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# EVALUATION OF WHEAT UNDER NORMAL AND LATE SOWING CONDITIONS

MOHAMMAD SAFDAR BALOCH[1*], MUHAMMAD AMJAD NADIM[1], MUHAMMAD ZUBAIR[2], INAYAT ULLAH AWAN[3], EJAZ AHMAD KHAN[3] AND SAJID ALI[3]

[1]*Agricultural Research Institute, Dera Ismail Khan, Pakistan*
[2]*Department of Forestry, Wildlife and Range Management, Bahauddin Zakariya University, Multan, Pakistan*
[3]*Department of Agronomy, Faculty of Agriculture, Gomal University, Dera Ismail Khan, Pakistan*
[*]*Corresponding author's e-mail: safdarbalochpk@yahoo.com*

**Abstract**

The effect of planting time (October-20, October-30, November-10, November-20, November-30, December-10, December-20 and December-30) on wheat (var. Zam-04, Gomal-8, Hashim-8, candidate lines DN-62 and DN-76) was assessed on number of tillers $m^{-2}$, number of days to heading, spike length (cm), number of grains $spike^{-1}$, 1000-grain weight (g), plant height at maturity (cm) and grain yield (kg $ha^{-1}$). The results revealed that wheat planted on October-20 and October-30 produced higher spike length, 1000-grain weight, plant height and grain yield with a comparable number of tillers and number of grains per spike. There was 7.2% reduction in grain yield on October-30 as compared to optimum planting time October-20. This reduction was subsequently increased up to 38.9% on December-30 sowing. The interaction between varieties and sowing dates was highly significant on wheat grain yield and its attributes. However, there was no statistical difference among wheat varieties for grain yield. It is recommended to plant wheat between October-20 to October-30 to attain higher grain yield.

## Introduction

Seasonal fluctuations in temperature have potential impacts on the phasic development and grain yield of crops. Wheat, being a winter cereal, requires particular environmental conditions for better emergence, growth and flowering (Dabre *et al*., 1993) and is more venerable if exposed to high temperatures during reproductive stages (Kalra *et al*., 2008). Too early sowing produces weak plants with poor root system, which leads to irregular germination, frequent death of the embryo and decomposition of endosperm due to activities of bacteria or fungi (Paul, 1992). While, late planting affects germination, growth, grain development (Haq & Khan, 2002) and produces poor tillering due to winter injury in low temperature (Tahir *et al*., 2009). Singh & Uttam, (1999) estimated yield loss @ 39 kg $ha^{-1}$ $day^{-1}$ in each delay in sowing from the optimum sowing time. Normal sowing prolongs the duration of tillering (Ishag, 1994) and produces more number of tillers, number of spikes, grains $spike^{-1}$ and grain weight that ultimately boosts up grain and straw yields (Qasim *et al*., 2008). Rajput & Verma, (1994) also observed that normal sowing time gave higher grain yield than late sowing.

The local climate and associated micrometeorological variations are key factors in optimizing the date of sowings in a particular location because the relations between maximum temperature and sowing date gives best predictions of the growth intervals in various wheat growing areas (French *et al*., 1979). Earlier reports also emphasized the need of studying response of crops to weather variations for evaluating the impact of seasonal temperature change and estimating yield dependence of temperature rise of crops (Kalra *et al*., 2008).

Wheat is the main staple diet of the people of Pakistan. It contributes 14.4% to the value added in agriculture and 3.1% to GDP (Anon., 2010). Dera Ismail Khan is one of the main wheat producing districts of Pakistan. With this in mind, it was felt imperative to examine and quantify the effects of different sowing dates and cultivars on the growth and yield of wheat under the agri-production environment of Dera Ismail Khan.

## Materials and Methods

Three wheat varieties viz., Zam-04, Gomal-8, Hashim-8 and two candidate lines DN-62 and DN-76 were planted under normal (October-20, October-30, November-10, November-20) and late (November-30, December-10, December-20 and December-30) sown conditions with equal intervals of ten days at the Agricultural Research Institute (ARI), Dera Ismail Khan (31° 49' N latitude and 70° 55' E longitude) during the year 2008-09. These varieties have been developed by ARI, Dera Ismail Khan and approved by the Provincial Seed Council (PSC) for general cultivation. The present trial was laid out in a randomized complete block design with three replications. The varieties were assigned to main plots and sowing dates as sub plots in a split plot design. The sub plot size was 1.8mx5m. There were 6, rows 5m long and 30cm apart. Fertilizers @ 150-120-90 kg NPK $ha^{-1}$ in the form of Urea, Di-Ammonium Phosphate and Potassium Sulphate respectively were applied to all treatments. All the phosphorous and ½ of the nitrogen were applied at the time of sowing and remaining ¼ nitrogen was top dressed with first irrigation and ¼ with second irrigation. The crop was sown with single row hand drill on a well prepared seedbed using recommended seed rate of 100 kg $ha^{-1}$. Weedicides (Buctril Super and Puma Super @ 750 ml $ha^{-1}$) were applied to control broad and narrow leaf weeds. The soil of site was silty clay, the pH = 7.78 and the organic matter content 0.88%. Meteorological data at the experimental site revealed the highest temperature (39°C) in May and the lowest (5°C) in December and January. The relative humidity was the highest in December and February (81%) and the lowest (38%) in November. The crop received rain showers from December to May. Table 1 shows the climatic situation during the crop growth season. Plant samples were collected randomly to determine number of tillers $m^{-2}$, number of days to heading, spike length (cm), number of grains spike$^{-1}$, 1000-grain weight (g), plant height at maturity (cm) and grain yield (kg ha$^{-1}$). The data were analyzed statistically using analysis of variance technique and significant means were separated using least significance difference test (LSD) for comparing the treatment means (Steel & Torrie, 1980).

**Table 1. Average monthly and seasonal meteorological data during 2008-2009.**

| Month | Temperature ($^{o}$C) | | Relative Humidity | | Rainfall (mm) |
|---|---|---|---|---|---|
| | Max | Min | 0800 Hrs. | 1400 Hrs. | |
| October | 32 | 20 | 76 | 55 | - |
| November | 27 | 09 | 71 | 38 | - |
| December | 23 | 05 | 81 | 56 | 9 |
| January | 21 | 05 | 76 | 57 | 3.5 |
| February | 23 | 09 | 81 | 54 | 15.5 |
| March | 28 | 13 | 79 | 60 | 48 |
| April | 33 | 17 | 71 | 54 | 15.5 |
| May | 39 | 23 | 70 | 43 | 1.0 |

## Results and Discussion

**Number of tillers (m$^{-2}$):** Tillering mainly depends upon the green photosynthetic area which is responsible for carbohydrate formation, grain filling and final grain yield (Khalifa, 1968). The data given in Table 2 revealed that maximum number of tillers (415.9 m$^{-2}$) was recorded in wheat variety Hashim-8. Candidate line DN-76 produced 405.4 tillers m$^{-2}$ which were statistically similar to Hashim-8. Another candidate line DN-62 produced minimum number of tillers 383.8 m$^{-2}$. From the analysis, it is shown that time of planting had statistically significant effect on tillers production. Sowing wheat on October-20 produced the maximum number of tillers 428.2 m$^{-2}$ followed by planting date November-20. Planting wheat on December-30 produced minimum number of tillers because of low germination (data not shown) per unit area due to low temperature. The interaction of varieties and planting time was statistically significant. The maximum number of tillers was recorded in wheat variety Zam-04 on October-20. It was statistically similar to Hashim-8 which produced 445.7 tillers on October-20 and 445.0 tillers m$^{-2}$ each on November-30 and December-10. Early sowing significantly increased the number of tillers, wherein the contribution of tillers towards final yield was maximum on October-20 which decreased in late sown crop especially at the end of December when the temperature was too low for germination (Wajid *et al*., 2004). The high temperature also reduced the number of tillers in late sown crop because the period between anthesis and senescence was shortened by relatively higher temperature (Akasha, 1968). Differences in number of tillers among varieties might be attributed to their genetic diversity (Shah *et al*., 2006).

**Table 2. Number of tillers m$^{-2}$ as affected by planting time in wheat.**

| Planting Time | Varieties | | | | | Means |
|---|---|---|---|---|---|---|
| | Zam-04 | Gomal-8 | Hashim-8 | DN-62 | DN-76 | |
| Oct- 20 | 446.7 a | 415.7 a-f | 445.7 a | 397.3 d-j | 435.7 ab | 428.2 a |
| Oct-30 | 391.7 e-j | 396.7 d-j | 396.7 d-j | 376.7 h-k | 354.7 kl | 383.3 ef |
| Nov-10 | 393.3 e-j | 366.7 jkl | 371.7 h-k | 373.0 h-k | 380.0 g-k | 376.9 ef |
| Nov-20 | 427.3 a-d | 409.0 b-g | 430.0 abc | 396.3 d-j | 426.7 a-d | 417.9 ab |
| Nov-30 | 388.3 f-j | 398.3 c-j | 445.0 a | 385.0 f-k | 380.0 g-k | 399.3 cd |
| Dec-10 | 388.0 f-j | 370.0 ijk | 445.0 a | 402.7 c-h | 442.0 a-e | 405.5 bc |
| Dec-20 | 390.0 f-j | 373.3 h-k | 380.0 g-k | 401.7 c-i | 396.0 d-j | 388.2 de |
| Dec-30 | 286.0 m | 378.7 g-k | 413.0 b-f | 337.7 l | 446.0 a | 372.3 f |
| Means | 388.9 b | 388.5 b | 415.9 a | 383.8 b | 405.1 a | |

$LSD_{0.05}$ (Varieties) = 11.23
$LSD_{0.05}$ (Planting time) = 14.21
$LSD_{0.05}$ (Varieties x Planting time) = 31.77
Means followed by different letter(s) in a column are significant at 5% level of probability.

**Number of days to heading:** The data mentioned in Table 3 indicated that Zam-04 took the maximum (97.75) days to heading (50% of the spikes having at least 1 anther burst), followed by Gomal-8 taking 95.50 days to heading. Candidate lines DN-62 and DN-76 took 90.38 and 90.13 days to heading. Similarly, variety Hashim-8 took minimum (84.25) time to heading. The data further showed significant differences in number of days to heading on various planting dates. The maximum days to heading (100.8) was recorded on November-10 followed by wheat planted on October-30, which took 98.20 days to heading presumably due to cold weather effect during early crop growth stages. The time from sowing to anthesis was shortened by twenty (20) days in December 30 sown crop as compared to November 10. It was probably due to relatively higher temperatures during anthesis of the late sown crop. Similarly, planting wheat on October 20 increased season length by seventy (70) days as compared to December 30 sowing, thereby taking more number of days to anthesis. A significant interaction of varieties and planting time revealed that wheat variety Zam-04 planted on October-30 and November 10 took the maximum (108) days to heading followed by Gomal-8 with 105 days to heading on the same planting dates (October 30 and November 10). In all cultivars, the time to heading was reduced with further delays in sowing. Hashim-8, with a shortest growth period, took 72 days to heading when planted on December 30. In early sown crop, the time to heading corresponds with favorable lower temperature in subsequent months of January and February, while the late sown crop in December suffered severely from heat stress during grain formation stage in March leading to abnormal/shriveled grain development and poor production. Differences in time to heading might also be due to involvement of different control mechanisms including vernalization and photoperiod sensitivity for a similar environment (Flood & Halloran, 1986). In early sowings (October and November), development of Zam-04 was delayed possibly due to a strong sensitivity to day length or to a greater vernalization requirement compared to other varieties/ candidate lines. Whereas, the temperature was reasonably low (23$^{o}$C) to meet vernalization requirement in December sown crop.

**Table 3. Number of days to heading as affected by planting time in wheat.**

| Planting Time | Varieties | | | | | Means |
|---|---|---|---|---|---|---|
| | **Zam-04** | **Gomal-8** | **Hashim-8** | **DN-62** | **DN-76** | |
| Oct- 20 | 97.00 gh | 101.0 cd | 83.00 q | 98.00 fg | 96.00 hi | 95.00 c |
| Oct-30 | 108.0 a | 105.0 b | 88.00 no | 96.00 hi | 94.00 jk | 98.20 b |
| Nov-10 | 108.0 a | 105.0 b | 92.00 lm | 100.0 de | 99.00 ef | 100.8 a |
| Nov-20 | 102.0 c | 96.00 hi | 89.00 n | 93.00 kl | 95.00 ij | 95.00 c |
| Nov-30 | 97.00 gh | 94.00 jk | 86.00 p | 91.00 m | 92.00 lk | 92.00 d |
| Dec-10 | 91.00 m | 88.00 no | 81.00 r | 83.00 q | 82.00 qr | 85.00 f |
| Dec-20 | 93.00 kl | 92.00 lm | 83.00 q | 87.00 op | 88.00 no | 88.60 e |
| Dec-30 | 86.00 p | 83.00 q | 72.00 t | 75.00 s | 75.00 s | 78.20 g |
| Means | 97.75 a | 95.50 b | 84.25 d | 90.38 c | 90.13 c | |

$LSD_{0.05}$ (Varieties) = 0.577
$LSD_{0.05}$ (Planting time) = 0.729
$LSD_{0.05}$ (Varieties x Planting time) = 1.632
Means followed by different letter(s) in a column are significant at 5% level of probability.

**Spike length (cm):** As shown in Table 4, maximum spike length (11.10cm) was recorded in Zam-04 whereas Hashim-8 produced shorter spike length of 9.56cm. Other varieties and candidate lines had similar spike length statistically. Date of planting also had significant effect on spike length. Planting wheat on October 20 and October 30 produced longer spikes (11.04 and 10.91cm). Short spike length was measured in December sown crop. The interaction of varieties and planting time showed the maximum spike length of 12.30, 12.23 and 11.43cm in wheat variety Zam-04 on October 20 and on subsequent two planting dates (October 30 and November 10) with ten days interval. Hashim-8 on November 10 and candidate line DN-76 on November 20 produced the shortest spike length of 7.80 and 7.83cm respectively.

**Table 4. Spike length (cm) as affected by planting time in wheat.**

| Planting Time | Varieties | | | | | Means |
|---|---|---|---|---|---|---|
| | **Zam-04** | **Gomal-8** | **Hashim-8** | **DN-62** | **DN-76** | |
| Oct- 20 | 12.30 a | 10.43 b-h | 10.70 a-h | 10.43 b-h | 11.33 a-d | 11.04 a |
| Oct-30 | 12.23 ab | 10.54 a-h | 9.96 c-h | 10.93 a-g | 10.87 a-g | 10.91 a |
| Nov-10 | 11.43 abc | 9.46 e-i | 7.80 i | 10.97 a-g | 10.33 c-h | 10.00 bc |
| Nov-20 | 11.27 a-e | 9.96 c-h | 9.86 c-h | 10.53 a-h | 7.83 i | 9.89 bc |
| Nov-30 | 11.17 a-f | 9.83 c-h | 10.84 a-g | 10.03 c-h | 9.70 c-h | 10.32 ab |
| Dec-10 | 10.63 a-h | 8.96 hi | 8.93 hi | 9.36 f-i | 9.13 ghi | 9.40 c |
| Dec-20 | 10.51 a-h | 9.86 c-h | 8.86 hi | 9.46 e-i | 9.73 c-h | 9.68 bc |
| Dec-30 | 9.27 ghi | 8.86 hi | 9.50 d-i | 10.10 c-h | 10.67 a-h | 9.68 bc |
| **Means** | 11.10 a | 9.74 bc | 9.56 c | 10.23 b | 9.95 bc | |

$LSD_{0.05}$ (Varieties) = 0.652
$LSD_{0.05}$ (Planting time) = 0.825
$LSD_{0.05}$ (Varieties x Planting time) = 1.846
Means followed by different letter(s) in a column are significant at 5% level of probability.

**Number of grains (spike$^{-1}$):** The study showed higher number of grains (54.19 spike$^{-1}$) in wheat variety Zam-04 followed by 49.86 grains spike$^{-1}$ in DN-62 (Table 5). Candidate line DN-76 produced the lowest 42.65 number of grains spike$^{-1}$. The data further indicated that earlier the planting time the higher the number of grains i.e., sowing wheat on October 30 and November 10 produced the maximum 56.35 and 51.84 grains spike$^{-1}$. Planting wheat on December 30 had minimum number of 41.73 grains spike$^{-1}$. The interaction between varieties and planting dates was statistically significant. Candidate line DN-62 on October 30, Hashim-8 on October-20 and Zam-04 on December-10 produced higher and almost similar 68.53, 62.00 and 61.80 grains spike$^{-1}$ respectively. The lowest number of grains (34.47 spike$^{-1}$) was recorded in Hashim-8 on December 30. Less number of grains produced in late sown crop (December 30), might be due to less production of photosynthates in shorter growing period. Difference among varieties for the number of grains spike$^{-1}$ was also due to their genetic variability.

**Table 5. Number of grains spike$^{-1}$ as affected by planting time in wheat.**

| Planting Time | Varieties | | | | | Means |
|---|---|---|---|---|---|---|
| | **Zam-04** | **Gomal-8** | **Hashim-8** | **DN-62** | **DN-76** | |
| Oct- 20 | 51.40 b-h | 46.93 d-j | 62.00 ab | 51.00 b-h | 36.93 ij | 49.25 bc |
| Oct-30 | 60.93 abc | 56.40 a-e | 46.40 d-j | 68.53 a | 49.47 b-i | 56.35 a |
| Nov-10 | 59.20 a-e | 52.33 b-h | 46.47 d-j | 55.60 a-f | 45.60 d-j | 51.84 ab |
| Nov-20 | 58.07 a-d | 47.27 c-j | 47.33 c-j | 49.27 b-i | 41.60 g-j | 48.71 bc |
| Nov-30 | 48.33 b-j | 46.33 d-j | 43.47 e-j | 41.00 g-j | 41.20 g-j | 44.07 cd |
| Dec-10 | 61.80 ab | 49.20 b-i | 47.20 c-j | 47.33 c-j | 42.27 f-j | 49.56 bc |
| Dec-20 | 40.40 a-g | 39.87 g-j | 47.67 c-j | 45.53 d-j | 38.60 hij | 43.21 cd |
| Dec-30 | 46.40 d-j | 41.67 f-j | 34.47 j | 40.60 g-j | 45.53 d-j | 41.73 d |
| **Means** | 54.19 a | 47.25 bc | 46.88 bc | 49.86 ab | 42.65 c | |

$LSD_{0.05}$ (Varieties) = 4.941
$LSD_{0.05}$ (Planting time) = 6.250
$LSD_{0.05}$ (Varieties x Planting time) = 13.98
Means followed by different letter(s) in a column are significant at 5% level of probability.

**1000-grain weight (g):** Thousand-grain weight is a genetic character and least influenced by the environment. There were non-significant variations among varieties for the grain weight (Table 6). However, Gomal-8 produced heavier seeds (45.63g) followed by Hashim-8 (44.79g). The data showed statistically significant differences among various planting dates. The highest and significantly similar grain weight was recorded in crop planted on October 20 followed by October 30. There was a gradual decrease in grain weight with each successive sowing date and the minimum grain weight (39.67g) was recorded on December 30. Many workers have also reported a decrease in wheat grain weight due to late sowing (Khan, 2000; Akhtar *et al*., 2006). This is because the delayed sowing shortens the duration of each development phase which ultimately reduces grain filling period resulting in lower grain weight (Spink *et al*., 2000). Also, the late sown crop has to face increasing temperatures at the anthesis stage, which generally decreases weight per grain (Ortiz-Monasterio *et al*., 1994). Smith & Humphreys (2001) reported that at higher temperatures the duration of grain filling period is reduced with a net effect of lower kernel weight. The higher temperature coupled with desiccating winds during the month of March-April brings forced maturity of late sown wheat and results in reduction of test weight (Singh & Dhaliwal, 2000). The interaction showed significant differences between varieties and planting time. Variety Gomal-8 produced the highest seed weight (57.67g) on October-30, followed by Zam-04 and Gomal-8 which produced 56.00g seed weight each on October 30 and October 20. It shows that the earlier planted crop enjoyed a prolonged growth period and favorable pre-heading conditions, which have had a carry over effect on grain weight *via* stem reserves or the setting of potential grain weight soon after anthesis (Ortiz-Monasterio *et al*., 1994).

**Table 6. 1000-grain weight (g) as affected by planting time in wheat.**

| Planting Time | Varieties | | | | | Means |
|---|---|---|---|---|---|---|
| | **Zam-04** | **Gomal-8** | **Hashim-8** | **DN-62** | **DN-76** | |
| Oct- 20 | 50.67 a-g | 56.00 ab | 54.33 abc | 51.00 a-f | 53.33 a-d | 53.07 a |
| Oct-30 | 56.00 ab | 57.67 a | 51.67 a-e | 50.33 a-h | 48.67 a-i | 52.87 a |
| Nov-10 | 34.00 n | 44.33 b-m | 44.33 d-m | 41.00 i-n | 41.67 g-n | 41.07 c |
| Nov-20 | 39.67 i-n | 42.33 f-n | 40.00 i-n | 36.67 mn | 40.00 i-n | 39.73 c |
| Nov-30 | 42.33 f-n | 41.33 h-n | 42.33 f-n | 47.67 b-j | 37.67 lmn | 42.27 c |
| Dec-10 | 42.33 f-n | 38.00 lmn | 41.33 h-n | 38.67 j-n | 42.00 f-n | 40.47 c |
| Dec-20 | 50.67 a-g | 46.67 c-l | 46.00 c-l | 47.33 b-k | 46.33 c-l | 47.40 b |
| Dec-30 | 39.00 j-n | 38.67 j-n | 38.33 k-n | 42.67 e-n | 39.67 i-n | 39.67 c |
| **Means** | 44.33 $^{NS}$ | 45.63 | 44.79 | 44.42 | 43.67 | |

$LSD_{0.05}$ (Planting time) = 4.165
$LSD_{0.05}$ (Varieties x Planting time) = 9.314
Means followed by different letter(s) in a column are significant at 5% level of probability.

**Plant height at maturity (cm):** Significant differences among varieties (Table 7) are found. The maximum plant height (102.6cm) was measured in Zam-04. Hashim-8 and DN-62 produced almost same plant height of 93.25 and 93.22cm respectively while DN-76 produced short statured plants of 88.10cm. Sowing wheat on October 20 and October 30 had significantly taller plants (105.9 and 105.6cm) because of the longer vegetative growth period, better environmental conditions especially the temperature and solar radiation (Qasim *et al*., 2008). The shortest and statistically similar plants of 84.83 and 82.01cm were observed in crop sown on December 20 and December 30 due to shorter growing period. Analysis of the data further reveals significant differences between varieties and planting dates. The tallest plants of 117.3 and 110.2cm were recorded in wheat varieties Zam-04 and Hashim-8 in October 30 and October 20 sowing dates, respectively. DN-76 produced the shortest plants (72.67cm) when sown on November-10. Differences in plant height among varieties might be attributed to their genetic diversity (Shahzad *et al*., 2002).

**Table 7. Plant height at maturity (cm) as affected by planting time in wheat.**

| Planting Time | Varieties | | | | | Means |
|---|---|---|---|---|---|---|
| | Zam-04 | Gomal-8 | Hashim-8 | DN-62 | DN-76 | |
| Oct- 20 | 107.5 abc | 104.3 bcd | 110.2 ab | 103.9 b-e | 103.9 b-e | 105.9 a |
| Oct-30 | 117.3 a | 101.7 b-g | 103.8 b-e | 106.0 bc | 99.33 c-i | 105.6 a |
| Nov-10 | 103.3 b-f | 89.67 h-m | 86.33 k-o | 99.67 c-h | 72.67 q | 90.33 c |
| Nov-20 | 106.7 bc | 92.33 g-m | 93.67 e-l | 97.33 c-j | 89.33 i-n | 95.87 b |
| Nov-30 | 107.5 abc | 84.67 l-p | 95.67 d-k | 94.00 d-l | 88.67 j-n | 94.09 bc |
| Dec-10 | 99.20 c-i | 85.47 k-p | 88.80 j-n | 87.13 j-o | 87.33 j-o | 89.59 c |
| Dec-20 | 93.13 f-l | 85.07 l-p | 85.23 l-p | 75.47 pq | 85.27 l-p | 84.83 d |
| Dec-30 | 85.80 k-o | 81.33 n-q | 82.33 m-q | 82.27 m-q | 78.33 opq | 82.01 d |
| **Means** | 102.6 a | 90.56 bc | 93.25 b | 93.22 b | 88.10 c | |

$LSD_{0.05}$ (Varieties) = 3.642
$LSD_{0.05}$ (Planting time) = 4.607
$LSD_{0.05}$ (Varieties x Planting time) = 10.30
Means followed by different letter(s) in a column are significant at 5% level of probability.

**Grain yield (kg ha$^{-1}$):** As shown in Table 8 that there were non-significant differences among wheat varieties for grain yield. Hashim-8 produced comparatively higher grain yield (2009 kg ha$^{-1}$) followed by Gomal-8 (1984 kg ha$^{-1}$). The lowest grain yield was obtained in candidate line DN-76. Among planting dates, the highest and statistically similar grain yield (2474 and 2296 kg ha$^{-1}$) was obtained from October 20 and October 30 sowing dates respectively whereas the last planting date (December 30) produced the lowest (1511 kg ha$^{-1}$) grain yield. The data again elucidated significant differences between varieties and planting dates. Varieties Gomal-8 and Hashim-8 produced similar grain yield (2556 kg ha$^{-1}$) to that of DN-62 on October 20. Higher grain yield in Gomal-8 and Hashim-8 was mainly due to their higher number of tillers and comparable grain weight. The lowest grain yield (1407 kg ha$^{-1}$) was produced in Zam-04 planted on December 30. This interaction between cultivar and sowing date for yield can largely be explained by differences in time to heading among the cultivars (Ortiz-Monasterio *et al*., 1994). All wheat varieties/lines produced poor grain yield when planted in December. This explains that the spikes population or mean seed weight in late planting could not compensate for the increases in the yield of earlier sowing due to high temperature at the anthesis stage and reduced season length (Naceur *et al*., 1999) and the low temperature of December which reduced germination of seeds and early vegetative growth.

**Table 8. Grain yield (kg ha$^{-1}$) as affected by planting time in wheat.**

| Planting Time | Varieties | | | | | Mean | % reduction in each date |
|---|---|---|---|---|---|---|---|
| | Zam-04 | Gomal-8 | Hashim-8 | DN-62 | DN-76 | | |
| Oct- 20 | 2333 a-e | 2556 a | 2556 a | 2519 a | 2407 abc | 2474 a | - |
| Oct-30 | 2370 a-d | 2481 ab | 2333 a-e | 2370 a-d | 1926 d-i | 2296 a | 7.2 |
| Nov-10 | 2111 a-g | 1889 e-i | 1889 e-i | 2037 b-h | 2111 a-g | 2007 b | 18.8 |
| Nov-20 | 2167 a-g | 2259 a-f | 1963 c-i | 1907 e-i | 1815 f-j | 2022 b | 18.2 |
| Nov-30 | 2111 a-g | 2111 a-g | 2222 a-f | 2037 b-h | 1889 e-i | 2074 b | 16.1 |
| Dec-10 | 1593 hij | 1519 ij | 1581 hij | 1630 hij | 1519 ij | 1563 c | 36.8 |
| Dec-20 | 1593 hij | 1736 g-j | 1759 g-j | 1593 hij | 1630 hij | 1663 c | 32.7 |
| Dec-30 | 1407 j | 1519 ij | 1593 hij | 1519 ij | 1519 ij | 1511 c | 38.9 |
| **Means** | 1961 $^{NS}$ | 1984 | 2009 | 1951 | 1852 | | |

$LSD_{0.05}$ (Planting time) = 204.0
$LSD_{0.05}$ (Varieties x Planting time) = 456.2
Means followed by different letter(s) in a column are significant at 5% level of probability.

In this study, the grain yield was 61.07% higher in October 20 sown crop than the subsequent sowing dates. The higher grain yield in early sown crop over late sowing was due to higher or comparable number of tillers m$^{-2}$, more number of grains per ear and higher mean grain weight on account of intercepting more solar radiation over an extended period of growth (Ali, 1999). Smith & Humphreys, (2001) developed simulation models to predict the effects of seasonal variation, sowing time etc and suggested that early wheat sowing should be done to obtain high yields. Hameed *et al.*, (2003) also observed better performance of wheat varieties when planted in last week of October or first week of November. The lower grain yield with delayed sowing was attributed to reduced number of grains due to high pre-anthesis temperatures (Fischer & Maurer, 1976) and cold temperatures. The reduction in yield may also be due to high post-anthesis temperatures (McDonald *et al*., 1983). There was overall 38.9% or 0.55% $ha^{-1}$ $day^{-1}$ or 13.7 kg $ha^{-1}$ $day^{-1}$ loss in grain yield between October 20 and Dec-30 planted wheat. This was also reflected in the work of Ibrahim *et al*., (1986) who reported 0.80% $ha^{-1}$ $day^{-1}$ loss in grain yield between November 30 and December 21 in Egypt. The earlier work reported by Sharma *et al*., (2006) support the present findings that wheat yield in late sowing by the end of December can reduce the grain yield by 30-40% compared with normal sowing.

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