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Research Article

Response of wheat cultivars toward successive delayed sowing under rainfed condition in Lower Dir

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Abstract

Meeting the food requirements of increasing population, production of more wheat is one of the key areas for researchers. Selection of cultivar with respect to sowing time for a particular agro-ecological zone plays a vital role in the improvement of wheat productivity. Therefore, an experiment was conducted to work out the suitable sowing time for the cultivars' high yield at the Herbarium of Malakand University, Dir (Lower), Khyber Pakhtunkhwa (KP), Pakistan during 2014-15. The experiment was laid out in RCB design with split plot arrangement, replicated three times. The plot size was 4x1.75 m accommodating six rows, 25 cm apart. Five sowing dates (November 11th, 21th, December 2nd, 12th and 22nd) were applied to main plot, while ten wheat cultivars (Pak-2013, Dharabi-2011, Tatara, Lalma, Chakwal-50, Shahkar-2013, Pirsabak-2005, Hashim-2008, KT-2000 and Siran-2010) were allotted to sub plot. More productive tillers m^{-2}, taller plants, longer spikes, more spikelets spike^{-1}, grains spike^{-1} maximum biological and grain yield were recorded for the plots sown on 11th November and linear decrease was recorded with delay in sowing. Among different cultivars higher number of productive tillers m^{-2} and taller plants were observed in Hashim-2008, while more spikelets spike^{-1}, grains spike^{-1} and biological and grain yield were higher for Pakistan-2013. With respect to sowing time and cultivars interaction, greater yields (3708 kg ha^{-1} and 3553 kg ha^{-1}) were recorded for Pakistan-2013 sown on November 11th and 21st, followed by PS-2005 on 21st November (3553 kg ha^{-1}) and 2nd December (3525 kg ha^{-1}), respectively. It was concluded that early sowing in the season improved the yield and yield component of wheat crop. Wheat cultivar Pakistan-2013 was found the best in all aspects. Hence, wheat cultivar Pakistan-2013 is recommended for early sowing, while wheat cultivars Shahkar-2013 and Chakwal-50 are recommended for late sowing in the rainfed areas of Malakand division particularly Dir valley.

Keywords: Cultivars; Sowing dates; Grain yield; Rainfed; Wheat

Introduction

Wheat (*Triticum aestivum* L.) is a long day self pollinated crop. In many countries of the Asia, it is cultivated for grain production where it mainly contributes to staple food for human consumption. Wheat crop ranked first in cultivation and production than the other crops in countries like Morocco, Uruguay, Syria, Australia and Argentina [1]. The total cultivated area covered by wheat in Pakistan is 9.2 million hectares. This produced 25.26 million tones grains with average yield of about 2824 kg ha^{-1}. In Khyber Pakhtunkhwa (KP) province, wheat is grown on 0.78 million hectares area by producing 1.4 million tons of grains. The average yield of KP is reported as 1755 kg ha^{-1} [2]. Due to global climatic change, water scarcity is the main proposed emerging big threats to agriculture crops in Pakistan. Water shortage resulted in drought effect that led to dearth and famine inhumanities. Therefore, accessibility of water is openly linked through foodstuff safety of the nation. Crop like wheat yield in rainfed climate of Pakistan is very low that needs enormous struggle for ensuring the potential food stuff safety in the deprived masses of the country. Agronomist are trying their best to address numerous matter associated to all crops in common and wheat crop in particular by developing varieties resistant to disease, for improvement wheat yield, and also re-validating the performance of existing cultivars in the area and in multiple locations of the region.

Wheat as one of the most essential food commodity of Pakistan, is cultivated on an area of about 0.153 million hectare under rainfed conditions of Malakand division (57% of total area). The average yield in rainfed area is far below than the yield achieved in the other rainfed area of this country [3]. Besides, many other factors including the predominated drought, non-availability of variety, variety identified for the area as a reserve of hope and sub-standard organizations are the main reasons of sinking yield. Keeping in view the topographic-cum-ecological conditions of the area, the cultivable land in this country has been classified into different ecological zones. Consequently, numerous organizations have been established in different ecological zones addressing the explicit problems of those particular areas, but as a result of inadequate budget for research they lacked to show potential performance. Similarly, the responses of crop plants vary with respect to the time of sowing in the season [4, 5].

The scientists are actively involved in development of drought and disease resistance cultivars that produced higher grain yield per hectare. A number of wheat cultivars are released by various researchers/institutions but their comparative study is still missing in the literature. The released and/or approved high yielding varieties are conceivably tested in the local climate of the area but their collective performance with climate change effect of the local weather and time of sowing is still an issue to be tackled properly.

The proper moisture at the start of sowing season ensures the better emergence and crop stand. Hence, the unavailability of irrigation water and change in rainfall pattern in the target locality are considered as the main issues behind the staggered wheat sowing. Moreover, the growing of short season vegetables like tomato, cucumber and peas etc in the northern areas of Pakistan including Lower Dir valley also delays the sowing of wheat because the land is occupied by the aforementioned crops. Therefore, the present study was aimed to figure out a reliable wheat cultivar on the basis of its performance under the rainfed condition for the area.

Materials and methods

Experimental site

A field trail was conducted at the Herbarium of Malakand University, Lower Dir, Khyber Pakhtunkhwa, Pakistan during 2014-15. Malakand is situated at 34.57° North latitude, 71.93° East longitude and 844 meters elevation above the sea level.

Experimental design and procedure

The experiment was performed in randomized complete block design with split plot arrangements replicated three times. Five sowing dates (November 11th, 21th, December 2nd, 12th and 22nd) were applied to main plot, while ten wheat cultivars (Pak-2013, Dharabi-2011, Tatara-96, Lalma-2014, Chakwal-50, Shahkar-2013, Pirsabak-2005, Hashim-2008, KT-2000 and Siran-2010) were allotted to sub plot. Each plot was 4 m long and 1.75 m wide accommodating 7 rows at 25 cm distance. Wheat cultivars, collected from various research stations were planted at the rate of 130 kg ha^{-1} on the aforementioned dates. Nitrogen (N) and phosphorus (P) were applied at the rate of 120 and 60 kg ha^{-1}. Half of N and full P were applied at sowing, while remaining half N at tillering stage. Field was irrigated for the respective sowing date only. Planting was done manually using hand hoe. Rain fall data was recorded during the crop growth period (Figure 1).

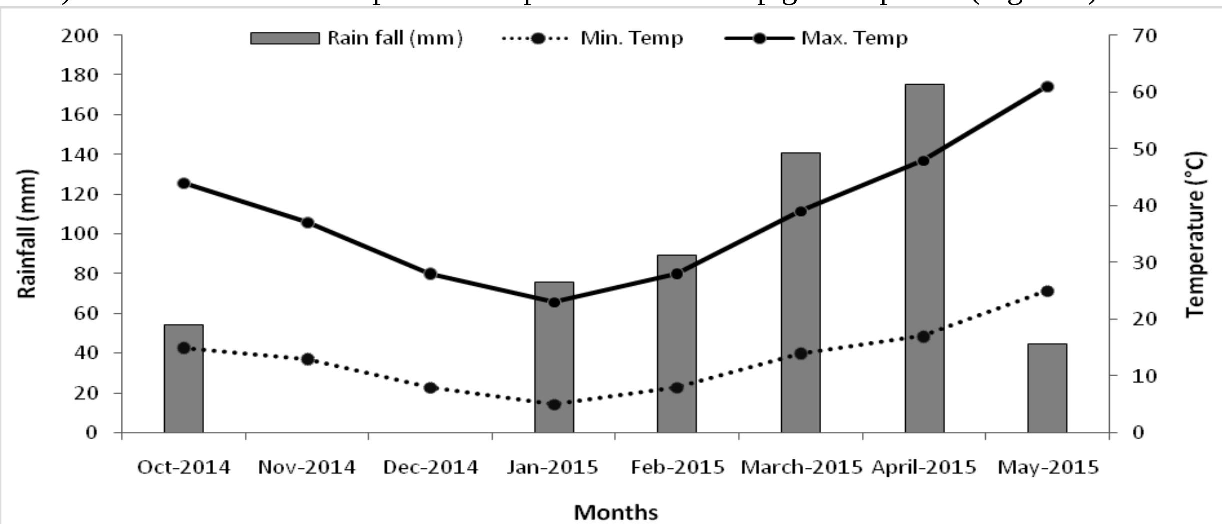

Figure 1. Average rainfall at Chakdara, Lower Dir (Farm Services Center, Chakdara, Lower Dir)

Data recording procedure

Using the prescribed procedures data were recorded on productive tillers, non-productive tillers, plant height, flag leaf area, spike length, spikelets per spikes, biological and grain yield. For recording data on the number of productive tillers m^{-2}, fertile spikes in one meter length at three randomly selected places in each experimental unit were counted and were converted by the given formula

$$\text{Productive tillers } m^{-2} = \frac{\text{No of productive tillers}}{\text{R-R distance (m) x R length (m) x R Nos}}$$

The difference between total tillers m^{-2} and productive tillers m^{-2} were recorded as non-productive tillers m^{-2}. Data on plant height was recorded by measuring the heights of randomly selected ten tillers in each plot from the basal node to tip of spike without awns at physiological maturity stage. The length and width of ten randomly selected flag leaves in each plot was measured with the help of measuring tape and flag leaf area was calculated with the formula suggested by **[6]**.

Flag leaf area (cm^2) = Leaf length (cm) × Leaf width (cm) × CF (0.75)

Data on spike length was recorded by taking the lengths of ten randomly selected spikes and was averaged for each plot. Data regarding spikelets $spike^{-1}$ were recorded by counting the number of spikelets in randomly selected ten spikes in a plot and was averaged accordingly. Biological yield (BY) data was recorded by harvesting four central rows (R) in each plot followed by sun drying for about seven days, weighing and converting to kg ha^{-1} using the formula

$$BY\ (kg\ ha^{-1}) = \frac{\underline{BY\ in\ four\ central\ rows}}{R\text{-}R\ distance\ (m) \times R\ length\ (m) \times R.\ Nos} \times 10000$$

Grain yield (GY) data was recorded on four central rows after manual harvesting in each plot followed by sun drying for about a week time. The grains were threshed separately for recording each plot grain yield. Data was converted to kg ha^{-1} as per formula:

$$GY\ (kg\ ha^{-1}) = \frac{\underline{GY\ in\ four\ central\ rows}}{R\text{-}R\ distance\ (m) \times R\ length\ (m) \times R.\ Nos} \times 10000$$

Statistical analysis

The recorded data was statistically analyzed by using analysis of variance techniques for randomized complete block design with split plot arrangement. Significant difference among different treatments was worked out by using least significant difference (LSD) test for main and interactive effects [7].

Results and discussions

Productive tillers m^{-2}

Sowing dates (SD), cultivars (V) and their interaction significantly affected productive tillers m^{-2} of wheat (Table 1). Higher productive tillers (215 m^{-2}) were recorded for early sowing on 11th November, followed by 21st November (206 m^{-2}), whereas fewer tillers (180 m^{-2}) were noted for delayed sowing on 22nd December. Wheat cultivar Hashim-2008 produced more tillers (214 m^{-2}) which was similar with Chalwal-50 (212 m^{-2}) in statistical way, while lower number of productive tillers (186 m^{-2}) were recorded for Dharbi-2011 which was similar to Shahkar-13. SD and V interactions showed significant response of wheat V to SD. Higher productive tiller m^{-2} (241 m^{-2}) was recorded for PS-2005, when sown on 2nd December, whereas Tatara had lesser productive tillers when sown late on 22nd December. Photo assimilates directly contribute to productive tillers. Early sowing produced more productive tillers with respect to late sowing. This might be due to the difference in length of vegetative growth period and crop growth rate as a result of variation in temperature [8, 9]. The response of cultivars on productive tillers was also significant. Among cultivars, Chakwal-50 and Hashim-2008 were found superior for productive tillers, whereas Dharabi-2011 and Shahkar-2013 produced less productive tillers. This may be due to genetic variability among the cultivars [10].

Table 1. Productive tiller m^{-2} of wheat varieties as affected by sowing dates under rainfed condition

	Sowing Dates (SD)					
Varieties (V)	**11th Nov**	**21st Nov**	**2nd Dec**	**12th Dec**	**22nd Dec**	**Mean**
Pakistan-2013	227	190	190	179	205	198 bcd
Dharabi-2011	214	171	208	174	161	186 e
Tatara-96	240	197	205	224	135	200 bc
Lalma-2014	200	208	199	200	226	207 ab
Chakwal-50	224	215	217	197	209	212 a
Shahkar-2013	199	225	156	194	162	187 e
PS-2005	223	210	241	177	158	202 bc
Hashim-2008	227	232	213	231	167	214 a
KT-2000	198	208	204	166	188	193 cde
Siran-2010	200	203	191	163	191	190 de
Mean	215 a	206 b	202 b	190 c	180 d	

LSD ($p \leq 0.05$) for SD = 5.77, LSD ($p \leq 0.05$) for V = 9.26, SD x V = 20.7

Non-productive tiller m^{-2}

SD and V significantly influenced non-productive tiller m^{-2} of wheat, whereas their interaction was non-significant (Table 2). Delay in sowing (22nd December) resulted an increase in number of non-productive tillers m^{-2} (12.8 m^{-2}) and thus early sowing (11th November) had the least number of non-productive tillers m^{-2} (9.7 m^{-2}), followed by 21st November (10.6 m^{-2}). In case of wheat cultivars lowest non-productive tillers were observed in Pak-2013, whereas KT-2000 resulted in higher non-productive tillers (14.5 m^{-2}). Delay in sowing gradually increased non-productive tillers of wheat. Plots seeded in November resulted in least non-productive tillers, while December sown plots produced higher number of non-productive tillers. This increase in number of unproductive tillers occurred as a result of alteration in temperature. Cultivar Pak-2013 and PS-2005 produced less non-productive tillers, while highest value was noted for KT-2000. Genetic variability is the main reason for differences in tillers number and spike production among different cultivars [11].

Table 2. Non-productive tiller m^{-2} of wheat varieties as affected by sowing dates under rainfed condition

	Sowing Dates (SD)					
Varieties (V)	**11th Nov**	**21st Nov**	**2nd Dec**	**12th Dec**	**22nd Dec**	**Mean**
Pakistan-2013	5.7	7.0	8.7	9.3	11.3	8.4 h
Dharabi-2011	8.7	10.7	11.3	11.3	12.7	10.9 f
Tatara-96	9.3	9.7	10.7	12.0	12.7	10.9 f
Lalma-2014	11.0	10.7	11.3	12.0	12.7	11.5 d
Chakwal-50	10.0	10.7	11.3	11.3	12.7	11.2 e
Shahkar-2013	10.3	11.3	11.3	12.7	13.3	11.8 c
PS-2005	7.3	8.3	9.3	10.0	11.3	9.3 g
Hashim-2008	10.0	11.7	12.3	12.7	12.7	11.9 c
KT-2000	13.3	13.7	14.3	15.3	15.7	14.5 a
Siran-2010	11.3	12.0	12.7	12.0	13.3	12.3 b
Mean	9.7 e	10.6 d	11.3 c	11.9 b	12.8 a	

LSD ($p \leq 0.05$) for SD = 0.76, LSD ($p \leq 0.05$) for V = 0.78, SD×V = ns, ns = non-significant

Plant height (cm)

SD, V and their interaction significantly affected plant height of wheat (Table 3). Taller plants (96 cm) were recorded for early sowing followed by rest of SD being statistically similar among each other except 22nd December which had the shortest plants (92 cm). Comparing wheat V, Hashim-2008, were among the taller cultivar (98 cm), however it was similar with PS-2005 (98 cm), followed by Pakistan-13 (96 cm) and Dharabi-2011 (95 cm), while lower plant height (88) was recorded for Siran-2010 (Table 6). SD and V interaction proved significant response of wheat V with delay in sowing for plant height. Plant height of Hashim-08 contrary to Siran-10 and KT-2000 increased with delay in sowing till 12th December, whereas Pakistan-13 had taller tillers when sown on 21st November. Lalma-2014 had increased plant height for later sowing in last week of December. Plant height gradually decreased with delay in sowing probably due to shorter vegetative growth period for late sowing and less number of tillers in late sown plots that resulted in reduced plant competition [12]. In case of cultivars, PS-2005 and Hashim-2008 produced taller plants while dwarf plants were observed for cultivar Siran-2010. Genetic makeup of the cultivar is vital factor which affects the plant height [13].

Table 3. Plant height (cm) of wheat varieties as affected by sowing dates under rainfed condition

	Sowing Dates (SD)					
Varieties (V)	**11th Nov**	**21st Nov**	**2nd Dec**	**12th Dec**	**22nd Dec**	**Mean**
Pakistan-2013	95	101	94	93	96	96 b
Dharabi-2011	98	97	93	98	90	95 bc
Tatara-96	99	94	96	85	91	93 d
Lalma-2014	93	95	93	88	97	93 d
Chakwal-50	92	86	87	96	93	91 e
Shahkar-2013	95	93	90	97	91	93 d
PS-2005	99	98	100	93	97	98 a
Hashim-2008	96	99	101	101	93	98 a
KT-2000	100	91	96	95	89	94 cd
Siran-2010	92	88	88	84	87	88 f
Mean	96 a	94 b	94 b	93 bc	92 c	

LSD ($p \leq 0.05$) for SD =1.22, LSD ($p \leq 0.05$) for V =1.35, SD×V =3.01

Flag leaf area (cm^2)

SD and V significantly influenced flag leaf area (cm^2) of wheat, whereas their interaction was non-significant (Table 4). Early sowing (11th November) resulted in maximum flag leaf area (35.2 cm^2) which was at par with 21st November sowing (33.1 cm^2) followed by 2nd December sowing (32.3 cm^2), while lower flag leaf area (30.0 cm^2) was recorded for sowing on 22nd December. Wheat cultivar PS-2005 had higher flag leaf area (37.6 cm^2) followed by Pak-2013 and Tatara (34.5 and 34.3 cm^2), statistically at par with one another, while lower flag leaf area (28.4 cm^2) was noted for Hashim-2008. Delay in sowing steadily decreased the flag leaf area. Early sowing resulted in greater flag leaf area than plants sown late. Difference in flag leaf area might be the outcome of different crop growth rates due to variation in growth period **[14]**. Regarding wheat cultivars, PS-2005 produced highest leaf area than other cultivars probably due to genetic variability among cultivars **[15]**.

Table 4. Flag leaf area (cm^2) of wheat varieties as affected by sowing dates under rainfed condition

	Sowing Dates (SD)					
Varieties (V)	**11th Nov**	**21st Nov**	**2nd Dec**	**12th Dec**	**22nd Dec**	**Mean**
Pakistan-2013	38.1	39.5	33.9	31.2	29.8	34.5 b
Dharabi-2011	29.6	35.3	34.3	32.9	25.4	31.5 cd
Tatara-96	35.7	32.2	34.4	35.2	34.2	34.3 b
Lalma-2014	38.2	32.7	35.0	30.0	29.5	33.1 bc
Chakwal-50	30.3	33.2	28.3	27.3	28.8	29.6 de
Shahkar-2013	38.5	32.8	32.6	29.9	32.4	33.2 bc
PS-2005	38.9	36.7	36.5	39.5	36.5	37.6 a
Hashim-2008	34.0	26.5	29.1	24.6	27.6	28.4 e
KT-2000	30.8	31.5	30.7	30.1	26.5	29.9 de
Siran-2010	37.4	30.9	28.7	23.5	29.7	30.0 de
Mean	35.2 a	33.1 ab	32.3 bc	30.4 c	30.0 c	

LSD ($p \leq 0.05$) for SD = 2.32, LSD ($p \leq 0.05$) for V = 2.76, SD×V = ns, ns = non-significant

Spike length (cm)

SD and V significantly influenced spike length of wheat, while their interaction was non-significant (Table 5). Lengthy spikes (10.8 cm) were recorded in early sowing (11th November) followed by 21st November (10.1) and 2nd December (9.6 cm), while smaller spikes (8.9 cm) were recorded in 22nd December sowing. In case of wheat cultivars, Dharabi-2011 had longer spikes

(10.4 cm) which were at par with Pak-2013, Siran-2010, Shahkar-2013 and Lalma-2014. Lower spike length (8.9 cm) was recorded for Chawkal-50. Spike length significantly decreased with late sowing. More assimilation of photosynthates due to prolonged growth period contributed to longer spikes **[10]**. Among cultivars, longer spikes were observed for Dharabi-2011, while shorter were for Chakwal-50. Cultivars have significant effect on spike length due to genetic variations **[16, 17]**.

Table 5. Spike length (cm) of wheat varieties as affected by sowing dates under rainfed condition

	Sowing Dates (SD)					
Varieties (V)	**11th Nov**	**21st Nov**	**2nd Dec**	**12th Dec**	**22nd Dec**	**Mean**
Pakistan-2013	10.7	10.5	10.7	10.1	9.3	10.2 ab
Dharabi-2011	11.3	11.2	10.0	9.4	10.3	10.4 a
Tatara-96	10.0	9.5	8.7	9.1	8.0	9.0 d e
Lalma-2014	11.7	10.2	10.0	9.7	8.7	10.0 abc
Chakwal-50	9.3	9.5	9.7	8.1	8.0	8.9 e
Shahkar-2013	11.7	10.2	10.0	9.1	9.0	10.0 abc
PS-2005	10.3	9.8	9.3	8.7	9.3	9.5 cd e
Hashim-2008	11.7	8.8	8.7	8.7	7.7	9.1 d e
KT-2000	10.3	10.2	9.0	9.4	9.3	9.6 bcd
Siran-2010	11.0	10.8	9.7	9.7	9.7	10.2 ab
Mean	10.8 a	10.1 b	9.6 bc	9.2 cd	8.9 d	

LSD ($p\leq 0.05$) for SD = 0.56 LSD ($p\leq 0.05$) for V = 0.62, V x SD = ns, ns = non-significant

Spikelets spike^{-1}

SD and V significantly differed for number of spikelets spike^{-1}, whereas their interaction was non-significant (Table 6). More spikelets (17.2) were recorded for 11th November sowing, while 22nd December sowing gave fewer spikelets spike^{-1} (15.8). Comparing wheat cultivars, Pak-013 had more spikelets, (17.1) and Chakwal-50 had less spikelet spike^{-1} (15.5). Spikelets spike^{-1} gradually decreased with delayed sowing. The reduction in spikelets may be due to shorter growing period prevailed during late season **[12]**. Pakistan-2013 was dominated over the rest cultivars which resulted higher number of spikelets. Spikelets number is a genetic future of the plant and variation in the spikelet number of different cultivars might be due to the difference in their genetic makeup **[18]**.

Table 6. Spikelets spike^{-1} of wheat varieties as affected by sowing dates under rainfed condition

	Sowing Dates (SD)					
Varieties (V)	**11th Nov**	**21st Nov**	**2nd Dec**	**12th Dec**	**22nd Dec**	**Mean**
Pakistan-2013	18.0	17.3	17.3	16.7	16.0	17.1 a
Dharabi-2011	17.7	16.3	17.0	16.7	16.0	16.7 abc
Tatara-96	17.7	16.3	17.0	17.0	15.7	16.7 abc
Lalma-2014	16.7	16.3	17.0	16.7	16.7	16.7 bc
Chakwal-50	16.3	15.7	15.3	15.7	14.7	15.5 d
Shahkar-2013	17.3	17.3	17.0	16.7	16.3	16.9 ab
PS-2005	17.0	16.7	16.7	16.7	16.0	16.6 bc
Hashim-2008	16.7	15.7	16.0	16.0	14.7	15.8 d
KT-2000	16.7	17.0	16.7	16.7	15.7	16.5 c
Siran-2010	18.0	16.7	16.3	16.7	16.0	16.7 abc
Mean	17.2 a	16.5 a	16.6 a	16.5 ab	15.8 b	

LSD ($p\leq0.05$) for SD = 0.72 LSD ($p\leq0.05$) for V = 0.37, SD×V = ns, ns= non-significant

Biological yield (kg ha^{-1})

SD, V and their interaction significantly influenced biological yield of wheat (Table 7). Higher biological yield (8433) was recorded for early sowing (11th November), followed by 21st November and 2nd December (7907 and 7851 respectively), while delayed sowing both 22nd and 12th December resulted in lower biological yield (7063 and 7106) respectively, which were similar in statistical approach. In case of wheat cultivars, Pak-2013 produced greater biological yield (8325), however it was similar to PS-5 and Shahkar-13. Hashim-2008 produced less biological yield (7120). SD and V interaction showed that biological yield decreased for all cultivars with delay in sowing, except KT-2000 and Lalma-2014 cultivars, where biological yield improved with delay up to 2nd December. More biological yield was obtained from early sowing of wheat due to more tillers, spikes, leaves and taller plants production as a result of prolonged growth period. Our findings are in match with [19] who also investigated decrease in wheat biological yield with delay in sowing. Early sowing (1st to 15th November) produced more biological yield (11953) over late sowing [20]. Higher biological yield was attained for Pak-2013 and PS-2005, while lowest from Dharabi, Lalma, Chakwal, and Siran-2010. Variation in tillers m^{-2}, plant height and leaf area is the possible reason for different biological yield of different cultivars [21].

Table 7. Biological yield (kg ha^{-1}) of wheat varieties as affected by sowing dates under rainfed condition

	Sowing Dates (SD)					
Varieties (V)	**11th Nov**	**21st Nov**	**2nd Dec**	**12th Dec**	**22nd Dec**	**Mean**
Pakistan-2013	8794	8589	8799	8389	7056	8325 a
Dharabi-2011	7905	7839	7849	7072	6800	7493 c
Tatara-96	8639	8467	8477	6839	6144	7713 bc
Lalma-2014	7361	7961	7971	7111	7317	7544 c
Chakwal-50	9394	6733	6743	6428	8111	7482 c
Shahkar-2013	9206	7872	7882	6779	8292	8006 ab
PS-2005	9172	8829	7827	7379	7200	8081 a
Hashim-2008	8056	6722	6732	7906	6183	7120 d
KT-2000	7972	8308	8318	6000	6644	7449 cd
Siran-2010	7828	7750	7910	7159	6878	7505 c
Mean	8433 a	7907 b	7851 b	7106 c	7063 c	

LSD ($p \leq 0.05$) for SD =209.8, LSD ($p \leq 0.05$) for V =358.9, SD×V=802.5

Grain yield (kg ha^{-1})

SD, V and their interaction significantly influenced grain yield of wheat (Table 8). Higher grain yield (3235) was produced in early sowing (11th November), followed by both 21st and 2nd December (3002 and 2948) which was statistically at par with each other respectively, while lower grain yield (2506) was recorded for late sowing (22nd December). Higher grain yield (3346) was obtained by Pak-013, followed by PS-2005 (3063) and Shahkar-2013 (2884), while lower yield (2700) was recorded for Hashim-2008 that was statistically similar to KT-2000, Chakwal-50 and Tatara cultivars. In case of SD and V interaction, grain yield of all cultivars was higher when sown early (11th November) except PS-2005 and Shahkar-2013 cultivars that had produced higher grain yield when sown on 21st November. Wheat cultivars Pakistan-13 and Shahkar-13 had relatively higher grain yield under late sowing as compared to other cultivars. More grain yield with early sowing might be the outcome of more spikes m-^{2}, more grains spike^{-1} and more thousand grains weight in early sown plots compared to late sown plots. Grain yield is reduced with delaying the sowing due to the decrease in proper growth duration, which resulted in lower growth and reduced yield [14, 22]. Early sowing (1st to 15th November) produced greater grain yield (4134 kg ha^{-1}) as compared to late sowing [20]. Cultivars Pak-2013 was found better in terms of grain yield over the other cultivars. Similar trend among cultivars were also reported by [23, 24].

Table 8. Grain yield (kg ha^{-1}) of wheat varieties as affected by sowing dates under rainfed condition

	Sowing Dates (SD)					
Varieties (V)	**11th Nov**	**21st Nov**	**2nd Dec**	**12th Dec**	**22nd Dec**	**Mean**
Pakistan-2013	3708	3553	3392	3117	2958	3346 a
Dharabi-2011	3317	2850	3183	2558	2367	2855 cd
Tatara-96	3225	2758	2817	2800	2050	2730 fg
Lalma-2014	3033	2956	2767	2675	2508	2788 def
Chakwal-50	3228	2433	2850	2383	2742	2727 fg
Shahkar-2013	3100	3250	2567	2600	2904	2884 c
PS-2005	3300	3542	3525	2508	2442	3063 b
Hashim-2008	3383	2750	2708	2517	2142	2700 g
KT-2000	3017	2922	2825	2483	2433	2736 efg
Siran-2010	3042	3007	2850	2683	2510	2818 cde
Mean	3235 a	3002 b	2948 b	2632 c	2506 d	

LSD ($p \leq 0.05$) for SD =117.0, LSD ($p \leq 0.05$) for V = 85.5, SD×V =191.3

Conclusion

It was concluded that early sowing on 11th November improved the yield and yield component of wheat crop. Wheat cultivar Pakistan-2013 was found the best in all aspects. For late sowing, wheat cultivars Shahkar-2013 and Chakwal-50 performed better than the others. Hence, based on the performance wheat cultivar Pakistan-2103 is recommended for early sowing, while wheat cultivars Shahkar-2013 and Chakwal-50 are recommended for late sowing for the rainfed areas of Malakand division particularly Dir valley.

Author's contributions

Conceived and designed the experiments: H Nawaz, S Shah, A Rab, H Fayyaz & H Raza, Performed the experiments: H Nawaz, A Rab, I Ali, F Khan, T Jan, H Khan & G Sadiq, Analyzed the data: H Nawaz, S Shan, H Fayyaz, A Rab & I Ali, Contributed reagents/ materials/ analysis tools: H Nawaz, A Rab, T Jan, SJ Ahmad, F Khan & G Sadiq, Wrote the paper: H Nawaz, S Shah & A Rab.

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