Research Article

Wheat Varietal Comparison at Different Sowing Intervals for Rainfed Cultivation Under Climate Change Scenario

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Abstract | The research study was carried out in Pakistan's Dera Ismail Khan (KPK) at the Arid Zone Research Centre. During 2017-18 on seventeen wheat Varieties/advance lines (C-2014, PR 112, A-2014, DN-84, PR 105, Atta Habib, KT 2000, Shahkar-2013, Pak-2013, Dharabi 011, PS 2005, Tatara, Lalma-2013, Zam-04, Chakwal-50, Hashim-08, Yarik) to compare their yield performance by delay sowing in season under rainfed condition. Sowing of wheat in rainfed area of Dera Ismail khan often depends on winter rainfall which may delays its planting in the season. Between November 10 and December 20, there were five planting dates that were spaced 10 days apart in a 3 replications of a split-plot layout in a randomised complete block design. The impact of planting dates on types and advance lines was examined using both main plots and sub plots. On days to maturity, the data were kept, spike length, grains/spike, 1000-grain weight and yield. The interaction between planting dates and types has a considerable impact on wheat grain production and its characteristics. Wheat varieties Lalma-2013 and Chakwal-50 produced highest yield on Nov. 10th sowing with minimum reduction in grain yield as 2.6% and 1.2% respectively on Nov.20th sowing. The Lalma-2013 and Chakwal-50 could be the best varieties for the rainfed areas of Dera Ismail Khan as compared to local varieties when sown not later than 20th Nov.

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Introduction

Wheat is an important staple food in the world. Every year, largest area is brought under wheat cultivation. In Pakistan, spring wheat is grown every year on an surrounding area of 9.04 million ha, yielding 23.86 million tonnes of grain annually. Wheat is grown in Khyber Pakhtunkhwa (KPK) on roughly 0.78 million acres, yielding 1.2 million tonnes of grain (MNFSR, 2014). KP's average yield is almost half that of the country as a whole. The province (KPK) plants 67% of its wheat land as a rainfed

crop, which is the cause. Few farmers wait for rain to moisten fields before sowing wheat in the season, which causes a significant delay in wheat sowing and lower yields. Farmers plant wheat in winter (Oct.-Nov.) in the expectation that rainfall happens. As a result of recent climate change, it is anticipated that Pakistan, particularly in KP, may receive less winter precipitation in the future, which could delay the sowing of wheat under rainfed conditions. At the start of the winter rains (October–November), wheat is planted in a rainfed state. Hanif and Ali (2014) expected a decrease in winter precipitation in the months of October and November and an increase in summer precipitation in the months of June and August, which might prolong the time a standing crop remains in the field late in the season or postpone the sowing of wheat in Pakistan. A famine and widespread hunger may result from drought stress, which is bad for crops in general and especially while sowing. Thus, future food security in the region is closely correlated with the amount of water available to crops during their growth and development (Aslam *et al*., 2003; Iqtidar *et al*., 2006). According to Kumar *et al*. (2005), Both under drought-stressed and rainfed situations, grain output was substantially linked with height of plants, spikelets that grow per spike, 1000-grain weight, and the biological yield. According to Baloch *et al*. (2010), under drought stress circumstances, there was a considerable decrease in grain yield and 1000-grain weight. In Pakistan, severe weather conditions have recently had a negative impact on agricultural productivity, notably food crops and it is anticipated that food production, would be jeopardised in the time to come as well (GFSI, 2012). The yield of wheat also depends on variations in temperature and precipitation during the reproductive and vegetative stages (Mitra and Bhatia, 2008).

Since climatic change is adversely effecting the food security in Pakistan, the emergent need is to selection of new genotypes with suitable time of planting for best performance and high yield for area to meet the requirement of increasing population and ultimately reduce the risk of food security by coping climate change. The present study was thus conducted on aforementioned prospective and aim to compare the yield of new selected wheat varieties/Advanced lines at different sowing times with delayed natural precipitation.

Materials and Methods

The experiment was carried out in 2017–18 under rainfed conditions at the Arid Zone Research Centre in Dera- Ismail-Khan, Khyber Pakhtunkhwa (KPK), Pakistan. Dera Ismail Khan is located 166 meters above sea level at 31.83° North latitude and 70.9° East longitude. Seventeen wheat varieties/Advance lines of various research station of Pakistan i.e. C-2014, PR 112, A-2014, DN-84, PR 105, Atta Habib, KT 2000, Shahkar-2013, Pak-2013, Dharabi 011, PS 2005, Tatara, Lalma-2013, Zam-04, Chakwal-50, Hashim-08, Yarik were sown on five different dates i.e. November 10, 20, 30, a randomized complete block design was used. Three replications and a split plot arrangement were also used, On December 10 and 20. Drilling was used to plant on a wet field. Six rows, spaced 25 cm apart and four metres long, made up each plot. It was seeded uniformly at a rate of 110 kg ha^{-1}. The middle four rows are where the data is collected, with the first and last row being eliminated. Although the crop was kept under rainfed conditions, an irrigation soaking wet was used prior to planting the experiment.

The meteorological data gathered at the experimental site throughout the crop period is given in Table 1.

Table 1: *Arid Zone Research Institute, D.I. Khan's agrometeorological data from 2017–18*.*

Month	Total rainfall (mm)	Avg. Max. Temp.	Avg. Min. Temp.	Relative Humidity %age	Wind speed KM/ day
October	4.3	32	19	77	2.39
November	16	27	9	79	2.19
December	-	20	5	81	2.00
January	28	19	5	87	2.16
February	27	22	8	84	2.64
March	85	26	12	84	3.00
April	38	33	18	71	3.00

**Source: D.I. Khan, PARC, and Arid Zone Research Institute*

The experimental field's soil type was clay loam. Data gathering was done using the four rows in the middle. The observations for days to maturity, height of plant, length of spike, grains $spike^{-1}$ number of tillers m^2, weight of 1000-grains, and grain yield were made on 10 randomly chosen plants. Using the computer programme STATISTIX 9.1, an analysis of variance was performed for each trait. Following that, Using the LSD at a 0.05% level of probability, the means of all relevant variables were compared.

Table 2: *Means and interaction of days to maturity (90%) in different wheat varieties and sowing.*

Varieties	Sowing date					Mean
	November 10	November 20	November 30	December 10	December 20	
C-2014	152.00 cd	146.33 gh	138.00 j	128.00 mn	116.00 p	136.07g
PR-112	158.00 a	151.00 c-e	142.00 i	133.00 kl	120.00 o	140.80 b
A-2014	152.00 cd	146.00 h	138.00 j	129.00 mn	116.00 p	136.20 g
DN-84	155.33 ab	146.00 h	139.00 ij	126.00 n	116.00 p	136.47 fg
PR-105	153.67 bc	147.00 f-h	139.00 ij	134.00 k	117.00 op	138.13 de
Atta Habib	151.00 c-e	147.33 f-h	139.33 ij	129.00 mn	117.00 op	136.73 fg
KT-2000	158.00 a	150.00 d-f	142.00 i	132.33 kl	117.67 op	140.00 bc
Shahkar-2013	154.00 bc	148.33 e-h	139.67 ij	130.67 lm	118.67 op	138.27 de
Pak-2013	153.67 bc	148.00 e-h	139.00 ij	130.00 lm	117.67 op	137.67 ef
Dharabi-011	155.33 ab	149.33 d-g	140.00 ij	133.00 kl	118.67 op	139.27 cd
PS-2005	155.33 ab	152.33 b-d	146.00 h	138.00 j	126.00 n	143.53 a
Tatara	152.33 b-d	147.33 f-h	139.33 ij	129.00 mn	118.00 op	137.20 e-g
Lalma 2013	154.00 bc	150.00 d-f	140.00 ij	132.33 kl	120.00 o	139.27 cd
Zam-04	153.67 bc	147.33 f-h	140.00 ij	130.00 lm	118.00 op	137.80 ef
Chakwal-50	153.33 bc	151.00 c-e	140.00 ij	130.67 lm	117.00 op	138.40 de
Hashim-08	150.00 d-f	148.33 e-h	139.67 ij	130.67 lm	120.00 0	137.73 ef
Yarik Local	158.00 a	152.33 b-d	142.00 i	134.00 k	120.00 0	141.27 b
Mean	154.10 a	148.71 b	140.18 c	131.16 d	118.45 e	

At a 5% level of probability, means in the same category that are separated by different letters deviate from one another significantly. LSD (sowing dates) 1.50: LSD (varieties/advance lines): LSD 1.36 (sowing dates x varieties/advance lines): 3.32.

Results and Discussion

Days until maturity

The different variety and advance lines' days to maturity were strongly impacted by the sowing dates (Table 1). When seeding was completed on November 10th, the maximum number of days re (158) to maturity were on average observed. gradually dropped to 116 days before maturity. As sowing was postponed till December 20th. Subhan *et al.* (2004a) and Khalifa *et al.* (1998) also stated reduction in days to maturity as a result of the sowing delay. Hashim-08, which exhibited significantly fewer days (150) as compared to PR-112, KT-2000, and Yarik (158) when sowed on Nov. 10th, showed a substantial variation in the variety's days to maturity. The distinctions between the varieties/lines did, however, become more apparent with time. C-2014, A-2014 and DN-84 matured in them minimum number of 116 days showing 23.7, 23.7 and 25.1% decrease while PR-105, Atta Habib, KT-2000, Pak-2013 and Chakwal-50 recorded 117 days, showing 23.9, 22.5, 25.5, 23.4 and 23.7% reduction in days to maturity, correspondingly, when sow on December 20th as compared with Nov. 10th (Table 2).

Spike length

Average spike length was considerably impacted and reduced from a maximum value of 10.48 cm for the crop sowed on November 10th to a minimum value of 8.69 cm on December 20th (Table 3). Yarik gave the longest spikes (11.8cm) and (11.30) when sown on Nov. 20th and 10th, respectively while A-2014 and Hashim-08 produced the smallest spikes (7.90 cm) when sown on Dec. 20th. The length of spike range from 11.30 cm (Yarik) to 9.30 cm (Tatara) when sown on November, 10th which decreased to 9.70 cm (Lalma-2013 and Zam-04) to 7.90 cm (A-2014 and Hashim-08) when sown on December, 20th. Ahmed *et al.* (1997) discovered that all cultivars with late sowing had shorter spike length. The outcome is also in according with Baloch *et al.* (2012).

Grains spike^{-1}

The number of grains per spike fell off dramatically from 45.59 to 27.35 when planting was done from Nov.10th to Dec. 20th (Table 4). Yarik produced lowest number of grains in each spike (39) while Lalma-2013 produced highest number of grains in each spike (49) when crop sown on Nov. 10th, which was not significantly different from Chakwal-50 (48),

Table 3: *Means and interaction of Spike length (cm) In different wheat varieties and sowing dates.*

Varieties	Sowing date					Mean
	November 10	November 20	November 30	December 10	December 20	
C-2014	10.17 i-q	9.97 l-s	9.5 r-a	9.13 y-f	9.17 x-f	9.59 d
PR-112	11.2 bc	10.80 b-h	9.87 m-v	9.30 u-d	9.23 w-e	10.07 bc
A-2014	10.20 h-q	10.23 g-p	9.9 m-u	9.33 t-c	7.90 l	9.51 de
DN-84	10.73 b-i	10.63 c-j	10.5 d-m	9.27 v-d	9.13 y-f	10.05 c
PR-105	11.00 b-d	10.27 f-o	9.7 o-y	9.17 x-f	8.23 i-l	9.68 d
Atta Habib	10.17 i-q	9.70 0-y	9.0 z-g	8.70 d-j	8.60 f-k	9.24 fg
KT-2000	10.20 h-q	10.07 j-s	8.2 i-l	8.63 e-j	8.10 j-l	9.05 gh
Shahkar-2013	10.87 b-f	11.00 b-d	9.3 t-c	8.80 c-i	8.33 h-l	9.67 d
Pak-2013	9.93 m-t	9.97 l-s	10.2 h-q	9.87 m-v	8.43 g-l	9.68 d
Dharabi-011	10.83 b-g	10.00 k-s	10.9 b-e	10.17 i-q	9.03 z-g	10.19 a-c
PS-2005	10.10 j-r	9.47 s-b	8.8 c-i	8.27 i-l	8.27 i-l	8.98 gh
Tatara	9.30 u-d	8.00 kl	8.1 j-l	8.20 i-l	8.70 d-j	8.47 i
Lalma 2013	10.87 b-f	10.60 c-k	10.3 f-o	9.77 n-x	9.70 o-y	10.24 a-c
Zam-04	11.1 bc	10.67 c-j	10.37 e-n	9.80 n-w	9.70 o-y	10.33 ab
Chakwal-50	10.6 c-l	9.90 m-u	9.13 y-f	8.90 b-h	8.10 j-l	9.32 ef
Hashim-08	9.60 q-z	9.33 t-c	8.9 a-h	8.50 g-l	7.90 l	8.85 h
Yarik Local	11.30 ab	11.8 a	9.90 m-u	9.63 p-z	9.27 v-d	10.39 a
Mean	10.48 a	10.14 b	9.57 c	9.14 d	8.69 e	

At a 5% level of probability, means in the same categories that are separated by different letters are substantially different from one another. LSD for sowing dates is 0.13 LSD for varieties/advance lines is 0.27 LSD for sown dates x varieties/advance lines is 0.60

Table 4: *Means and interaction of grains spike^{-1} in different wheat varieties and sowing dates.*

Varieties	Sowing date					Mean
	November 10	November 20	November 30	December 10	December 20	
C-2014	45.67 b-f	43.00 f-i	40.0 j-l	34.33 o-r	29.00 u-w	38.40 bc
PR-112	46.67 a-d	45.00 c-f	39.0 k-m	33.00 q-s	28.00 v-x	38.33 bc
A-2014	45.00 c-f	42.00 g-j	36.0 n-p	32.00 r-t	27.00 w-y	36.40 d
DN-84	47.00 a-c	46.67 a-d	38.0 l-n	33.00 q-s	28.00 v-x	38.53 bc
PR-105	43.67 e-h	41.67 g-k	35.0 o-q	31.00 s-u	26.00 x-z	35.47 de
Atta Habib	47.00 a-c	45.67 b-f	37.0 m-o	32.00 r-t	28.00 v-x	37.93 c
KT-2000	45.00 c-f	43.00 f-i	40.0 j-l	34.00 p-r	28.00 v-x	38.00 c
Shahkar-2013	46.00 b-e	46.67 a-d	43.0 f-i	30.00 t-v	26.00 x-z	38.33 bc
Pak-2013	42.00 g-j	40.67 i-l	34.0 p-r	32.00 r-st	25.00 yz	34.73 e
Dharabi-011	46.00 b-e	47.00 a-c	41.0 h-k	35.33 n-q	27.00 w-y	39.27 b
PS-2005	45.67 b-f	46.67 a-d	42.0 g-j	34.00 p-r	28.00 v-x	39.27 b
Tatara	46.67 a-d	45.33 b-f	40.0 j-l	32.00 r-t	25.00 yz	37.80 c
Lalma 2013	49.00 a	47.00 a-c	44.0 d-g	37.00 m-o	31.00 s-u	41.60 a
Zam-04	46.67 a-d	45.00 c-f	39.0 k-m	36.00 n-p	30.00 t-v	39.33 b
Chakwal-50	48.00 ab	46.33 a-e	41.0 h-k	37.00 m-o	31.00 s-u	40.67 a
Hashim-08	46.00 b-e	47.00 a-c	43.0 f-i	37.00 m-o	24.00 z	39.40 b
Yarik Local	39.00 k-m	32.00 r-t	30.0 t-v	28.00 v-x	24.00 z	30.60 f
Mean	45.59 a	44.16 b	38.94 c	33.39 d	27.35 e	

At a 5% level of probability, means in the same categories that are separated by different letters are substantially different from one another. LSD (sowing dates) is equal to 0.68 LSD (varieties/advance lines) is equal to 1.24 LSD (sowing dates x varieties/advance lines) is equal to 2.78

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PR-112 (46.67), DN-84 (47), Atta Habib (47), Tatara (46.67), Zam-04(46.67) when sown on Nov.10th and was also non-significant from DN-84 (46.67), Chakwal-50 (46.33), Shahkar-2013 (46.67), Dharabi-011(47), PS-2005 (46.67), Lalma-2013 (47), Hashim-08(47) when sown on Nov.20th. Averaged across all sowing intervals, Lalma-2013 produced the maximum number of grains in each spike (41.60) which was not considerable dissimilar from Chakwal-50 (40.67) while Yarik produced minimum number of grains in each spike (30.60). The number of grains in each spike almost decreased with delay sowing in descending order which may be due to either elevated temperature or genetic variability of the varieties response to drought stress at grain filling stage. The results are in accordance with Ishaq (1993) who reported that high temperature decreased the number of grains in each spike to fewer grains in each spikelet. Slafer and Whitechurch (2001), The appropriate fertilization of the ovule to create grains may not have taken place as the photoperiod and temperature increased. The substantial relationship between sowing dates and genotype demonstrates how various genotypes respond differently to temperature and photoperiod in terms of grain development. The outcome are also in line with Subhani *et al.* (2011). It is also observed from data (Table 4) that in different genotypes, the number of grains in each spike is not directly correlated with spike length. Yarik, for instance, produced the longest spikes but almost the fewest grains per spike, demonstrating that while genotype may influence the amount of grains in each spike, the phenomena is primarily influenced by the environment.

1000-grain weight

An average 1000-grains weight range from 46.86 g to 35.85 g, when crop sown on Nov. 10th to Dec. 20th (Table 6). The minimum thousand grains weight was recorded in Shahkar-2013(44.2g) and Dharabi-011(44.2g) which is not significantly different from C-2014(44.5g) when sown on Nov. 10th while the maximum thousand grains weight was observed in Lalma-2013 (50.5g) which is not significantly different from Chakwal-50 (49.3g) and A-2014 (48.7g) when crop sown on Nov.10th and also not significantly different from Lalma-2013 (49.4g), Chakwal-50 (49g) and Zam-04 (48.7g) when sown on Nov. 20th. The thousand grains weight decreased in almost all varieties/lines by delay sowing apart from

Table 5: *Means and interaction of 1000 Grain weight in different wheat varieties and sowing dates.*

Varieties	Sowing date					Mean
	November 10	November 20	November 30	December 10	December 20	
C-2014	44.5 i-n	43.5 k-q	32.0 f-h	35.2 c-e	37.3 z-b	38.49 g
PR-112	45.7 f-j	38.5 w-z	42.0 p-t	39.0 v-z	33.6 ef	39.75 f
A-2014	48.7 a-d	49.4 ab	44.0 j-p	41.7 q-u	35.3 b-e	43.81 c
DN-84	47.3 c-g	44.7 i-m	37.5 z-a	37.0 z-c	33.7 ef	40.03 f
PR-105	47.3 c-g	47.3 c-g	44.3 i-o	36.2 a-d	33.8 ef	41.80 d
Atta Habib	48.2 b-e	44.3 i-o	43.5 k-q	38.3 x-z	32.0 f-h	41.27 de
KT-2000	48.3 b-e	47.7 b-f	46.3 e-i	44.3 i-o	39.7u-y	45.27 b
Shahkar-2013	44.2 j-o	41.6 q-u	42.5 n-s	38.3 x-z	36.0 a-d	40.52 ef
Pak-2013	46.3 e-i	47.7 b-f	44.0 j-p	42.0 p-t	40.3 t-x	44.07 c
Dharabi-011	44.2 j-o	43.2 l-q	44.7 i-m	37.8 y-a	37.3 z-b	41.43 d
PS-2005	46.0 f-j	44.1 j-o	37.0 z-c	41.9 q-t	40.9 r-v	44.50 bc
Tatara	46.3 e-i	47.2 d-g	45.3 g-k	32.4 fg	30.8 gh	40.41 ef
Lalma 2013	50.5 a	49.4 ab	47.0 d-h	45.0 h-l	42.4 o-s	46.86 a
Zam-04	48.4 b-d	48.7 a-d	42.0 p-t	37.3 z-b	33.9 ef	42.06 d
Chakwal-50	49.3 a-c	49.0 a-d	46.3 e-i	40.7 r-v	37.2 z-c	41.98 d
Hashim-08	46.3 e-i	42.7 m-r	41.5 q-u	34.8 de	35.3 b-e	40.12 f
Yarik Local	45.0 h-l	40.5 s-w	38.3 x-z	31.0 gh	30.0 h	36.97 h
Mean	46.86 a	45.25 b	42.25 c	38.41 d	35.85 e	

At a 5% level of probability, means in the same categories that are separated by different letters are substantially different from one another. LSD (sowing dates) is equal to 0.60 LSD (varieties/advance lines) is equal to 0.90 LSD (sowing dates x varieties/advance lines) is equal to 2.04

Table 6: *Means and interaction of Grain yield Kg ha^{-1} in different wheat varieties and sowing dates.*

Varieties	Sowing date					Mean
	November 10	November 20	November 30	December 10	December 20	
C-2014	3211 j-n	2880 p-q	1892 v-z	1700 z-d	1459 e-j	2229 f
PR-112	3304 g-k	2670 q-r	2374 st	1738 y-c	1202k-n	2257 f
A-2014	3461 d-i	3218 j-n	2409 s	1814 w-a	1193 k-n	2419 e
DN-84	3603 b-d	2180 t-u	3397 d-j	1749 y-b	1246 i-n	2435 e
PR-105	3264 h-l	3035 m-p	2280 st	1514 c-g	1085 m-o	2235 f
Atta Habib	3557 b-f	3259 h-m	2445 s	1671 a-e	1117 l-o	2410 e
KT-2000	3477 c-h	3109 k-o	2267 st	2010 uv	1477 e-i	2468 de
Shahkar-2013	3591 b-e	3070 l-p	2715 q	1495 c-g	1149 k-o	2404 e
Pak-2013	3251 i-m	3190 j-n	2321 st	1869 v-a	1350 g-k	2396 e
Dharabi-011	3378 d-j	3353 f-j	2855 p-q	1928 v-y	1272 i-m	2557 d
PS-2005	3586 b-e	3523 b-g	2956 o-p	1977 u-x	1333 g-l	2675 c
Tatara	3547 b-f	3540 b-f	2858 p-q	1440 f-j	1028 n-o	2483 de
Lalma 2013	3955 a	3709 b	3267 h-l	2381 st	1761 x-b	3015 a
Zam-04	3465 d-i	3375 e-j	2472 r-s	1816 v-a	1315 g-l	2488 de
Chakwal-50	3733 ab	3688 bc	3001 n-p	2040 uv	1506 d-g	2794 b
Hashim-08	3366 e-j	3208 j-n	2712 q	1775 x-b	1082 m-o	2429 e
Yarik Local	2668 q-r	2384 st	1573 b-f	1274 h-m	964 o	1773 g
Mean	3436 a	3212 b	2505 c	1776 d	1267 e	2229

At a 5% level of probability, means in the same categories that are separated by different letters are substantially different from one another. LSD (sowing dates) = 27.85; LSD (varieties/advance lines) = 101.08; and LSD (sowing dates x varieties/advance lines) = 220.99

Nov. 10th except in A-2014 (49.4g), Pak-2013(47.7g), Tatara (47.2g) and Zam-04(48.7g) which increased thousand grain weight when sown on Nov.20thand then gradually decreased as compared to crop sown on Nov. 10th. The averaged minimum thousand grain weight across all planting time was recorded in Yaik (36.97g) while maximum thousand grains weight was recorded in Lalma-2013 (46.86g). The 1000-grain weight likely dropped as a result of the delayed sowing because the prolonged photoperiod and higher temperature may not have given the wheat plants enough time to increase grain size sufficiently (Slafer and Whitechurch, 2001). The strong relations between genotype and dates of sowing demonstrates how various genotypes respond to temperature and photoperiod in terms of grain size in different ways. The results are according with those of Malik *et al.* (2009), who claimed that wheat sown in November yielded higher of 1000 grains than sowing it in December.

Grain yield

Grain yield significantly affected by different planting dates and various varieties (Table 6). When planting was completed on November 10th, the highest grain output was noted (3436 kg ha^{-1}), which gradually and drastically declined to 1786 kg ha^{-1} by December 20th when sowing dates are averaged, Lalma-2013 had the maximum grain yield (3015 kg ha^{-1}), followed by Chakwal-50 with 2794 kg ha^{-1}, and Yarik with 1733 kg ha^{-1}, which might be explained by the lower number of grains in each spike and smaller grain size. Lalma-2013 and Chakwal-50 gave the maximum grain yield (3955 kg ha^{-1} , 3733 kg ha^{-1}) on Nov. 10th which are statistically similar, closely followed by DN-84 (3603 kg ha^{-1}) , Shahkar -2013 (3591 kg ha^{-1}), PS-2005 (3586 kg ha^{-1}) and Tatara (3547 kg ha^{-1}) when planted on Nov. 10th and again Lalma-2013 (3709 kg ha^{-1}) , Chakwal-50 (3688 kg ha^{-1}) and Tatara (3540 kg ha^{-1}) when sown on Nov. 20th while Yarik produced minimum yield (2668 kg ha^{-1}) on Nov. 10th and subsequent sowing dates among all varieties/ advance lines. The higher grain yield in Lalma-2013 and Chakwal-50 mainly attributed to more number of grains in each spike and comparable weight of grains. These results are similar to Shahzad *et al.* (2002) and Tahir *et al.* (2009). Less grains per spike and a lower 1000-grain weight were the primary causes of the reduced grain yield in late sowing. These results are in according with those of Spink *et al.* (2000); Aslam

et al. (2003) and Tahir *et al*. (2009). Mehboob *et al*. (2005); Khan *et al*. (2007) and Baloch *et al*. (2012) also, it has been noted that late sowing reduces grain output per hectare.

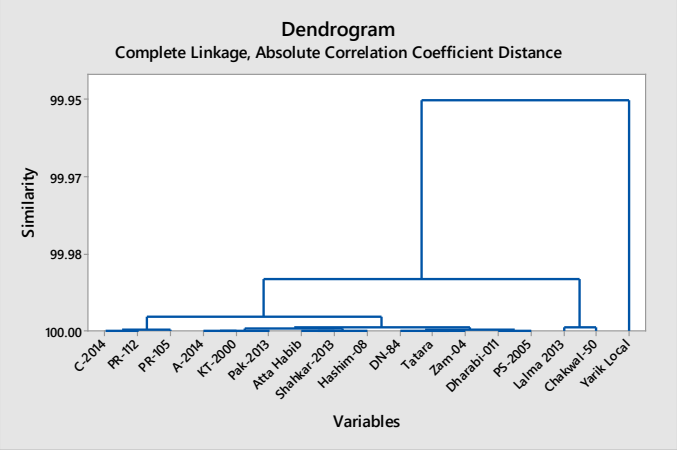

Figure 1: *Dandogram from cluster analysis for rainfed cultivation in different wheat genotypes. The wheat genotypes Lalma 2013 and Chakwal-50 are grouped together in one cluster.*

Conclusions and Recommendations

Based on this study, the grain yield was 63.15% higher in Nov. 10th sown crop than subsequent crops and minimum grain yield reduction in Nov. 20th sown crop 8.6% across all varieties. The Lalma-2013 and Chakwal-50 produced highest yield on Nov. 10th sowing with minimum reduction in grain yield as 2.6% and 1.2%, respectively on Nov. 20th sowing. The Lalma-2013 and Chakwal-50 could be the best varieties for the rainfed areas of Dera Ismail Khan as compared to local varieties when sown not later than 20th Nov. and bring about a large improvement in local wheat production productivity, which could have a big impact on future food security. The maximum grain production from late seeding may have been caused by a large number of tillers for each square meter, more grains for each spike, and heavier grains. The earlier research by Sharma *et al*. (2006), which showed that wheat production decreased by 30–40% in late sowing by the end of December compared to regular sowing, confirmed the current findings.

Novelty Statement

The selected Lalma-2013 and Chakwal-50 wheat genotypes with suitable time of planting for best performance for high yield can meet the requirement of increasing population and ultimately re-duce the risk of food security by coping climate change.

Author's Contribution

Muhammad Qazzafi Khan: Planned reserach work.
Iqtidar Hussain: Supervised the research.
Ejaz Ahmad Khan: Executed research and wrote the manuscript.
Sara Zafar: Rephrased the research article.
Zuhair Hasnain and Moneeza Abbas: Helped in statistical analysis.

Conflict of interest
The authors have declared no conflict of interest.

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