ISSN : 1812-5379 (Print)
ISSN : 1812-5417 (Online)
http://ansijournals.com/ja

JOURNAL OF AGRONOMY

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

OPEN ACCESS Journal of Agronomy

ISSN 1812-5379
DOI: 10.3923/ja.2020.113.119

Research Article
Genetic Potential and Stability of Wheat Genotypes in Response to Sowing Time

[1]Ansaar Ahmed, [2]Ibni Amin Khalil, [3]Murad Ali, [4]Imtiaz Hussain, [5]Muhammad Imtiaz and [6]Gulzar Ahmad

[1]International Maize and Wheat Improvement Center, Cereal Crop Research Institute, Pirsabaq, Nowshera, Pakistan
[2]Agriculture Research Institute, Dera Ismail Khan, Pakistan
[3]Cereal Crop Research Institute, Pirsabaq, Nowshera, Pakistan
[4]National Agriculture Research Center, Islamabad, Pakistan
[5]International Maize and Wheat Improvement Center, Crop Science Institute, National Agriculture Research Center, Park Road, Islamabad, Pakistan
[6]Agriculture Research Station, Swabi, Pakistan

Abstract
Background and Objective: Wheat crop is among the leading cereals and its grain is used as a staple food in many countries of the world. Several environmental factors are effecting the performance of wheat crop. Late plantation of wheat crop in Pakistan is one of the factors that reduce the yield. The main aim of this study was to identify and select superior wheat genotype with good adoptability to sowing time under the current changing climatic scenario. **Materials and Methods:** The present study was carried out to screen newly developed wheat lines across different sowing dates to identify appropriate planting time for these new lines. A set of 7 wheat genotypes was planted on different sowing dates, starting from October, 25-December, 25 with 10 days interval. **Results:** Data analyses revealed significant effect of sowing time on overall performance of wheat genotype was observed. On the average, wheat crop sown till 15th of November gave better results whereas delayed sowing resulted in reduced grain yield. Similarly, the genotypes also exhibited significant variable performance across different sowing time. However Pr-128 performed well across all sowing dates and was also identified as stable genotypes in overall performance across various sowing dates. **Conclusion:** From the present study it could be suggested that the most optimum time for sowing of wheat crop is 5-15 of November. Moreover, the genotype Pr-128 in addition to normal sowing it can also be used as short duration variety in those areas where the wheat sowing is delayed due to late harvesting of other crops i.e., Maize, sugarcane etc.

Key words: Adaptability, genotype×sowing date, GGE biplot, stability, *Triticuma estivum*

Citation: Ansaar Ahmed, Ibni Amin Khalil, Murad Ali, Imtiaz Hussain, Muhammad Imtiaz and Gulzar Ahmad, 2020. Genetic potential and stability of wheat genotypes in response to sowing time. J. Agron., 19: 113-119.

Corresponding Author: Ansaar Ahmed, International Maize and Wheat Improvement Center, Cereal Crop Research Institute, Pirsabaq, Nowshera, Pakistan

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is an essential food crop in Asia as well as in many countries of the world. Its grain significantly contributed for human food supply and its straw for animal's feed. In Pakistan, total area under spring wheat is 8.8 million hectares which produces 25.1 million tonnes grain/ year with average[1] yield 2851kg ha^{-1}. Like other provinces of Pakistan, wheat is also the major diet of the Khyber Pakhtunkhwa (KP). KP is food insecure region as it produced 1.15 million tons wheat annually against consumption of 2.9 million tons[2]. Improvement in wheat productivity at farm level would not only increase food security of farmer but also improve food availability at affordable prices in the province[3]. Average wheat grain yield of KP farmers is 1807 kg ha^{-1} that is far lower than national average wheat yield of Pakistan (2851 kg ha^{-1}).

Late plantation of wheat crop is one of the limiting factors that reduce the yield. Therefore, sowing of wheat crop on proper sowing date play a key role to augment the production and avoid climate effects due to variations[4]. Several methodologies can be practiced for boosting up wheat productivity through the utilization of new high yielding disease resistant varieties and by adopting proper sowing date. Wheat is sown in winter which requires specific temperature and light for optimum growth[5]. If the temperature is above the optimum level much early plantation resulting in poor plants. Wheat growth and nutrient uptake efficiency of plants increases when sowing at optimum temperature. On the other hand delay sowing practices cause reduction in crop growth and yield[6]. It has been reported that early sowing of wheat enhances germination per unit area, plant height, spikelets/spike/grain/spike and weight of 1000 grains over late sowing[7].

Sial *et al.*[8], reported reduction in plant height, days to heading, maturity and grain yield due to late sowing of wheat crop. Sohail *et al.*[9], reported that late sowing reduced the wheat grain upto 29%. Tahir *et al.*[10], reported maximum grain yield at proper sowing date and lower grain yield in late sowing. Ali *et al.*[11], investigated date of sowing effect on wheat grain yield and reported that wheat sown on November 10 gave highest grain yield. Delay in planting from November 20 gradually reduced the wheat yield. Ibrahim[12] reported that most of time due to delayed planting, 86% losses in grain yield in short maturing varieties of 90-100 days has been observed. In this regards, Sial *et al.*[8] determined appropriate crop yields associated with sowing dates in changing climate. Range of optimum planting date for different varieties varies with cropping husbandry and growing conditions of a particular region evaluated by sowing them at varying dates.

The Cereal Crops Research Institute (CCRI), Pirsabaq Nowshera KP in collaboration with CIMMYT Int. identify and selected several wheat varieties with high yield, improved quality and resistance to biotic and abiotic stresses. These newly developed wheat lines needs to be tested across different sowing dates to identify their response to varying environments. The environment is changing abruptly therefore screening of newly developed wheat lines under different planting dates is extremely important to test their potential. Today in the scenario of changing climate the interactions of G$\times$E is big challenge for plant breeders to develop improved climate resilient wheat varieties. G$\times$E interaction is a well-known methodology for identification adaptability and stability of genotypes. Researchers are always enthusiastic to develop a genotype that has stability in performance across environments[13].

Thus, here, the importance of planting time for wheat was kept in mind and a set of newly developed wheat lines were evaluated across varying sowing dates using the GGE biplot technique proposed by Yan and Kang[14] to recommend appropriate planting date and genotype (s) for irrigated areas of the KP. Keeping in view the importance of wheat and its lower yield due to varietal selection and late sowing in the country, the present study was conducted with aim to evaluate the yield potential of different advance lines/genotypes under various sowing time and to select the best for especially late sowing.

MATERIALS AND METHODS

Study area: The experiment was conducted at CCRI, Pirsabaq Nowshera (34 °N latitude, 72°E longitude and 288 m altitude) under irrigated conditions during 2017-18, 2018-19. The mean temperature and rainfall during the growing period is given in Table 1.

The experiment was comprised of 49 treatments of different sowing dates and genotypes combinations. Each genotype was planted in 6 rows while row to row separation was kept as 30 cm therefore, the area of individual plot was 9 m^2. Two commercial wheat varieties i.e., Pirsabak-2013 and Khaista-2017 along with five advance lines namely PR-123, PR-125, PR-128, PR-129 and PR-130 (Table 2) were sown on seven different sowing dates i.e., October 25, November 5, 15, 25, December 5, 15 and 25 in a randomized complete block design replicated thrice. Uniform cultural practices were applied during both the years. The agronomic practices like seeding rate was applied at 100 kg ha^{-1}, NPK at ratio of 120:90:60 kg ha^{-1} in form of Urea, DAP and MOP, respectively. Basal dose of DAP and MOP were applied at

Table 1: Comparison of meteorological data during the growing cycle at CCRI for 2017-18 and 2018-19

	Average minimum temperature (°C)		Average maximum temperature (°C)		Rainfall (mm)	
Months	2017	2018	2017	2018	2017	2018
October	14.5	13.5	32.7	28.7	000.0	032.9
November	08.1	08.1	23.0	23.7	060.8	004.2
December	02.5	00.5	19.6	18.7	015.0	000.0
January	00.1	02.4	18.9	18.3	000.0	022.8
February	04.6	05.0	21.0	19.5	040.4	054.8
March	10.9	08.5	27.3	23.6	029.2	104.0
April	15.5	15.2	31.5	31.0	101.7	051.6
May	18.6	17.3	34.7	35.5	050.0	016.0
Total rainfall (mm)					297.1	286.3

Table 2: Parentage of wheat genotypes used in the study

Wheat genotypes	Parentage
PR-123	ND643/2*WBLL1/4/WHEAR/KUKUNA/3/C80.1/3*BATAVIA//2*WBLL1
PR-125	KACHU/3/PBW343*2/KUKUNA//PBW343*2/KUKUNA
PR-128	SALEEM-2000 X Pirsabak-2005
PR-129	PASTOR//HXL7573/2*BAU/3/SOKOLL/WBLL1/4/HUW234+ LR34/PRINIA//PBW343*2/KUKUNA/3/ROLF07/5/WHEAR/SOKOLL
PR-130	MILAN/S87230//BAV92*2/3/AKURI
Pirsabak-13	CS/TH.SC//3*PVN/3/ MIRLO/BUC/4/MILAN /5/TILHI
Khaista-17	KAUZ//ALTAR 84/AOS/3/MILAN/ KAUZ/4/HUITES /7/ CAL/NH//H567.71/3/SERI/4/CAL/ NH//H567.71 /5/2*KAUZ/6/PASTOR

planting time while split doses of urea was applied as half sowing and other half at first irrigation[15]. Central four were selected for data recording on grain yield (t ha^{-1}).

Statistical analysis: Analysis of variance procedure was followed for the statistical analysis of recorded data according to the model suggested by Annicchiarico[16] for genotype by environment data combined over years. Least significant differences (LSD) test using 5% level of probability the means were equated. GGE-biplot, a graphical approach was also used to identify stability in performance of genotypes across different sowing dates as proposed by Yan and Kang[14].

RESULTS

Grain yield: Data pertaining grain yield are given in Table 3. For grain yield, year main effect was significant (p<0.01). Average grain yield was significantly higher (5.1 t ha^{-1}) during the year 2017, as compared to (4.6 t ha^{-1}) 2018. Similarly genotypes differed significantly from each other regarding grain yield. In addition, the sowing date's main effect and genotypes×sowing dates interaction were also found significant. Data regarding grain yield performance of wheat genotypes across different sowing dates over two years are presented in Table 4. Among the genotypes, PR-128 produced significantly higher grain yield during both years (5.5 and 5.0 t ha^{-1}) whereas two genotypes produced the lowest grain yield 4.6 t ha^{-1} (PR-129) and 4.1 t ha^{-1} (PR-130) during the first and second year of experimentation, respectively. Since,

Table 3: Mean squares for grain yield (t ha^{-1}) of wheat genotypes evaluated across different sowing dates for 2 years

Sources	DF	Grain yield (t ha^{-1})
Year (Y)	001	18.1**
Reps (Y)	004	00.6
Genotype (G)	006	04.1**
Sowing date (SD)	006	07.2**
G×SD	036	00.2**
G×Y	006	00.3**
SD×Y	006	00.2^{NS}
G×SD×Y	036	00.3**
Error	192	00.1

**Significant at 5, 1% level of probability, NS: Non-significant

sowing dates×years effect was non-significant therefore average over both the years were taken into consideration. Wheat genotypes planted on 15th of November produced significantly higher grain yield (5.3 t ha^{-1}) whereas it was reduced to 4.2 t ha^{-1} when plantation of genotypes was delayed till 25th of December. Data regarding effect of sowing time on grain yield of wheat genotypes is presented in Table 5. The present study indicated 2.9% increase when wheat plantation was shifted from 25th of October to 15th of November. However, delaying wheat sowing after 15th of November resulted in yield reduction which was found highest (-18.2%) during 25th of December.

Since, Genotype×Sowing date effect was found significant, therefore, mean yield data of genotypes across different sowing dates presented in Table 4 was further analyzed using GGE biplot analysis, so as to clearly visualize graphically the G×E interaction the existing. All the genotypes

Table 4: Pooled data regarding grain yield (t ha^{-1}) of seven wheat genotypes evaluated under different date of sowing

		Sowing dates							
Genotypes	Years	October 25	November 05	November 15	November 25	December 05	December 15	December 25	Genotype mean
PR-123	2017	5.7	5.7	5.9	5.3	5.1	4.8	4.7	5.3
	2018	5.0	5.1	5.3	5.1	4.6	4.2	4.0	4.8
PR-125	2017	5.5	5.5	5.8	5.9	5.4	4.2	3.8	5.2
	2018	5.1	5.1	5.2	5.1	4.3	4.2	4.0	4.7
PR-128	2017	5.8	5.8	5.8	5.7	5.3	5.1	4.9	5.5
	2018	5.0	5.0	5.3	5.2	5.1	4.8	4.4	5.0
PR-129	2017	4.9	4.8	4.8	4.5	4.6	4.4	4.1	4.6
	2018	4.8	4.6	4.6	4.7	4.2	4.0	3.6	4.4
PR-130	2017	5.0	5.2	5.3	5.1	4.5	4.4	4.0	4.8
	2018	4.1	4.3	4.5	4.3	4.1	3.7	3.5	4.1
PS-13	2017	5.7	5.6	5.7	5.5	5.0	4.9	4.7	5.3
	2018	5.2	5.2	5.3	5.1	4.9	4.6	4.3	4.9
Khaista-17	2017	5.3	5.4	5.5	5.5	5.0	4.6	4.5	5.1
	2018	4.8	4.8	5.0	4.9	4.5	4.2	4.0	4.6
Year mean	2017	5.4	5.4	5.5	5.4	5.0	4.6	4.4	5.1
	2018	4.9	4.9	5.0	4.9	4.5	4.2	4.0	4.6
Sowing date mean		5.1	5.1	5.3	5.1	4.7	4.4	4.2	

$LSD_{(0.05)}$ for genotype = 0.1, $LSD_{(0.05)}$ for sowing dates = 0.1, $LSD_{(0.05)}$ for genotype×sowing dates = 0.3

Table 5: Differences in grain yield (%) of wheat genotypes as influenced by different sowing dates combined over years

		Sowing dates						
Sowing dates	Grain yield (t ha^{-1})	October 25	November 05	November 15	November 25	December 05	December 15	December 25
October 25	5.1	-	0.5	2.9	0.3	-7.4	-13.5	-18.2
November 05	5.1	-	-	2.4	-0.1	-7.8	-13.9	-18.6
November 15	5.3	-	-	-	-2.5	-10.0	-15.9	-20.5
November 25	5.1	-	-	-	-	-7.7	-13.8	-18.5
December 05	4.7	-	-	-	-	-	-6.6	-11.7
December 15	4.4	-	-	-	-	-	-	-5.5
December 25	4.2	-	-	-	-	-	-	-

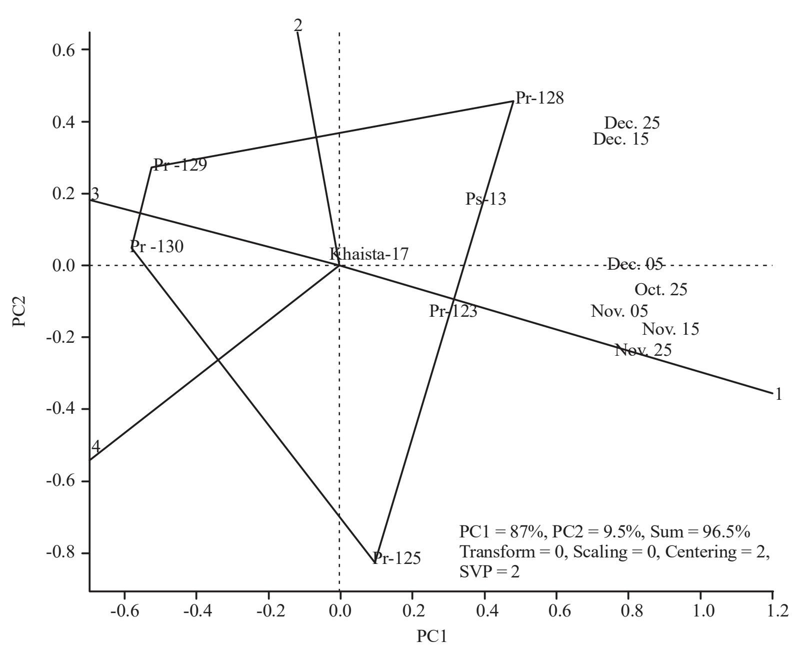

Fig. 1: Polygon view of biplot regarding grain yield performance of 7 genotypes across 7 sowing dates

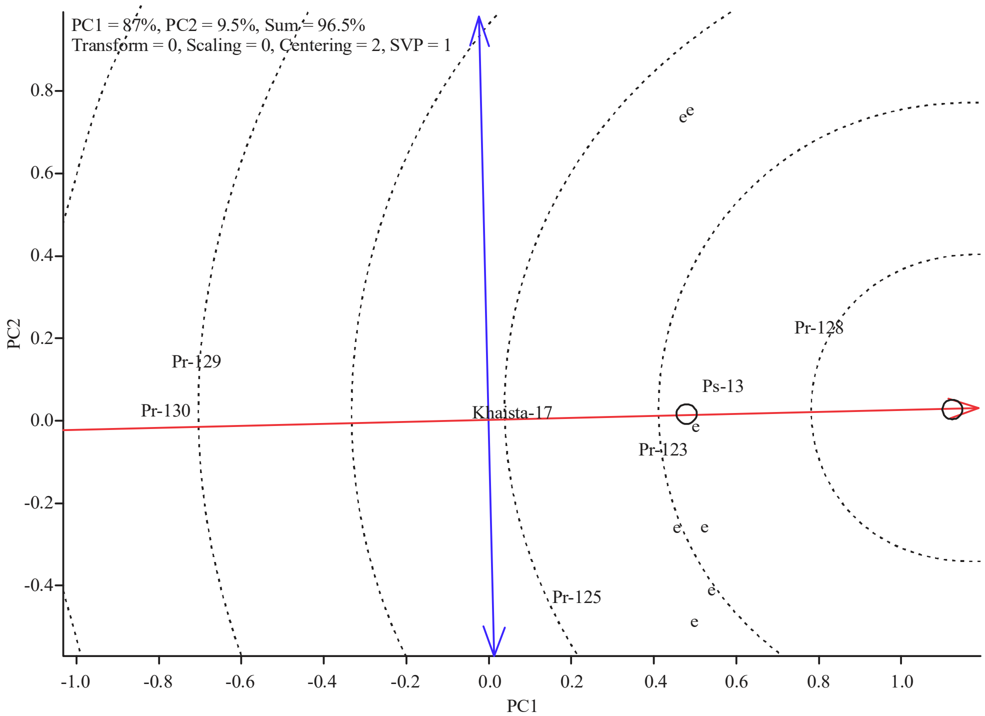

Fig. 2: Biplot regarding stability and grain yield performance of 7 genotypes evaluated across 7 sowing dates

in the biplot were arranged in such a way that some of them were on the vertices, while the rest were inside the polygon (Fig. 1) with some genotypes being the most responsive are placed on the vertices. Similarly, the different sowing dates are denoted in uppercase letters. The whole biplot is divided into various sectors and the most important one is between vertex 1 and 2 where all the sowing dates are present. In this sector genotype Pr-128 occupied position on the vertex which showed that it out classed all other genotypes in performance across all sowing dates. Moreover, the other genotype PS-13 also occupied position in the same sector therefore it is clear that it also performed better across all sowing dates. On the other hand the remaining genotypes occupied position in the opposite direction therefore it is clear that they did not performed well across different sowing dates.

The Fig. 2 demonstrates the average grain yield and stability in performance of various genotypes across different sowing dates. Mean performance in term of yield of wheat genotypes was calculated by the prediction of respective markers to the ATC X-axis (Single arrowed line), while consistency of wheat genotypes was approached by the projection of the respective markers to the ATC Y-axis. Moreover, ideal genotype status of genotypes via were compared using GGE biplot which is presented in Fig. 2 as the center of the concentric circle, representing wheat having the optimum grain yield across various sowing dates and was at best level in term of grain yield. Since, genotype Pr-128 and PS-13 is present in the center of the concentric circle therefore ranked on top regarding performance and stability whereas, Pr-123 and Pr-125 occupied second position being placed in the second concentric circle.

DISCUSSION

Since, wheat is the staple food of the country therefore special considerations are given for its yield improvement. However, the per unit area yield of wheat in country is comparatively low than other advanced countries. Besides others, improper wheat varieties for late plantation is one of the factors that reduce grain yield of wheat. During the present study fluctuation in yield of wheat was observed in late plantation which might be due to shorter duration of growth and development[17]. In one of the studies, Qasim *et al.*[18], reported higher wheat grain yield when planted in early November whereas planted in late December drastically reduced wheat yield[19]. The reduction in wheat grain yield due to late plantation might be due to decreased growing period or less flexibility of genotypes to adapt to short growing period and exposure of plants to high temperature at terminal growth stage[20]. In a similar sort of experimentation conducted by Sharma *et al.*[21], also supported the phenomena about yield reduction due to late sowing ranging from 30-40% compared with normal plantation. They further stated that, more grain yield produced by early planted wheat might be due to extended growth period for both vegetative and reproductive stages of the crop. The possible reason for this might be due to maximum utilization of resources during the plant growth stages viz. grain filling duration, growth behavior of crop, which subsequently result in accumulation of optimum dry matter due to delay plantation. In addition to this, the short of phenological development might be possible reason for utmost decreasing in various yield component and so is the final produce[22,23]. Other possible reason for low grain yield in late planted wheat might be due to increase in temperature[24]. Modarresi *et al.*[25], also reported that high temperature could decrease grain yield upto 46%.

For analysis of multi sowing time data set, the GGE biplot is one of the advance and best possible ways to effectively identify G$\times$E interaction. The GGE biplot visually demonstrate the performance of genotypes which enable the researcher to identify best suited genotype for specific environment or sowing time. The better way to know clearly the interaction patterns among wheat genotypes and date of sowing and to efficiently understand a biplot the polygon view of the biplot was used[14]. Genotypes more responsive to sowing time were visualized on the vertexes those having either the best or the poorest performance in one or all sowing date[26]. During this two years study, it has been found that genotype PR-128 on the average performed well across all sowing dates. It also outclassed the check cultivar PS-13 which is already recommended for late plantation therefore PR-128 on approval could be recommended to farming community especially in those areas where wheat plantation is delayed due to late harvesting of crops (i.e., Rice, sugarcane, Tobacco, potato etc). Moreover, it can also be used in future wheat breeding program.

CONCLUSION

The present study suggested that the most optimum time for sowing of wheat crop is 5-15th of November. The genotype PR-128 performed well across all sowing dates therefore upon approval as a variety it can be used as short duration variety in sugarcane, tobacco and potato growing areas where the wheat plantation is delayed due to late harvesting of these crops.

SIGNIFICANCE STATEMENT

This study discovers the optimum planting time for various wheat genotypes which could be useful as a guideline for planting suitable genotype on suitable planting date. Moreover, PR-128 can be a relatively good option to plant late in season with relatively less yield losses per unit area if sowing has been postponed till 25th November in the season. Under changing climatic conditions this study will help the researchers to develop the most promising wheat cultivars with relatively less yield losses per unit area due to delayed plantation. In addition, the PR-128 can be used as a potential parent in future wheat breeding programs.

ACKNOWLEDGMENTS

Authors are highly thankful of the US Agency for International Development (USAID) for the in-time financial support through the Agricultural Innovation Program (AIP) for Pakistan grant number AID-BFS-G-11-00002.

REFERENCES

1. Government of Pakistan, 2018. Economic survey of Pakistan. Economic Advisory Wing, Finance Division, Islamabad. http://www.finance.gov.pk/survey/chapters_19/Economic_Survey_2018_19.pdf
2. Government of Khyber Pakhtunkhwa, 2018. Crops statistics of Khyber Pakhtunkhwa. Crops Reporting Services, Agriculture, Livestock Cooperative Department, Peshawar.
3. Ahmad, M. and U. Farooq, 2010. The state of food security in Pakistan: Future challenges and coping strategies. Pak. Dev. Rev., 49: 903-923.
4. Murungu, F.S. and T. Madanzi, 2010. Seed priming, genotype and sowing date effects on emergence, growth and yield of wheat in a tropical low altitude area of Zimbabwe. Afr. J. Agric. Res., 5: 2341-2349.
5. Dabre, W.M., S.B. Lall and G.L. Ingole, 1993. Effects of sowing dates on yield ear number, stomatal frequency and stomatal index in wheat. J. Maharashtra Agric. Univ., 18: 64-66.
6. Yajam, S. and H. Madani, 2013. Delay sowing date and its effect on Iranian winter wheat cultivars yield and yield components. Ann. Bio. Res., 4: 270-275.
7. Anwar, S., W.A. Khattak, Inamullah, M. Islam, S. Bashir, M. Shafi and J. Bakht, 2015. Effect of sowing dates and seed rates on the agro-physiological traits of wheat. J. Environ. Earth Sci., 5: 135-141.
8. Sial, M.A., M.A. Arain, S. Khanzada, M.H. Naqvi, M.U. Dahot and N.A. Nizamani, 2005. Yield and quality parameters of wheat genotypes as affected by sowing dates and high temperature stress. Pak. J. Bot., 37: 575-584.

9. Sohail, M., I. Hussain, Riaz-ud-Din, S.K. Tanveer, M. Qamar and S.H. Abbas, 2014. Evaluation of advance wheat lines for agronomic traits in rainfed environment. Pak. J. Agric. Res., 27: 79-88.
10. Tahir, M., A. Ali, M.A. Nadeem, A. Hussain and F. Khalid, 2009. Effect of different sowing dates on growth and yield of wheat (*Triticum aestivum* L.) varieties in district Jhang, Pakistan. Pak. J. Life Soc. Sci., 7: 66-69.
11. Ali, M.A., M. Ali and Q. Mohy-Ud-Din, 2004. Determination of grain yield of different wheat genotypes as influenced by planting dates in agro-ecological conditions of Vehari. Pak. J. Life Soc. Sci., 2: 5-8.
12. Ibrahim, O.H., 1996. Effect of sowing time on wheat production. Proceedings of the National Research Review Workshop on Wheat Production and Environment in Sudan, August 27-30, 1995, Wad Medani, Sudan.
13. Yadav, S.S., A.K. Verma, A.H. Rizvi, D. Singh, J. Kumar and M. Andrews, 2010. Impact of genotype×environment interactions on the relative performance of diverse groups of chickpea (*Cicer arietinum* L.) cultivars. Arch. Agron. Soil Sci., 56: 49-64.
14. Yan, W. and M.S. Kang, 2003. GGE Biplot Analysis: A Graphical Tool for Breeders, Geneticists and Agronomists. 1st Edn., CRC Press, Boca Raton, FL., USA., ISBN-13: 9781420040371, Pages: 288.
15. Shehzadi, S., Z. Shah and M. Wisal, 2017. Impact of organic amendments on soil carbon sequestration, water use efficiency (wue) and yield of irrigated wheat. Biotechnol. Agron. Soc. Environ., 21: 36-49.
16. Annicchiarico, P., 2002. Genotype×environment interactions: Challenges and opportunities for plant breeding and cultivar recommendations. FAO Plant Production and Protection Paper No. 174, FAO., Rome.
17. Shahzad, M.A., Wasi-ud-Din, S.T. Sahi, M.M. Khan, Ehsanullah and M. Ahmad, 2007. Effect of sowing dates and seed treatment on grain yield and quality of wheat. Pak. J. Agri. Sci., 44: 581-583.
18. Qasim, M., M.Q. Faridullah and M. Alam, 2008. Sowing dates effect on yield and yield components of different wheat varieties. J. Agric. Res., 46: 135-140.
19. Sattar, A., M.M. Iqbal, A. Areeb, Z. Ahmed, M. Irfan, R.N. Shabbir and S. Hussain, 2015. Genotypic variations in wheat for phenology and accumulative heat unit under different sowing times. J. Environ. Agric. Sci., 2: 1-8.
20. Suleiman, A.A., J.F. Nganya and M.A. Ashraf, 2014. Effect of cultivar and sowing date on growth and yield of wheat (*Triticum aestivum* L.) in Khartoum, Sudan. J. For. Prod. Ind., 3: 198-203.
21. Sharma, N.P., K.V. Sumesh, D.L. Vaibhav and M.C. Ghildiyal, 2006. High temperature effect on grain growth in wheat cultivars: An evaluation of responses. Indian J. Plant Physol., 11: 239-245.
22. Spink, J.H., T. Semere, D.L. Spares, J.M. Whaley, M.J. Foulkes, R.W. Clare and R.K. Scott, 2000. Effect of sowing date on the optimum plant density of winter wheat. Ann. Applied Biol., 137: 179-188.
23. Turk, M.A. and A.R.M. Tawaha, 2002. Impact of seeding rate, seeding date, rate and method of phosphorus application in faba bean (*Vicia faba* L. *minor*) in the absence of moisture stress. Biotechnol. Agron. Soc. Environ., 6: 171-178.
24. Riaz-Ud-Din, G.M. Subhani, N. Ahmad, M. Hussain and A.U. Rehman, 2010. Effect of temperature on development and grain formation in spring wheat. Pak. J. Bot., 42: 899-906.
25. Modarresi, M., V. Mohammdi, A. Zali and M. Mardi, 2010. Response of wheat yield and yield related traits to high temperature. Cereal Res. Commun., 38: 23-31.
26. Yan, W. and I. Rajcan, 2002. Biplot analysis of test sites and trait relations of soybean in Ontario. Crop Sci., 42: 11-20.