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Suitable genotype and optimization of seed rate for late sown wheat

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Abstract
A field experiment was conducted to identify suitable genotype and seed rate of wheat under late sown conditions during *Rabi* season of 2017-18 at Research Farm of CCS Haryana Agricultural University, Hisar. Experiment was laid out in split plot design with four replications. The experiment was comprised of three wheat genotypes *viz.* WH 1124, HD 3059 and DBW 90 as main plot treatments and five seed rates *viz.* 100.0, 112.5, 125.0, 137.5 and 150.0 kg/ha as sub plot treatments. Among genotypes, WH 1124 was found most suitable wheat genotype for late sown condition, produced significantly tallest plant (98.2 cm), highest dry matter accumulation/mrl (153.4 g), higher LAI at 90 DAS (4.54), lowest leaf senescence score at 30 DAA (9.09), higher total tillers/mrl (88.6), highest effective tillers per mrl (85.2), grains per spike (53.5), spikelets per spike (18.3), test weight (38.7) resulted in highest grain (4,843 kg/ha), straw (7,015 kg/ha) and biological yield (11,858 kg/ha). While among different seed rates, seed rate of 150 kg/ha was found optimum to obtain higher yield of late sown wheat produced significantly tallest plant (98.4 cm), highest dry matter accumulation/mrl (153.6 g), higher LAI at 90 DAS (4.50), higher total number of tillers/mrl (91.3), highest effective tillers (86.5), grains per spike (50.5), highest grain yield (4,909 kg/ha), straw yield (6,991 kg/ha) and biological yield (11,900 kg/ha). However,, spike length, number of spikelets per spike was not affected significantly by various seed rates. Among genotypes, maximum days to attain 50 per cent heading (75.6 days) and 50 per cent anthesis (79.1 days) was taken by HD 3059 and maximum duration (109 days) to achieve maturity was observed in DBW 90. Phenological stages of wheat were not affected significantly by different seed rates. Highest gross returns (₹130,562/ha), net returns (₹52,735/ha) and B: C (1.68) were obtained with WH 1124. Among different seed rates inspite of having highest cost of cultivation (₹78,353/ha), highest gross returns (₹131,259/ha), net returns (₹52,906/ha) and B: C (1.68) was obtained in wheat sown at seed rate of 150.0 kg/ha.

Keywords: Wheat genotypes, seed rates, phenological stages, productivity, economics

Introduction
Wheat (*Triticum aestivum* L.) is the world's largest cultivated cereal crop, which belongs to family Poaceae and genus *Triticum*. India is one of the largest wheat producing country after China and contributes more than 30 per cent to the world wheat production. India produced about 97.4 million tons of wheat from an area of 30.7 million hectare with an average productivity of 3172 kg ha^{-1} (ICAR-IIWBR, 2017) [6]. Wheat is the most important *Rabi* cereal crop of Northern India, which is the second most important staple crop after rice in India. Haryana, which is one of the major wheat growing state, produced 11.5 million tons of wheat from 2.6 million hectares area with an average productivity of 4514 kg ha^{-1} during 2016-17 (Anonymous, 2017) [2].

Wheat sowing is delayed mainly due to late harvesting of *Kharif* crops in northern part of country. Different genotypes have their own mechanisms to cope up with heat stress like rolling, shedding and thickening of leaves, reduction in leaf size and duration of growth, transpirational cooling and other adjustments in morphology (Wahid *et al*., 2007) [22]. Crop genotypes may vary in their growth behaviour and yield contributing factors *viz*., tillers/m^2, spike/m^2, grains/spike, grain weight. The appropriate combination of these yield attributes is needed for harvesting maximum productivity. Generally, among wheat yield attributes, the most significant contributor is spikes/m^2. Depending on the effective tillering of a cultivar, optimum spike density can be achieved through seed rate adjustments.

The varieties having high tillering ability can contribute higher yield at low seed rate and *vice-versa* (Chhokar *et al.*, 2017) [4].

Among the agronomic factors, seed rate is an important production factor which determines the crop vigour and ultimate yield of the crop (Korres and Williams 2002) [9], So, optimum planting geometry is a pre-requisite to realize the full genetic potential of a variety, which can be achieved through seed rate. With increasing seed rate there is an increase in yield mainly through more spikes per unit area, which compensated for a decrease in seeds per spike (Chhokar *et al*. 2017) [4]. Through increase in seed rate, the canopy expands more rapidly, more radiation is intercepted and more dry matter is produced which results in efficient utilization of environmental resources by changing relative importance of intra and interplant competition for light, water and nutrients during crop development and thereby affects wheat yield considerably (Naveed *et al*., 2014) [14]. Low seed rate increase the inter-plants competition during the grain filling stage because of the tendency to produce more spike bearing tillers (Marshall and Ohms, 1987) [13]. Hence, it was a general assumption that low seed rates increase the weight of the single spikes, but decrease the number of spikes per unit area and the situation is vice versa in the higher seed rates, *i.e.* higher number of spikes per unit area but lesser grain weight per spike (Tompkins *et al*., 1991) [21]. One of the drawbacks of using higher seed rate above optimum value is that higher seed densities increase the occurrence of lodging and diseases leading to grain yield reduction (Beuerlein and Lafever, 1989) [3]. Therefore, keeping the above facts in consideration, the current experiment was conducted to find out the suitable genotype and optimum seed rate of wheat under late sown conditions.

Materials and Methods

The field experiment was conducted during *Rabi* season of 2017-18 at Research Farm of CCS Haryana Agricultural University, Hisar. The experiment was laid out in split plot design with four replications. The experiment was comprised of three wheat genotypes *viz.* WH 1124, HD 3059 and DBW 90 as main plot treatments and five seed rates *viz.* 100.0, 112.5, 125.0, 137.5 and 150.0 kg/ha as sub plot treatments. All agronomic practices were applied evenly to all plots as per the recommendation of CCS Haryana Agricultural University, Hisar.

After harvesting and bundling, the wheat bundles were sundried for 4 to 5 days. After recording of biological yield, bundles were threshed separately and weight of collected grains was converted into kg/ha.

Cost of cultivation and gross returns (₹/ha) of various treatments were calculated on the basis of approved inputs and output cost fixed by Directorate of Farm, CCS HAU, Hisar. Net returns (₹/ha) were worked out by subtracting the total cost of cultivation of each treatment from the gross income of respective treatment. Whereas, Benefit cost ratio (B: C) was worked out by following formula:

$$\text{B:C} = \frac{\text{Gross returns (₹/ha)}}{\text{Cost of cultivation (₹/ha)}}$$

The experimental data was statistically analyzed by the methods of analysis of variance (ANOVA) as described by Panse and Sukhatme (1985) [18].

Results and Discussion

Growth Parameters

Plant height

The perusal of data presented in Table 1 showed that plant height of wheat was affected significantly by different genotypes and seed rates. Among different genotypes of wheat, significantly tallest plants (98.2 cm) were recorded in genotype WH 1124 at harvest which might be due to its genetic makeup. The finding is in line with Rawat *et al*. (2000) [19], who reported significant difference in plant height of various wheat genotypes due their genetic variation. Whereas, among different seed rates, 150 kg/ha produced tallest plants (98.4 cm) which was statistically at par with seed rates of 137.5 kg/ha (97.9 cm) and 125.0 kg/ha (97.4 cm), but significantly higher over rest of the seed rates. The taller plants with higher seed rates might be due to dense population which increased competition for solar radiation among plants and ultimately lead to increase plant height. The result is in line with Khalil *et al*. (2011) [8].

Dry matter accumulation

Data in Table 1 revealed that among different genotypes, maximum dry matter (153.4 g/mrl) per meter row length was recorded in WH 1124 at harvest which might be due to more plant height, more tillers and higher leaf area of this genotype. The result is also supported with the findings of Kumar *et al*. (2002) [10]. Whereas, among different seed rates, maximum dry matter accumulation per meter row length (153.6 g/mrl) was observed with highest seed rate of 150.0 kg/ha which was statistically at par with seed rate of 137.5 kg/ha, but significantly higher over rest of the seed rates. It might be due to dense plant population, taller plants and higher leaf area index, which ultimately increased accumulation of photosynthates and resulted in higher dry matter accumulation. Similar result was also reported by Noy-Meir and Briske (2002) [16].

Leaf area index

The data showed in Table 1 leaf area index (LAI) of wheat was not affected significantly by different genotypes Whereas, among various seed rates, highest seed rate of 150 kg/ha at 90 DAS produce maximum LAI (4.50) which was statistically at par with seed rate of 137.5 kg/ha (4.36) and 125.0 kg/ha (4.23). It might be due to higher number of tillers which resulted in higher number of leaves which ultimately increased positively LAI of the crop compared to rest of the genotypes. The findings are in line with those of Pandey *et al*. (1998) [17].

Phenological studies

The perusal data (Table 1) indicated that days to emergence were not significantly affected among different genotypes. Minimum days to 50 per cent heading (72.6 days) were taken by DBW 90, which was closely followed by WH 1124 and HD 3059. Likewise minimum days to 50 per cent anthesis (78.0 days) were recorded by DBW 90, which was statistically at par with WH 1124. Whereas, significantly higher days to achieve maturity (111.1 days) were recorded by DBW 90, which, was statistically at par with WH 1124.

The same variation among wheat genotypes to attain different phonological stages were reported by Gupta *et al*. (2002) [5] and Sarker *et al*. (2009) [20]. As attainment of phenological stages are related to genetic makeup of the genotypes. Different phenological stages were affected non significantly

by various seed rates. These results are agreed with finding of Nizamani *et al.* (2014) [15].

Yield attributes

At harvest, genotype WH 1124 resulted in significantly higher number of total tillers (88.6) as compared to other genotypes which might be due to higher tillering habit of the genotype (Table 2). The result is in line with those of Jat and Singh (2004) [7]. Among seed rates, seed rate of 150 kg/ha being at par with seed rate of 137.5 kg/ha resulted in significantly higher number of total tillers (91.3) as compared to rest of the seed rates. It might be due to higher plant population, tillering and better leaf area development, which resulted in maximum solar radiation interception and adequate synthesis and translocation of carbohydrates to all growing auxiliary buds which ultimately resulted in higher number of total tillers. The results are in conformity with findings of Kumar *et al*. (2018) [11].

Data revealed that numbers of effective tillers per meter row length were significantly higher (85.2 and 86.5) in WH 1124 and at highest seed rate of 150 kg/ha, respectively. Length of spike was not affected significantly by different genotypes as well as various seed rates. Longest spike (9.8 cm) was observed in HD 3059 among genotypes; and at seed rates of 100 kg/ha among various seed rates. Significantly higher number of grains per spike was reported in WH 1124 (53.5) among different genotypes and at lowest seed rate of 100 kg/ha (52.6) which was statistically at par with seed rate of 112.5 kg/ha (51.8). Significantly higher number of spikelets per spike (18.3) were observed in WH 1124 over DBW 90 whereas, number of spikelets per spike was not affected significantly by various seed rates. The results are in line with those of Kumar *et al*. (2018) [11] who observed non-significant effect of different seed rates on number of spikelets per spike. Significantly boldest grains (38.7g) were obtained in WH 1124 among genotypes and at lowest seed rate of 100 kg/ha, which was statistically at par with seed rates of 112.5 and 125.0 kg/ha. The results might be attributed to genetic makeup of the genotypes also reported by Akhter *et al*. (2017) [1].

Yield and Economics

The data of yield presented in Table 3 revealed that grain and biological yield were significantly affected by genotypes and seed rates. Among different genotypes, biological yield (11,858 kg/ha), grain yield (4,843 kg/ha) and straw yield (7,015 kg/ha) was significantly higher in WH 1124 over rest of genotypes except straw yield which was statistically at par with HD 3059. The results might be attributed to higher yield attributes of genotypes. While comparing the different seed rates, significantly higher biological yield (11,900 kg/ha), grain yield (4,909 kg/ha), straw yield (6,991 kg/ha) and harvest index (41.4%) was obtained with highest seed rate of 150 kg/ha, which was statistically at par with seed rates of 137.5 and 125.0 kg/ha in terms of biological and grain yield. It might be due to higher number of effective tillers per unit area. The results were in collaboration of Malik *et al*. (2009) [12].

Data of economics mentioned in Table 3 revealed that among genotypes, maximum gross returns (₹130,562/ha), net returns (₹52,735/ha) and B: C (1.68) was obtained with WH 1124. Among seed rates, highest seed rate of 150.0 kg/ha gave maximum gross returns (₹131,259/ha), net returns (₹52,906/ha) and B: C (1.68), which was closely followed by seed rates of 137.5 and 125.0 kg/ha which might be due to higher yield of the crop. The finding is in line with those of Kumar *et al.* (2002) [10].

Table 1: Effect of sowing dates and wheat genotypes on growth and phenological stages of wheat

Treatments	Plant height at harvest (cm)	Dry matter accumulation at harvest (g/ mrl)	Leaf Area Index at 90 DAS	Days to 50% emergence	Days to 50% heading	Days to 50% anthesis	Days to maturity
Genotypes							
WH 1124	98.2	153.4	4.54	11.8	73.8	78.1	110.2
HD 3059	95.5	146.2	4.14	11.3	75.6	79.1	109.2
DBW 90	97.0	143.6	3.84	11.2	72.6	78.0	111.1
SEm ±	0.3	0.6	0.01	0.3	0.1	0.2	0.3
C.D. at 5%	1.1	2.1	NS	NS	0.3	0.7	1
Seed rate (kg/ha)							
100	95.0	141.1	3.66	11.3	74.2	78.4	110.2
112.5	95.7	143.9	4.11	11.5	73.7	78.8	110.2
125	97.4	148.0	4.23	11.5	73.9	78.1	110.1
137.5	97.9	152.0	4.36	11.3	73.8	78.2	110.1
150	98.4	153.6	4.50	11.3	74.3	78.5	110.3
SEm ±	0.8	1.1	0.09	0.1	0.4	0.4	0.1
C.D. at 5%	2.2	3.3	0.27	NS	NS	NS	NS

Table 2: Effect of sowing dates and wheat genotypes on yield attributing characters of wheat

Treatments	Total tillers/mrl (No.)	Effective tillers/mrl (No.)	Spike length (cm)	Grains per spike (No.)	Spikelets per spike (No.)	1000-grain weight (g)
Genotypes						
WH 1124	88.6	85.2	9.6	53.5	18.3	38.7
HD 3059	86.7	82.9	9.8	51.1	17.8	37.6
DBW 90	85.1	81.7	9.7	49.7	17.3	37.4
SEm ±	0.5	0.6	0.1	0.4	0.2	0.2
C.D. at 5%	1.6	2.2	NS	1.6	0.7	0.8
Seed rate (kg/ha)						
100	82.1	79.3	9.8	52.6	18.2	38.7
112.5	84.0	81.4	9.7	51.8	17.9	38.3
125	87.3	83.8	9.6	51.2	17.7	37.8

137.5	89.3	85.1	9.5	51.0	17.6	37.5
150	91.3	86.5	9.5	50.5	17.4	37.4
SEm ±	0.8	0.9	0.2	0.4	0.2	0.3
C.D. at 5%	2.4	2.5	NS	1.1	NS	1

Table 3: Effect of sowing dates and wheat genotypes yield and economics of wheat

Treatments	Grain yield (kg/ha)	Straw yield (kg/ha)	Biological yield (kg/ha)	Harvest Index (%)	Gross returns (Rs./ha)	Net returns (Rs./ha)	B: C
Genotypes							
WH 1124	4,843	7,015	11,858	40.9	130,562	52,735	1.68
HD 3059	4,695	6,871	11,566	40.6	126,839	49,012	1.63
DBW 90	4,634	6,718	11,351	40.8	124,908	47,080	1.61
SEm ±	46	57	92	0.2			
C.D. at 5%	164	201	326	NS			
Seed rate (kg/ha)							
100	4,475	6,731	11,207	39.9	121,806	44,503	1.58
112.5	4,583	6,739	11,322	40.5	124,094	46,530	1.60
125	4,790	6,887	11,677	41	129,033	51,206	1.66
137.5	4,863	6,991	11,853	41	130,989	52,900	1.68
150	4,909	6,991	11,900	41.4	131,259	52,906	1.68
SEm ±	65	80	130	0.3			
C.D. at 5%	186	NS	375	0.8			

Conclusion

Among genotypes, WH 1124 was found most suitable and economical wheat genotype for late sown conditions, and among seed rates, seed rate of 150 kg/ha was found optimum to obtain higher yield and economical performance for late sown wheat.

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