Research Article

Efficacy of Seed Size to Improve Field Performance of Wheat under Late Sowing Conditions

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Abstract | Delayed wheat sowing is the main factor responsible for the lower yield of wheat owing to low temperature during emergence and early growth. Seed size has an appreciable potential to improve stand establishment, growth, and yield under late sowing conditions. Therefore, the present study was performed to assess the impact of diverse seed sizes (SS) on the growth and yield of wheat crop under late sowing conditions. The study was comprised of different sowing dates (SD), SD_1: 15th December, SD_2: and 30th December and different seed size classes i.e. bold (having a diameter of > 2.7 mm), medium (having a diameter of > 2.3 mm to 2.7 mm), small (having a diameter of ≤ 2.3 mm) and mixed seeds. The results indicated that different sowing dates and seed size classes had a significant effect on germination, growth, and yield of wheat crop. The crop sown on 15th December took less time to start emergence (7.8 days) and resulted in maximum plant height (81 cm), grains per spike (44.5), productive tillers (321.5), spike length (10.2 cm), 1000 grain weight (37.2 g), and grain yield (3.83 t ha^{-1}) and maximum time to start emergence (11 days) and minimum plant height (60 cm), grains per spike (35.7), productive tillers (273), spike length (8.6 cm), 1000 grain weight (32 g), and grain yield (2.7 t ha^{-1}) was recorded in the crop sown on 30th December. In the case of seed size classes, bold seed performed appreciably well and took less time to start emergence (8.5 days) and had more plant height (74.7 cm), productive tillers (326), spike length (10.1 cm), grains per spike (45), 1000 grain weight (37 g), and grain yield (3.67 t ha^{-1}) compared to other seed size classes. In conclusion, bold seed size can significantly improve the wheat production under late sown conditions due to better stand establishment, vigorous germination, and increase in yield related traits.

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Introduction

Wheat is a major grain crop and primary staple food of Pakistan and it is a major source of carbohydrates and energy (Chattha *et al.*, 2017a, 2018). The seed of wheat contains 2.11% minerals, 68% carbohydrate, 2.9% fat, 15.4% proteins and an important source of calories and micro-nutrients

(Anjum *et al*., 2005; Chattha *et al*., 2017b; Hassan *et al*., 2019). An increase in the productivity of wheat crop is a foremost aspect to feed the growing population and to eliminate malnutrition. However, different factors including the poor nutrient management, sowing times, late harvesting of cotton, non-availability of higher yielding varieties, and disease attack significantly reduced the wheat yield (Chattha *et al*., 2017; Zain *et al*., 2017).

Among these factors; sowing time plays an essential role in the growth and productivity of the wheat crop, and the optimum sowing time leads to higher productivity without incurring additional costs (Ouda *et al*., 2016). Normal sowing provides more time for tillering and resulting in more tillers, spikes, grain weight, grains per ear and consequently the higher yield (Qasim *et al*., 2008). Early sowing of wheat produces weak tillers with deprived root system due to high temperature which also causes poor germination and death of an embryo. Late sowing causes weak tillering and slow plant growth due to low temperature (Tahir *et al*., 2009) which resulted in poor germination, stand establishment (Timmermans *et al*., 2007) and consequently leads to lower production (Farooq *et al*., 2008). Moreover, late sowing also reduced tillering and increases the chances of injury during winter (Joshi *et al*., 1992) and favors the disease attack which triggers the lower production (Gul *et al*., 2012). Additionally, late planting of wheat disrupts the connection between source and sink (Sial *et al*., 2005), and the crop is often exposed to heat stress during grain filling stages which causes a substantial reduction in yield and quality (Savin *et al*., 1996; Hassan *et al*., 2020).

Poor crop establishment is a major problem for the lower wheat production under late sown conditions, however, sowing of good quality seeds is a cost-effective method to improve stand establishment and yield under these conditions (Chivasa *et al*., 1998). Seed size is an essential component of seed quality which affects plant performance in the context of germination, growth, and yield (Adebisi *et al*., 2011). Likewise, bold seeds are considered to be more vigorous and they have higher germination and yield potential compared to the smaller seeds (Khurana and Singh, 2001). Bold seeds contain a large amount of food reserves than small and medium-sized seeds (Gunaga *et al*., 2011), which favors better germination and subsequent growth and yield. However, a little research work has been done to determine the effect of seed sizes on the performance of late-planted wheat crop grown in semi-arid areas. Therefore, considering, the importance of all these facts and problems, this research was planned to determine the impact of different seed sizes on growth and yield of wheat under late sown conditions.

Materials and Methods

Experimental site and design

The research work was done at the Agronomy Farm, University of Agriculture, Faisalabad, Pakistan during the rabi season of 2018-19. The randomized complete block design (RCBD) with split plot arrangements was used to perform the trail with three replications. The studied site has a semi arid hot climate furthermore the weather conditions during the growing season are given in Figure 1. The soil samples from the diverse parts of experimental field were collected with the help of an auger and subjected to determine different physio-chemical properties by following the standard procedures of Homer and Pratt (1961). The experimental soil had sandy loam texture with pH 7.8, organic matter 0.83%, available phosphorus 4.7 mg kg^{-1}, available potassium 170 mg kg^{-1}, and total nitrogen 0.03%.

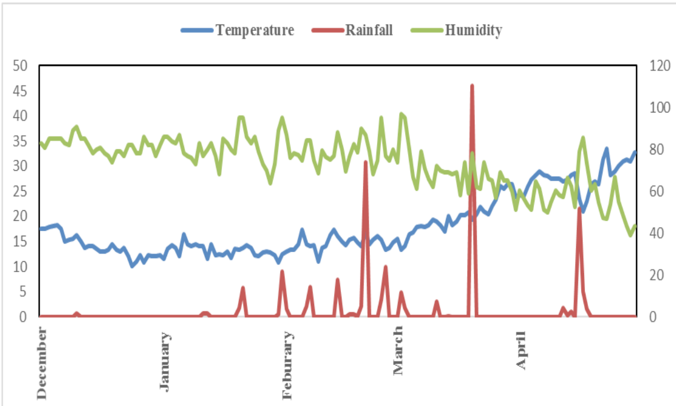

Figure 1: *Weather conditions during the crop growth period.*

Treatments and plant material

The experiment consisted of different sowing dates, i.e., SD_1 = 15th December, SD_2 = 30th December, and seed sizes i.e., S_1 = bold (> 2.7mm), S_2 = medium (2.7mm) and S_3=small (< 2.3mm) S_4 = mixed seed. The seed of variety Punjab-2011 was collected from Ayub Agricultural Research Institute, Faisalabad. Three seed classes such as bold, small, and medium seed were obtained by grading the seed with the help of a seed grader.

Crop husbandry

The field was cultivated 2-times followed by planking to prepare the final seedbed. The recommended seed rate of 125 kg/ha^{-1} was used and sown with a hand drill in 22.5 cm apart rows. Fertilizers were applied after conducting soil analysis at the rate of 100:80:60 kg NPK ha^{-1} respectively. Single superphosphate (SSP) (18% P) urea (46% N), and sulfate of potash (50% K) were applied as a fertilizer. All the P, K, and 1/3 of the N fertilizers were applied as basal dose rest of N was applied twice (at tillering and booting stage). In total four irrigations were applied to the crop for attaining better growth.

Observations

The plots were visited daily after sowing to note the time to start emergence. A unit area (m^2) was marked in each plot and tillers were counted at final harvesting. Similarly, ten plants were chosen from each plot and their height was measured and averaged. Ten spikes were taken and their length was measured and the number of grains was counted. The crop was harvested and weighed to determine biological yield and grain yield and later on converted into t ha^{-1}.

Statistical analysis

The collected data on different traits were statistically evaluated by using Fisher's analysis of variance and means were separated by the least significant difference test at 5 percent probability level (Steel *et al*., 1997).

Results

The results indicated different SD and seed size (SS) had a significant impact on the time to start germination (TSG) (Table 1). The maximum TSG (10.50 days) was taken by seed sown on 30th December and the lowest TSG was taken by crop sown on 15th December (Table 1). In the case of SS maximum TSG (10.16 days) was taken by small seeds after that mix seeds and lowest TSG (8.5 days) was taken by bold seeds (Table 1). Similarly, the diverse SD and SS also significantly affected the growth and yield traits. Taller plants (81 cm) were noticed in crop sown on 15th December and the shortest plants (59.75 cm) were noticed in crops sown on 30th December (Table 1). Among, SS maximum plant height (74.63 cm) was noted in bold seeds after that medium seeds that were remained same with medium, small, and mixed sees and minimum plant height (67 cm) was noticed in small seeds (Table 1).

Table 1: *Effect of different sowing dates and seed size on Plant height, productive tillers, spike length.*

Sowing dates (SD)	Time to start emergence (days)	Plant height (cm)	Productive tillers (m^{-2})	Spike length (cm)
15th December	7.92b	81.00a	321a	10.26a
30th December	10.50a	59.75b	273b	8.658b
LSD ≤0.05 P	0.36	4.30	43.11	0.49
Seed Sizes (SS)				
Bold	8.50c	74.63a	326a	10.13a
Medium	9.33b	70.37b	299b	9.48b
Small	10.16a	67.00b	271c	8.51c
Mixed	8.83bc	69.50b	292b	9.70b
LSD ≤0.05 P	0.66	3.49	19.83	0.27
SD×SS	NS	NS	NS	NS

Means with different letters differed 0.05 P level. NS: non-significant.

The maximum productive tillers (321.5 m^2) and spike length (10.25 cm) were noticed in crops sown on 15th December, and lowest productive tillers (273 m^2) and spike length (8.66 cm) were noticed in crop sown on the 30th December (Table 1). Amongst SS; maximum productive tillers (326.1 m^2) and spike length (10.13 cm) were noticed in bold seeds after that medium seeds and minimum tillers (271.7 m^2) and spike length (8.51 cm) was noticed in small seeds (Table 1). The effect of different SD and SS on grains/spike and thousand grain weight (TGW) was significant. Maximum grains/spike (44.58) and TGW (37.18 g) was noticed in crop sown on 15th December, and the lowest grains/spike (35.75) and TGW (31.96 g) was recorded from crop sown on the 30th December (Table 2). The maximum grains/spike (45.17) and TGW (36.97 g) was produced by bold seeds after that medium seeds and lowest grains/spike (34) and TGW (32.03 g) were recorded from the small seeds (Table 2).

The results indicated that SD and SS had a significant impact on the biological and grain yield and harvest index (Table 2). The maximum biological yield (8.75 t ha^{-1}) and grain yield (3.83 t ha^{-1}) were obtained from crop sown on 15th December and lowest biological yield (6.86 t ha^{-1}) and grain yield (2.68 t ha^{-1}) were noticed from the crop sown on the 30th December (Table 2). Amongst SS; bold seeds performed appreciably well and resulted in maximum biological yield (8.27 t ha^{-1}) and grain yield (3.67 t ha^{-1}) after that medium seeds and lowest biological (7.44 t ha^{-1})

and grain yield (2.83 t ha^{-1}) was noticed in small seeds (Table 2). Maximum harvest index (HI) (43.76%) was recorded in crop sown on 15th December and lowest HI (39.05%) was recorded in crop sown on 30th December. Amongst SS; maximum HI (44.43%) was noticed for bold seeds that was comparable with medium seed size class and the lowest HI (38.81%) was noticed in small seeds (Table 2). The data were subjected to the Pearson correlation analysis (Table 3). A negative correlation was recorded between TSE and all the studied traits, whilst the rest of all the parameters have a positive association with each other (Table 3).

Discussion

Sowing dates and seed size classes had a significant impact on the emergence, subsequent growth and yield of wheat crop. Late sowing delayed the wheat germination and subsequent seedling emergence due to restricted various physiological and metabolic processes (Akhtar *et al*., 2012), which, therefore, resulted in a subsequent reduction in final production. Bold seeds took less time to emerge compared to all the other seed types (Table 1). Bold seeds are considered to be more vigorous and have a large quantity of stored reservoirs which favors the metabolic process and therefore, triggers better and early emergence (Mustafa *et al*., 2018). The various SD and SS significantly affected plant height and tillers production. Late sowing considerably reduced the plant height owing to a lower temperature at the early stages which restricted the process of photosynthesis and leads to a reduction in the production of assimilates which in turn substantially reduced the vegetative growth (Mumtaz *et al*., 2015; Kalwar *et al*., 2018). Bold seeds achieved greater early growth, making plants more competitive against weeds and pest attacks and therefore, ensure better growth and development (Rukavin *et al*., 2002).

Table 2: *Effect of different sowing dates and seed size on number of grains per spike, 1000-grain weight, biological yield and grain yield.*

Sowing dates (SD)	Grains per spike	1000-grain weight (g)	Biological yield (t ha^{-1})	Grain yield (t ha^{-1})	Harvest index
15th December	44.58a	37.18a	8.75a	3.83a	43.76a
30th December	35.75b	31.96b	6.85b	2.68b	39.05b
LSD ≤0.05 P	1.43	3.46	1.19	0.22	3.22
Seed Sizes (SS)					
Bold	45.17a	36.97a	8.27a	3.67a	44.43a
Medium	42.16b	34.35b	7.75b	3.38b	43.65a
Small	34.00d	32.03c	7.45c	2.83d	38.81c
Mixed	39.33c	34.97b	7.75b	3.13c	40.03b
LSD ≤0.05 P	1.84	1.76	0.23	0.24	1.90
SD×SS	NS	NS	NS	NS	NS

Means with different letters differed 0.05 P level. NS: non-significant

Table 3: *Pearson correlation among the studied traits.*

Variables	TSE	PH	PT	SL	GPS	TGW	BY	GY	HI
TSE	1								
PH	-0.96**	1							
PT	-0.93*	0.90**	1						
SL	-0.96*	0.90*	0.92*	1					
GPS	-0.91*	0.86**	0.98**	0.93**	1				
TGW	-0.97**	0.93**	0.97**	0.96**	0.96**	1			
BY	-0.96**	0.99**	0.92**	0.90**	0.88**	0.95**	1		
GY	-0.94**	0.96**	0.96**	0.94**	0.95**	0.96**	0.97**	1	
HI	-0.82**	0.81**	0.92**	0.88**	0.96*	0.87*	0.81**	0.93**	1

TSE: time to start emergence, PH: plant height, PT: productive tillers, SL: spike length, GPS: grains per spike, TGW: 100 grain weight, BY: biological yield, GY: grain yield, HI: harvest index.

In late planting, tillering was decreased owing to the fact as the temperature was gradually increased and sensitivity to high temperature was also increased which in turn reduced the tillering production in wheat (Kalwar *et al*., 2018). Moreover, bold seeds had maximum tillers compared to other seed types. Bold seed ensures adequate plant populations across the wide range of field conditions and therefore, leads to a substantial increase in the tillers production, whilst small seeds are less vigor and have poor germination which triggers lower tillering Gan and stobbe (1995). Late planting also reduced the spike length and grains/spike due to the shorter growing period and increase in temperature at the reproductive stage causes the reduction in seed production (Shahzad *et al*., 2007). Moreover, a short growing period also favors the less assembly of assimilates in the smaller growing period and heat stress at later stages due to late sowing also induced the pollen abortion and sterility and therefore resulted in fewer seeds/spike (Dhaka *et al*., 2006).

Late sowing also caused a substantial reduction in the grain weight, grain and biological yield. Late sowing shrinks the length of the growing period, which eventually decreased the grain filling period and also provides less time for photo-assimilates to move toward the sink which resulting in less kernel weight (Al-Karaki *et al*., 2007; Hossain *et al*., 2012). Bold seeds also resulted in maximum grain weight compared to other seed size classes (Table 2). Bold seeds produced healthier seedlings and uniform stand establish and favor the better assimilates production and consequently leads to the production of seeds weight with more weight (Shahwani *et al*., 2014). Late planting also reduced the biological and grain yield (Table 2). The reduction in biological yield in late planting can be due to less emergence, poor stand establishment and low tillers production which are correlated with previous outcomes of Anwar *et al*. (2015) they also concluded that biological yield decreased in late sowing owing to the shorter growing season, poor stand establishment and less tillering. Moreover, the maximum biomass yield was noted in bold seeds owing to higher emergence, better stand establishment, and higher tillers compared to other seed size classes (Zareian *et al*., 2013).

Late sowing also led to a significant reduction in grain yield and harvest index. Poor growth in late-planted wheat and heat stress at post-anthesis stage induced the reduction in tillers production, seed weight, and other yield contributing traits which consequently leads to a reduction in grain yield (Shirpurkar *et al*., 2007; Baloch *et al*., 2012). The grain yield is the function of many yields contributing traits and the maximum grain yield was noticed in bold seeds which can be due to higher tillers production, better grains/spike, spike length, and grain weight as compared to other SS classes (Stougaard and Xue, 2004). A substantial reduction in harvest index (HI) was noticed in late sowing which can be due to a reduction in grain and seed yield (Andarzian *et al*., 2015). Moreover, the maximum HI was reported in bold seeds which can be due to higher grain and biological yield.

Conclusions and Recommendations

The results indicated that delaying sowing led to a significant reduction in the growth and productivity of wheat. The seed size classes had clear differences in the context of growth and productivity. The bold seeds performed appreciably well and resulted in maximum improvement in growth and yield compared to other seed size classes. Therefore, the bold seed size can improve wheat productivity under late sown conditions due to vigorous germination and an increase in yield related traits. However, more studies should be conducted on diverse soils and agro-ecosystems prior to make it a recommendation for the farming community.

Novelty Statement

Limited information is available about the effect of different seed sizes classes on the performance of late-planted wheat crop grown in semiarid areas. Therefore, this study was performed to underpin the impact of seed sizes on growth and yield of wheat under late sown conditions.

Author's Contribution

Muhammad Muhsin, Muhammad Umer Chattha and Imran Khan: Conducted the experiment and write the original draft.
Muhammad Nawaz, Muhammad Bilal Chattha, Sadia Khan, Muhammad Mahmood Iqbal, Muhammad Ahsin Ayub and Usman Anwar: Review and editing.
Muhammad Talha Aslam and Muhammad Zubair Amin: Helped in data collection.
Muhammad Umair Hassan: Wrote the original draft.

Conflict of interest

The authors have declared no conflict of interest.

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