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Morpho physio characteristics of climate resilient wheat varieties sown under different sowing dates under rainfed conditions of Pakistan

Hafiz Muhammad Jhanzab[1], Sikander Khan Tanveer[1], Syed Haider Abbas[1]*, Imtiaz Hussain[2], Maqsood Qamar[1] and Sundas Waqar[1]

[1]Wheat Program, Crop Sciences Institute, National Agricultural Research Centre (NARC), Islamabad, Pakistan
[2]Plant Sciences Division, Pakistan Agricultural Research Council (PARC), Islamabad, Pakistan

***Corresponding author: Syed Haider Abbas (haider_kazmi2001@yahoo.com)**

Abstract

Erratic climate has influenced the optimum time of sowing of wheat and grain production by variations in temperature during growth period of crop. Production of wheat is highly sensitive to elevated temperatures. Suitable time of sowing is very imperative to achieve higher yield on sustainable basis. An investigation was carried out to check the response of growth and yield of different advanced lines under three varying planting windows. For this purpose, a field investigation was taken at National Agricultural Research Center (NARC) area Islamabad which was laid down in randomized design with three repeats. Results revealed that maximum plant population / m^2, plant height (cm), and leaf area (cm^2) were recorded with SD1 (03 Nov), followed by SD2 (26 Nov) and minimum response was recorded with SD3 (03 Dec). Similarly, yield & yield attributes were significantly influenced by sowing of wheat under different sowing dates. Maximum no. of tillers/m^2, spike length (cm), and biological yield were recorded with SD1, followed by SD2 and minimum was recorded with SD3. Significantly and maximum 1000-grains weight and yield kg/ha was recorded with SD1. Among, genotypes significantly maximum yield was obtained with NR-499. In conclusion, wheat planted on SD1 produced maximum yield as compared with other planting windows.

Keywords: Climate change, Genotypes, Growth, Sowing dates, Yield

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Introduction

Wheat (*Triticum aestivum* L.) as a king of cereal is the mainstay of agricultural economy in the majority parts of the world. Wheat is the second world largest food after rice. It is a very imperative cereal crop among the majority populations of the world and staple diet of two billion people. Its grain provides minerals, vitamins and energy (Saleem et al., 2007). Globally, this cereal is widely used in humans as well as animals' diets. In Pakistan, wheat is an imperative rabi crop which illustrated the growth of 2.5% and reached to 24.946 million tons (Pakistan Economic Survey, 2019-20).

Optimum and appropriate environment for all crops resulted in higher economic yield and it aids genotypes to express their full growth potential. Wheat, as a cereal, requires specific environmental conditions for improved growth and production and vulnerable if exposed to high temperatures through reproductive phase at grain formation (Kalra et al., 2008). Favorable temperature essential for anthesis & grain filling phase of wheat ranges from 12 to 22 ◦C. Reduction in grain yield can be occurred if temperature increases from this level (Tewolde et al., 2006; Fisher, 2007). Increasing temperature is considering a growth limiting factor to produce crops particularly under the current variable climatic conditions. It has been estimated and anticipated that increase in temperature till 2050 reached from 1.5-4.5 ˚C (Houghton et al., 2001). High temperature accelerates the process of development of grain filling (Gaju et al., 2009), thus resulted in reduction of assimilation of carbohydrates, deposition of starch in grains and yield of grains (Tribol & Triboi-Blondel, 2002; Labuschagne et al., 2009). This sector is facing greater challenges for fulfilment of dietary needs, healthy, food safety, mounting risk of diseases and intimidation to production of agriculture especially from varying weather scenario (Biswal et al., 2012). Therefore, determining the opportune time of sowing for new wheat varieties may help to achieve their potential economic yield significantly.

In wheat, yield and quality of grains are contingent on genetic factors, environment, and the interaction among them (Yan; Holland, 2010). With the management of sowing date, potential variety and environmental factors production of wheat can be increased by 10-80% (Coventry et al., 2011). In the same way, baking quality is also inclined by sowing date (Singh et al., 2002). In addition, early sowing of wheat resulted feeble plants with deprived root system, uneven germination, recurrent deaths of embryo and putrefaction of endopsperm owing to activities of fungi or bacteria (Paul, 1992). Whereas late planting affects germination, growth and development of grains (Haq & Khan, 2002) and produced poor tillers due to winter injury in low temperature (Tahir et al., 2009). Therefore, it is very necessary to find the relationship between varying environments and newly develop genotypes.

The impediment in the date of sowing of wheat not only affects yield, but it also affects all attributes of growth and development. It is usually highly connected with reduction in grain size, weight (Radmehr et al., 2003), no. of spikes/plant no. of grains/spike, harvest index, and leaf area index (Jessop and Ivins, 1970). Appropriate sowing time for wheat plays significant role in growth and development. However, in varying climatic conditions of Pakistan, it is estimated that yield may decreased by 58.2% in delayed sowing practice (Ali et al., 2004). Precise and exact information of sowing time of specific variety at particular location is crucial for meeting potential yield of grains (Ortiz-Monasterio et al., 1994).

Increasing population is a prominent problem of this century. Ensuring food security for world increasing population will be a challenging task especially for developing countries. Therefore, climate change is another infuriating problem of the agriculture sector. Attaining higher production from existing varieties in changing environmental conditions is very difficult. Sowing of wheat at its appropriate time provides optimum period for completing growth and development of plants ultimately accumulation of greater biomass in increased biological and grain yield. Keeping in view the above scenario a study was conducted to find the best sowing dates for potential cultivars to attain higher yield in diverse environmental conditions.

Materials and Methods

The experiment was carried out at National Agricultural Research Centre (NARC) Islamabad, Pakistan under rain fed conditions to find the best sowing dates for potential 10 promising genotypes for arid environment of Pakistan. In October area under study received 22.3 mm rainfall and 84.78 mm was received in November 2019. Moreover, maximum temperatures recorded in October and November 2019 were 29.03 ^{o}C and 22.23 ^{o}C. Healthy and disease free seeds of different nurseries and varieties e. g (NR-499, NR-505, NR-514,NR-519,NR-529,NR-449,NR-443, Pak-13, Borl-16, Zincol-16) were collected and treated with fungicide to cure seed borne diseases. All these varieties were sown on different three dates: Sowing Date1 (03 Nov), Sowing Date2 (26 Nov), Sowing Date3 (03 Dec) at seed rate @ 50 kg/acre. N. P ratio per acre was 1: 1.5. Randomized complete block design with split plot arrangements of treatments were used for this study. In the main plots sowing dates were kept and in sub plots entries of wheat were placed. All sowing operation was carried out with the help of highly precise wheat planter having adjustment of 1.5 x 5 m.in the calibrated planter seed rate were adjusted automatically. During the investigation, broad leaf weedicide and narrow leaf weedicides were applied to control the weeds Data on growth parameters such as plant population/m^2, plant height (cm), as well as yield attributes (no. of tillers/m^2, Spike length (cm), Biological yield (g) and Yield kg/ha) were collected.

Statistical analysis

Means were statistically analyzed with Statistix software to compare the means by using tukey test on least significant differences described by Steel and Torrie (1997) to find the inferences and drawing the conclusion.

Results

Plant population of different genotypes affected under various sowing dates

Experimental results depicted that different sowing dates significantly affect the plant population of different genotypes. Maximum plant population was recorded with SD2 (193.17) followed by SD1 (177.58) and minimum was recorded with control (69.05) at 5 % level of significance. Similarly, response of genotypes to varying environment is presented in (Table 1). Maximum plant population was recorded with NR-443 (159) followed by NR-529 (157). Minimum plant population was analysed with Bor-16 (124.67) at 5 % level of significance.

Diverse sowing dates affected plant height of various genotypes of wheat

Plant height is an important parameter among the plant growth attributes (Table 1). Maximum plant height was analyzed with SD1 (98 cm) followed by SD2 (85.46 cm). Minimum plant height was recorded with SD3 (78 cm) at 5 % level of significance. There were no significant differences were found among the genotypes to sowing dates. However, maximum plant height was recorded with Pak-13 (89 cm), followed by NR-505 (88.78 cm) at 5 % level of significance.

Different sowing dates affected Leaf area of various genotypes of wheat

Maximum leaf area was recorded with sowing date 1 (16.2 cm^2), followed by SD2 (14.192 cm^2) and minimum was recorded with SD3 (13.33 cm^2) at 5 % level of significance. It is depicted from the experiments that appropriate sowing regime is necessary for obtaining maximum leaf area that is necessary for interception of light resulted in higher photosynthesis. Leaf area response of promising genotypes to sowing dates is presented in (Table 1). There were no significant differences were found between different genotypes however, maximum leaf area was recorded with NR-505 (15.90 cm^2), followed by Borl-16 (15.57 cm^2). Minimum leaf area was analyzed with NR-449 (13.28 cm^2) in comparison with other genotypes at 5% level of significance.

Table 1 Characteristics of various genotypes planted under different sowing dates

Treatments	Plant population	Plant height (cm)	Leaf area (cm^2)
Sowing dates			
SD1	193.17[a]	97.866[a]	16.204[a]
SD2	177.58[a]	85.460[b]	14.192[b]
SD3	69.05[b]	77.973[c]	13.332[b]
LSD value	16.073	3.7546	1.8307
Genotypes			
NR-499	137.06[ab]	87.663[a]	14.558[a]
NR-505	155.28[a]	88.784[a]	15.902[a]
NR-514	144.00[ab]	87.259[a]	14.520[a]
NR-519	140.56[ab]	87.778[a]	14.017[a]
NR-529	157.72[a]	86.804[a]	14.070[a]
NR-449	150.00[ab]	87.798[a]	13.288[a]
NR-443	159.00[a]	85.900[a]	15.236[a]
Pakistan-13	147.39[ab]	88.986[a]	14.270[a]
Borl-16	124.67[b]	82.459[a]	15.576[a]
Zincol-16	150.33[ab]	87.568[a]	14.321[a]
LSD value	29.344	6.8549	3.342

Means sharing different letters differ significantly from each other by LSD (P=0.05).

Response of sowing dates to no. of tillers of various genotypes of wheat

Sowing dates affected the tillers significantly, maximum no. of tillers were recorded with SD1 (421.93), followed by SD2 (332.80). Minimum tillers were recorded with SD3 (201.67) where wheat was planted late in December, 2019 (Table 2). Similarly, maximum no. of tillers were recorded with NR-449 (366), followed by NR-505 (357.44). Minimum no. of tillers was recorded with NR-529 (248.11) at 5 % level of significance.

Spike length of various genotypes affected under different sowing dates of wheat

Different sowing dates affected the length of spike of wheat. There were no significant differences were found between SD1 & SD2 among spike length, however, minimum spike length (8.74 cm) was recorded with SD3 (Table 2). Genotypes response towards spike length did not affect significantly, however maximum spike length was recorded with NR-514 (10.08 cm), NR-443 (10.07 cm) followed by NR-449 (9.87 cm). Minimum was recorded with NR-499 (9.22 cm) but statistically at par with other genotypes.

Table 2 Yield attributes response of various genotypes planted under different sowing dates at NARC, Islamabad

Treatments	No. of tillers	Spike length (cm)	Biological yield (g)
Sowing dates			
SD1	421.93[a]	10.164[a]	1520.2[a]
SD2	332.80[b]	10.170[a]	915.8[b]
SD3	201.67[c]	8.748[b]	496.0[c]
LSD value	34.204	0.6411	95.745
Genotypes			
NR-499	350.11[ab]	9.221[a]	1286.8[a]
NR-505	357.44[ab]	9.584[a]	1177.6[a]
NR-514	331.56[abc]	10.080[a]	983.2[bc]
NR-519	301.67[bcd]	9.260[a]	834.4[cd]
NR-529	248.11[d]	9.756[a]	678.4[d]
NR-449	366.00[a]	9.872[a]	1151.9[ab]
NR-443	318.78[abc]	10.078[a]	947.4[c]
Pakistan-13	310.00[abcd]	9.442[a]	898.6[c]
Borl-16	276.22[cd]	9.763[a]	956.4[c]
Zincol-16	328.11[abc]	9.883[a]	858.8[c]
LSD value	62.447	1.1705	174.81

Means sharing similar letters did not differ significantly at 5 % probability level.

Different sowing dates affected biological yield of various genotypes of wheat

Significantly maximum biological yield was recorded with SD1 (1520.2 g), followed by SD2 (915.8 g). Minimum was recorded with SD3 (496 g) (Table 2). Significantly, maximum biological yield was recorded with NR-499 (1286.8 g), followed by NR-505 (1177.6 g). Minimum was recorded with NR-529 (678.4 g).

Influence of 1000-grains weight of various genotypes of wheat sown under different sowing dates

Sowing dates greatly affected the 1000- grains weight of different genotypes of wheat. There were no significant differences were found between SD1 and SD2 however, minimum was analyzed with SD3 (27.93 g) (Table 3). Significant and maximum 1000 grains weight was recorded with NR-449 (37.11 g), followed by NR-499 (34.44 g). Minimum 1000 grains weight was recorded with NR-529 (23.44 g).

Different sowing dates affected yield of various genotypes of wheat

Varying sowing dates greatly affected yield of wheat. Maximum yield was recorded with SD1 (3969.8 kg/ha), followed by SD2 (2234.9 kg/ha), and minimum was recorded with SD3 (1363.8 kg/ha) respectively (Table 3, Fig. 1). Among genotypes, maximum yield was recorded with NR-449 (3937.5 kg/ha), followed by NR-499 (3188 kg/ha). Minimum was recorded NR-529 (1311.4 kg/ha) respectively (Table 3, Fig. 1).

Table 3 Yield and 1000-g weight response to different sowing dates and genotypes

Treatments	1000-grains weight	Yield (kg/ha)
Sowing dates		
SD1	30.600[a]	3969.8[a]
SD2	30.667[a]	2234.9[b]
SD3	27.933[b]	1363.8[c]
LSD value	1.5273	432.90
Genotypes		
NR-499	34.444[ab]	3188.0[ab]
NR-505	34.111[b]	3156.9[ab]
NR-514	32.889[b]	2717.2[bc]
NR-519	27.222[c]	2094.2[cde]
NR-529	23.444[d]	1311.4[e]
NR-449	37.111[a]	3937.5[a]
NR-443	27.000[c]	1844.4[de]
Pakistan-13	26.889[c]	2254.1[cd]
Borl-16	28.00[c]	2595.0[bcd]
Zincol-16	26.222[cd]	2129.8[cd]
LSD value	2.7884	790.35

Means sharing different letters differ significantly at 5 % level of significance.

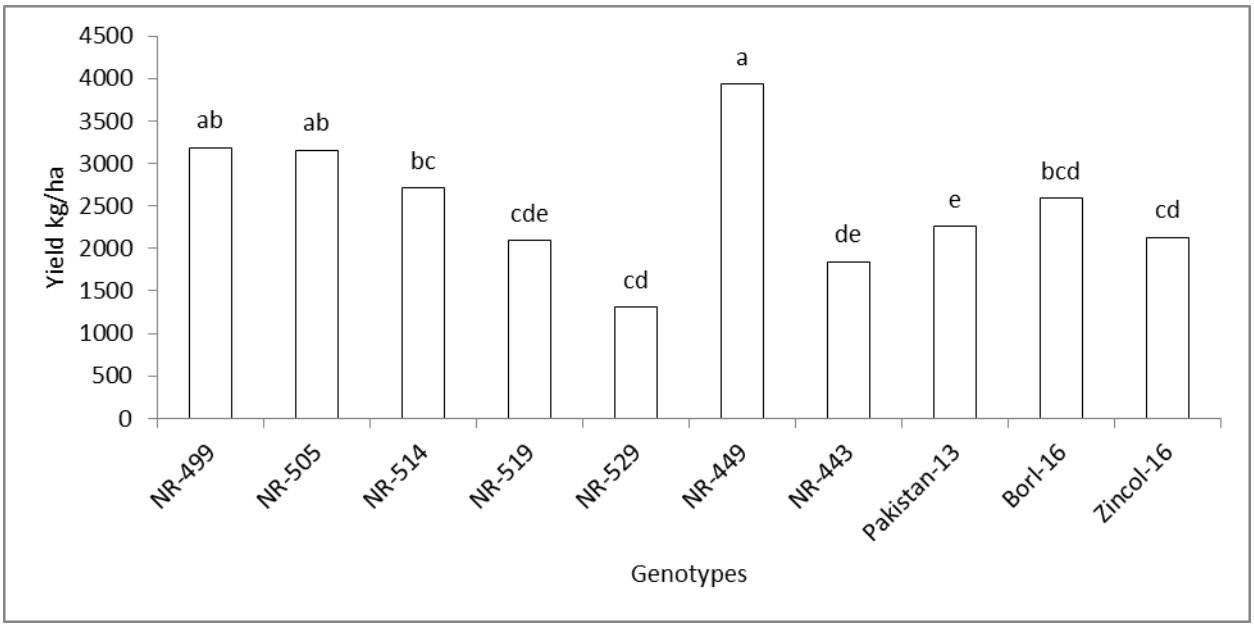

Fig. 1 Yield response of different genotypes of wheat

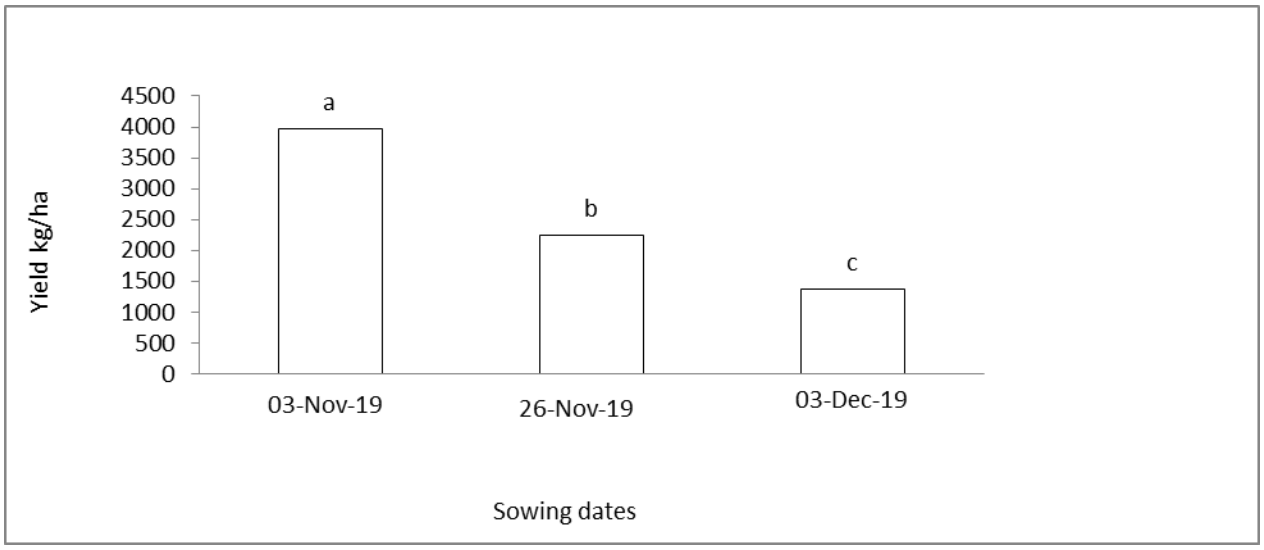

Fig. 2 Effect of different sowing dates on yield of wheat

Discussion

Optimum environmental conditions are prerequisite for attaining higher yield. It has been recognized from research that each variety has its specific requirements of temperature and light for flowering and development of grains (Haider, 2007; Aslani and Mehrvar, 2012). Razzaq et al. (1986a) documented that sowing dates highly affected emergence, growth and days to earing of wheat. However, emergence and number of days to earing for 15th November decreased with delayed planting to 15th December. Decrease rate of emergence of wheat is due to reduction in temperature on late sowing. Crop stand establishment and emergence is considerably affected from temperature (Hussain et al., 2012a). Cultivation of wheat under late sowing resulted in reduction in air and soil temperature causes decrease in emergence and crop stand establishment (Jame and Cutforth, 2004). It has been reported in various studies that elevated temperature affected emergence of crops (Hussain et al., 2012a; Shah et al., 2017).

Sowing of wheat form 25th October to 15th December reduced height of plant from 11-19 % (Basir et al., 2015). In late planting, height of plant decreased at high temperature and photoperiod ultimately reduces the growth cycle (Slafer and Rawson, 1994). Low temperature affected the germination and decreased no. of tillers in wheat. In late sowing high rate of seed is necessary for attaining maximum yield. In late planting, less degree days are available for tiller development and extra plant populations are needed for the compensation of smaller amount of tillers. It has been reported that timely sowing revealed in enhanced straw production of wheat and normally increased yield of grain in comparison with mid to late date of sowing (Donaldson et al. 2001). Jain et al. 1992 concluded that late sowing of wheat crop considerably decreased yield in all varieties in comparison with planted on December 20. Results are in accordance with the investigation of Naeem (2001), Sardana et al. (2002) and Singh et al. (2002) that various cultivars significantly exhibited different response of average grain weight of the crop.

Late planted crop decreased no. of tillers due to high temperature during the growth stage of tillering (Qasim et al., 2008; Hussain et al., 2012b; Tahir et al., 2019) and also decreased duration of grain filling at reproductive stage lead to reduction in enzyme activity and yield of crop (Wallwork et al., 1998; Barnabás et al., 2008; Hussain et al., 2012b). Difference in wheat yield of various varieties have been recorded planted under various sowing dates (Kelley, 2001; Tapley et al., 2013). Length of spike also decreased under late sowing due to high sensitivity of wheat crop to temperature and photoperiod (Slafer and Whitechurch, 2001). Reproductive tillers /unit area is an imperative yield determining factor of wheat crop. Due to long day plant, spikes are only to be developed while days turn into longer (Hatam, 1994). Plants of late planted crop can only produce flowers when proper photoperiod conditions exist. Late planted crop matures early in comparison with normal sown because of start of summer season. Therefore, crop establishment under late sown received lesser number of growing degree days, lead to reduction in yield of crop significantly (Lone et al., 1999). Delayed sowing of wheat reduced the germination of seed because of low temperature. Results of our experiment are in accordance with Razzaq et al. (1986b) revealed that delayed sowing resulted in reduced germination/m^2. Variation in germination% amongst genotypes can be recognized to genetic assortment (Aslam et al., 2003). Ultimately it can be inferred that delayed planted crop reduced in grain yield/hectare (Spink et al., 2000). Sowing of crop at proper time under favorable conditions increased growth and productivity of crop (ElGizawy, 2009). Maximum yield can be obtained when crop is sown earlier as it received extensive duration of grain filling in comparison with late sowing caused warmer environment reduced yield due to reduction in length of growing season (Miralles et al., 2001; Hussain et al., 2012b).

Late planted crop reduced length of spike due to rise in temperature while high plant population also reduced length of spike owing to increment in plant competition. Under late planting window, rise in temperature caused shorten the growing periods (Ahmad et al., 2018). Maximum LAI was recorded at 10th and 25th November sowing dates and decrease in late planting. Increased leaf area index was recorded as a result of conducive environmental conditions. Reduction in leaf area index was due to low temperature in the month of December and sown later established lower radiations at critical growth stages (Hussain et al., 2012a). Variable sowing dates highly affected the growth and development of crop however, photoperiod, temperature, and genetic composition of variety (Wollenweber et al., 2003; Howarth, 2005). Duration of crop steadily reduced under late planting from October 16th to March 15th because increased in temperature improved crop development process in comparison with normal temperature (Wahid et al., 2007; Rahman et al., 2009; Hakim et al., 2012). Wheat varieties under late sowing faced harsh temperature stress that considerably affected growth, phenology and lastly production (Hussain et al., 2012). Crop planted under late sowing reduced duration of crop lead to decreased weight of grain, size of grain, biological yield, harvest index and yield (Andarzian et al., 2014).

Conclusion

Experiment was carried to find the best sowing date for different genotypes and advance lines. Results of this study depicted that sowing on November 03 and after November 26 decreased yield and yield related attributes of all wheat varieties. Number of tillers and 1000-grain weight were most affected traits of wheat varieties due to sowing dates. However, yield of different varieties was variably affected mainly by number of tillers followed by biological yield under the influence of sowing dates. In conclusion, sowing on November 03 produced highest yield and number of tillers was critical yield determining component in response to sowing date.

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