher number of effective tillers/m^2 and grains/earhead. Mali and Choudhary (2013) also reported the grain yield differences in genotypes due to differential yield attributes.

Straw yield was also significantly influenced by plant spacing (Table 2). On pooled data basis, the highest straw yield (84.7 q/ha) was obtained with 15 cm row spacing, which was significantly higher than 20 cm (80.7 q/ha) and 22.5 cm (77.6 q/ha) row spacing but statistically at par with 17.5 cm (83.2 q/ha) row spacing. However, the difference between 17.5 and 20.0 cm row spacing was non significant. More plant height and number of effective tillers/ m^2 might be responsible for higher straw yield in 15 cm row spacing. Closer spacing produced more straw yield as compared to wider row spacing. More straw yield produced at narrower spacing than wider spacing indicating better resources utilisation (water, nutrient and light) in narrow rows than wider rows (Mali and Choudhary, 2013 and Kalpana *et al.*, 2014). Among the varieties, WH 711 recorded significantly higher straw yield (83.9 q/ha) than PBW 550 (78.9 q/ha), but statistically at par with DBW 17 (81.8 q/ha).

The harvest index was not influenced significantly by different row spacing but significant difference in harvest index was recorded among the varieties (Table 2). Variety PBW 550 recorded significantly higher harvest index (40.1%) than DBW 17 (38.6%) and WH 711 (38.0%).

Higher harvest index of PBW 550 might be due to higher grain yield and lower straw yield (Bakht *et al*., 2007 and Nizamani *et al*., 2014).

The study concludes that narrow row spacing (15 cm) produced significantly higher grain yield as compared to wider spaced crop. Row spacing of 15 cm recorded about 8.54 and 12.21%, 3.35 and 7.04%, 1.22 and 0.70% higher yield than 22.5, 20 and 17.5 cm row spacing during 2011-12 and 2012-13, respectively. Row spacing of 15 cm should be adopted for its contribution towards higher grain yield. Among the varieties, PBW 550 gave numerically higher grain yield than DBW 17 and WH 711.

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