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Performance of Yield and Other Agronomic Characters of Four Wheat (*Triticum aestivum* L.) Genotypes under Natural Heat Stress

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Abstract: Four wheat genotypes viz., CT-0231, CT-99187, Bakhtawar-92 and Saleem-2000 were planted at NIFA experimental field on four different planting dates in order to test their performance against heat stress. The influence of heat stress was studied on yield and some other agronomic characters viz., days to 50% emergence, days to 50% heading, days to 50% maturity, plant height (cm), Biological yield (kg ha^{-1}) grain yield (g/plot), grain yield (kg ha^{-1}), harvest index (%) and lodging percentage. A gradual decrease in all the parameters was observed as a result of the late planting dates except for number of days taken to 50% emergence which was increased for all the genotypes in correlation with late planting. However, increase in grain yield (g/plot), grain yield (kg ha^{-1}) and harvest index was observed for all the four genotypes at planting date 2. Which was considered to be the optimum sowing date for the genotypes under consideration

Key words: Wheat genotypes, different planting dates, heat stress

INTRODUCTION

Wheat is the world primer crop in regard to its antiquity, acreage and importance as an international item of food. At present total area under wheat cultivation is 8033.9 thousand hectare with annual yield 19183.3 tons and annual production of 2388 kg ha^{-1}[1]. This yield is far below to those of the leading wheat producing countries in the world (Table 1).

Table 1: Area production and yield of some world leading wheat-producing countries during 2002-2003

Countries	Area (ha)	Production (tones)	Yield (kg ha^{-1})
India	25000	69320	2773
China	22040	86100	3907
USA	21383	63590	2974
Russian Federation	22000	34030	1547
France	4909	30705	6255
Australia	12456	24078	1933
Canada	10467	23552	2250
Pakistan	8089	19210	2381
Turkey	9400	1900	2021

Source: Agriculture Statistics of Pakistan 2002-2003

Beside other constraints of low wheat yield in Pakistan, late planting associated with late or terminal heat stress is one of the main reason caused by late picking of cotton and late harvesting of sugarcane, rice and maize crop in different agro climatic zones of Pakistan. Numerous other factors as lack and untimely availability of irrigation water, farm machinery (tractors, seed drills etc.) fertilisers and any rain after harvesting of the preceding crop (sugarcane, rice, cotton etc.) may further delay wheat sowing[2].

Terminal or late heat stress especially during anthesis and grain feeling stage of the late planted wheat is considered one of the major environmental factors drastically reducing wheat production throughout most of the wheat growing areas in different agro-ecologies of the country[3].

The effects of late heat stress on yield and other growth parameters have been widely reported. The obvious effects of high temperatures on wheat growth include reduced crop stand, shorter life cycle, reduced tillering, lesser biomass production, reduced head size, reduced number of grains/spike, lower grain weight, lower test weight and ultimately reduced grain yield[4]. In Pakistan, wheat yields are quite sensitive to late planting because the late planted wheat is exposed to high temperature in the later part of the growth cycle, generally from flowering to maturity[5]. With shortening of the growth period, the late sown wheat crop is severely damaged by high temperature at reproductive and grain filling stages forcing premature ripening and thus resulting in substantial yield loss and grain quality deterioration[6-8]. Khan[9] reported a yield loss of 42 kg ha^{-1} per day or 1% loss per day if planting is delayed from 10th November until 10th January. Genetic variability regarding tolerance to high temperature does exist among existing wheat germplasm. Kanani and Jadon[10] assessed 110 genotypes of bread wheat in India and found 18 genotypes including Hindi-62, C-306, K-65 and NP-876 to be suitable for growing under high temperature.

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Hue and Rajaram[11] studied 16 bread wheat genotypes for two years in the late planting and one year under normal planting at Ciudad, Obregon, Sonora. They concluded that grains/spike, biomass, harvest index and test weight could be considered potential selection criteria for grain yield under high temperature.

In light of the yield losses and low grain quality caused by heat stress in wheat as a result of late planting, the present study was organized in order to select genotypes best studied for heat stress, under late planting conditions.

MATERIALS AND METHODS

A field experimental was conducted at NIFA experimental field Tarnab, Peshawar during rabi 2003-2004. Four wheat genotypes viz., CT-00231, CT-99187, Bakhtawr-92 and saleem-2000 were planted at four different sowing dates (10-11-2003, 21-11-2003, 08-12-2003 and 22-12-2003) in four replications using split plot design with main plots for sowing dates and sub plots for genotypes. Thirty grams seeds were planted in four rows per entry with plot size of 2.5x1.2 = 3 m^2. For data recording of different parameters as days to emergence, days to maturity, plant height, days to heading and 1000 grain weight; ten plants at random were selected from each sub plot. For recording biological yield, grain yield (kg ha^{-1}) and 1000 grain weight, two central rows of each sub plot were separately harvested. The recorded data were statistically analyzed using computer software MSTAT-C. For significant F ratios, New Duncan's Multiple Range Test (DMRT)[12] was applied for comparison among the treatment means.

RESULTS AND DISCUSSION

Days to 50% emergence: A gradual increase in the number of days to 50% emergence was observed for all the genotypes, in association with delay in sowing. The mean values regarding days to emergence ranged from 8.3-15.0. Maximum increase (87.5%) in days to emergence was observed for CT-99187, CT-00231 and Saleem-2000 while minimum increase (72.2%) was observed for Bakhtawar-92 (Table 2). The present results resemble to those of Micanovic[13] who investigated effects of sowing date on several growth parameters in wheat including days to emergence and found that emergence was delayed with late sowing. In general, number of days to emergence was increased for all the genotypes with late sowing. Highly significant differences in the mean values for days to emergence were observed due to sowing dates and genotypes whereas, non significant differences were observed due to interaction between sowing dates and genotypes (Table 3).

Days to 50% heading: In general, decrease in days to 50% heading was observed for all the genotypes with delay in sowing (Table 2). The mean values for days to 50% heading were ranged between 90.8-118.5, 91.8-119, 91.5-120.3 and 91.3-120.3 for CT-00231, CT-99187, B-92 and Saleem-2000, respectively (Table 2). Highly significant differences in the mean values for the character under consideration were observed as a result of sowing dates as well as genotypes. Whereas, non-significant differences in the mean values for the character was observed due to interaction between sowing dates and genotypes (Table 3). The present results are in agreement with those of Yadav and Singh[14] who also found decrease in days to heading associated with late sowing.

Days to maturity: A gradual decrease in days to maturity was observed when sowing was delayed. The range between the mean values for the character was 156.8-128.8, 155.5-128.5, 158.5-128.8 and 157.5-129.5 for CT-00231, CT-99187, B-92 and Saleem-2000, respectively (Table 2). Whereas, the percent decrease in days to maturity for the genotypes was observed to be 18, 17, 19 and 18%, respectively. Highly significant differences in the mean values for days to maturity were observed because of sowing dates as well as the genotypes whereas, the differences in the mean values for interaction between sowing dates and the Genotypes were significant (Table 3). The present results coincide with those of Begum and Saifuzzaman[15] who also found enhancement in physiological maturity with delay in sowing. The encasement in physiological maturity was brought by the late heat stress caused by late sowing.

Plant height (cm): It is evident from Table 3 that mean values for plant height were decreased for all the genotypes as a result of late sowing. The range between the mean values was 122.7-106.5, 110.3-100, 97.2-80.31 and 99.5-83.4 whereas, the percent decrease in plant height was observed as 13, 9, 17 and 16%, respectively (Table 2). Highly significant differences in the mean values were observed due to sowing dates as well as due to the genotypes whereas, the differences for interaction between sowing dates and genotypes were significant (Table 3). Yadav *et al.*[16] also found decrease in plant height with late sowing. It seems to be caused mainly by shortening of life cycle as a result of terminal heat stress associated with late planting.

Biological yield (kg/plot): The biological yield (kg/plot) for all the genotypes was reduced with late sowing. The range in the mean values for biological yield was 2.30-01.17, 2.10-1.65, 2.25-1.83 and 1.83-1.80 while the percent decrease in the character was 24.8, 21.4, 18.7 and

Table 2: Effects of various sowing dates on different parameters of four wheat genotypes

Characters	Genotypes	Sowing dates 10-11-2003	21-11-2003	08-12-2003	22-12-2003	Mean	Range	% increase	% decrease
Days to 50% emergence	CT-00231	8	11	9.8	14.8	10.9B	08-14.8	85.0	0.0
	CT-99187	8	12	10.5	15	11.4B	08-15	87.5	0.0
	Bakhtawar-92	9	13.3	11	15.5	12.2A	09-15.5	72.2	0.0
	Saleem-2000	8	12.8	10	14.8	11.4B	08-14.8	85.0	0.0
	Mean	8.3D	12.3B	10.3C	15.0A	----	8.3-15	80.7	0.0
Days to 50% heading	CT-00231	118.5	110.5	99.8	90.8	104.9B	90.8-118.5	30.5	0.0
	CT-99187	119.0	111.3	100.8	91.8	105.7A	91.8-119	29.6	0.0
	Bakhtawar-92	120.3	111.5	100.5	91.5	105.9A	91.5-120.3	31.5	0.0
	Saleem-2000	120.3	111.5	100.5	91.3	105.9A	91.3-120.3	31.8	0.0
	Mean	119.5A	111.2B	100.4C	91.3D	----	91.3-119.5	30.9	0.0
Days to 50% maturity	CT-00231	156.8BC	148.0D	136.8E	128.8F	142.6A	156.8-128.8	0.0	17.9
	CT-99187	155.5C	146.5D	136.5E	128.5F	141.8B	156-129	0.0	17.3
	Bakhtawar-92	158.5A	147.5D	137.5E	128.8F	143.1A	158-128	0.0	19.0
	Saleem-2000	157.5AB	147.0D	137.8E	129.5F	142.9A	157-129	0.0	17.8
	Mean	157.1A	147.3B	137.1C	128.9D	----	157-129	0.0	17.8
Plant height (cm)	CT-00231	122.7A	112.4B	104.8DE	106.5CD	111.6A	122-106	0.0	13.1
	CT-99187	110.3BC	101.3EF	99.6EF	100.0EF	102.8B	110-100	0.0	9.1
	Bakhtawar-92	97.2F	86.0GH	84.4HI	80.3I	87.0D	97-80	0.0	17.5
	Saleem-2000	99.5EF	90.8G	85.4HI	83.4HI	89.8C	100-83	0.0	17.0
	Mean	107.4A	97.6B	93.5C	92.5C	----	107-93	0.0	13.1
Biological yield (kg/plot)	CT-00231	118.5	110.5	99.8	90.8	118.5	2.30-1.73	0.0	24.8
	CT-99187	119.0	111.3	100.8	91.8	119.0	2.10-1.65	0.0	21.4
	Bakhtawar-92	120.3	111.5	100.5	91.5	120.3	2.25-1.83	0.0	18.7
	Saleem-2000	120.3	111.5	100.5	91.3	120.3	1.83-1.80	0.0	1.6
	Mean	2.12A	2.08A	2.02A	1.75B	-----	2.12-1.75	0.0	17.5
Grain yield (kg/ha)	CT-00231	4383.5	5299.8	4150	3900	4433.3	4383.-3900	0.0	11.0
	CT-99187	4200	4533.3	4200	4516.8	4362.5	4516.-4200	0.0	7.0
	Bakhtawar-92	4983.3	4483.3	4416.8	4333.5	4554.2	4983-4333	0.0	13.0
	Saleem-2000	3933.3	4900	4700.3	4100	4408.4	3933-4100	4.2	0.0
	Mean	4375	4804.1	4366.8	4212.6	----	4804-4213	0.0	12.3
Harvest index (%)	CT-00231	28.50	34.42	28.83	33.97	31.43	28.5-33.97	19.2	0.0
	CT-99187	30.13	34.58	31.25	41.03	34.24	30.13-41.0	36.1	0.0
	Bakhtawar-92	33.25	35.75	34.50	35.70	34.80	33.25-35.7	7.4	0.0
	Saleem-2000	32.47	35.15	36.00	34.20	34.46	32.47-34.2	5.3	0.0
	Mean	31.09A	34.97A	32.64A	36.22A	----	31.9-37.97	19.0	0.0
Lodging percentage at maturity	CT-00231	70.0A	25.0BC	27.5BC	15.0C	34.4A	70-15	0.0	78.6
	CT-99187	70.0A	15.0C	32.5ABC	12.5C	32.5A	70-12.5	0.0	82.1
	Bakhtawar-92	25.0BC	5.0C	20.0BC	2.5C	13.1B	25.0-2.5	0.0	90.0
	Saleem-2000	67.5A	0.0C	60.0AB	10.0C	34.4A	67.5-10	0.0	85.2
	Mean	58.1A	11.3AB	35.0AB	10.0B	----	58.8-10.0	0.0	83.0

Means sharing same alphabets are not significantly different according to DMRT. Capital alphabets represent significance at 5% level of probability

Table 3: Mean square values of analysis of variance (ANOVA) for various plant characters in wheat genotypes planted at different sowing dates

S.O.V	D.F	Days to emergence	Days to heading	Days to maturity	Plant height (cm)	Biological yield (kg/plot)	Grain yield (kg/ha)	Harvest index (%)	Lodging percentage at maturity
Replication	3	0.224	1.063	0.641	6.605	0.099	722414	3.567	876.56
Dates (A)	3	132.141^{HS}	2431.27^{HS}	2395.3^{HS}	735.58^{HS}	0.444^{HS}	1033915^{NS}	85.001^{NS}	8318.23^{HS}
Error (a)	9	0.168	3.160	3.863	8.85	0.054	457561	28.27	1140.45
Genotypes (B)	3	4.724^{HS}	3.854^{HS}	5.599^{HS}	2116.6^{HS}	0.156^{S}	107142^{NS}	38.91^{NS}	1714.06^{HS}
(AXB)	9	0.613^{NS}	0.563^{NS}	1.543^{S}	14.28^{S}	0.087^{NS}	601178^{NS}	22.29^{NS}	689.06^{NS}
Error (b)	36	0.377	0.316	0.668	6.67	0.054	384910	20.13	366.15
Total	63	138.247	2440.226	2407.614	2888.58	0.45	3307120	198.168	13104.51

^{S} = Significant at 5% level of probability, ^{HS} = Significant at 1% level of probability, ^{NS} = Non-significant

1.6% for CT-00231, CT-99187, B-92 and Saleem-2000, respectively (Table 2). Highly significant differences in the mean values were observed as a result of different sowing dates as well as genotypes. However, the differences in the mean values because of interaction between sowing dates and genotypes were non-significant (Table 3). Since biological yield is directly correlated with the grain yield, therefore, the present results in regard to biological yield are in support to those of Reynolds *et al.*[6] and Midmore *et al.*[7] who also found reduction in grain yield as a result of the terminal heat stress associated with late sowing.

Grain yield (kg ha^{-1}): Mean values regarding grain yield reveal that yield of all the genotypes was increase when planted on 21st October except for B-92 which was decreased by 10% in comparison to that of early planting data (10th October). It reveals that 21st October is the optimum sowing date for all the genotypes except B-92 and the range between the mean values regarding grain yield was recorded to be 4338-3900, 4516-4200, 4983-4333 and 3933-4100 in comparison between early sowing date 10th October and late sowing date 22nd December for CT-0231, CT-99187, B-92 and Saleem-2000, respectively. The percent decrease in grain yield was 11, 07 and 13 for CT-0231 and B-92, respectively while the percent increase in grain yield was recorded as 4.2 for Saleem-2000, only Table 2. In general, grain yield was declined with delay in sowing. Non-significant differences in the mean values for grain yield were observed due to sowing dates, genotypes and interaction between genotypes and sowing dates (Table 3). Loss of grain yield due to late sowing has also been reported by Cooper[17] and Naik *et al.*[18].

Harvest index: In general, mean values regarding harvest index were gradually increased for all the genotypes as a results of late sowing. Maximum increase in harvest index was observed for all the genotypes when sown on 21st October which is seemed to be the optimum sowing date for all the genotypes. The range between the mean values for harvest index was 28.5-33.97, 30.13-41.0, 33.25-35.7 and 32.47-34.20 whereas, the percent increase was 19.2, 36.1, 7.4 and 5.3% for CT-00231, CT-99187, B-92 and Saleem-2000, respectively (Table 2). Non-significant differences in the mean values were found as a result of dates of sowing, genotypes and interaction between dates and genotypes (Table 3).

Lodging percentage: Mean values regarding lodging percentage were decreased in association with late sowing. It was probably because of the decrease in plant height in correlation with late sowing. However, maximum decrease in lodging percentage for all the genotypes was observed when they were sown on 21st October (Table 2). Highly significant differences in the mean values for lodging percentage were observed as a result of sowing dates as well as genotypes whereas, the differences in the mean values for interaction between different sowing dates and genotypes were significant (Table 3).

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