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AGRONOMIC EVALUATION OF DIFFERENT BREAD WHEAT (*TRITICUM AESTIVUM* L.) GENOTYPES FOR TERMINAL HEAT STRESS

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Abstract

A field experiment was conducted at Nuclear Institute for Food and Agriculture (NIFA), Peshawar, to identify high yielding bread wheat genotypes against terminal heat stress in the central agro ecological zone of NWFP. The genotypes included in the trial were selected on the basis of yield performance and other agronomic characters under normal and late planting conditions from NIFA Observation Nursery (NON) sown during 2001-2002. For the confirmation of their desired traits the selected genotypes were again planted under the same sowing conditions during 2002-2003 using two different sowing dates as a separate factor. Statistical analysis of the data revealed that significant differences in days to heading, days to maturity, plant height, biological yield, spikes per m^2, 1000 grain weight (g), grain yield kg ha^{-1} and hectolitre weight (kg) were observed for all the genotypes with respect to early and late sowing dates. The results indicated that the overall performance of the genotypes was the best with respect to normal sowing. Though all the characters were negatively affected as a result of late sowing yet the genotypes CT-01217, CT-01222 and CT-01085 with grain yield of 4745, 4334 and 4334 kg ha^{-1} respectively performed well with respect to harvest index (40.5, 31.0 and 36.5%) and medium plant height character (89, 92 and 91 cm) as compared to those of the best check line (Bakhtawar-92) which is an indication that some bread wheat genotypes among existing germplasm may have in built resistance/tolerance against terminal heat stress under late planting condition.

Introduction

Wheat is an important cereal all over the world and our country Pakistan as well. It is a staple food on world level and is used in the form of different products. It accounts for more than 80% area and production of all the cereals grown in the country. The area grown under wheat in the country is estimated to be about 8.494 million hectares with an annual production of 23.52 million tonnes (Anon., 2006-2007). The demand for wheat due to overwhelming increase in the population has been raised than the previous. The per capita availability of wheat is 137.02 kg/annum which is too low to meet the requirement of the population increasing at the rate of 2.1% annually. In order to meet the demand for food within the country we need to increase the production at least by 04% in accordance with the population growth rate.

Wheat is recommended to be sown in late October or early November. Though timely sowing of wheat is a prime condition to achieve the maximum yield per hectare yet there are several constraints (viz., delay in rain fall, unavailability of irrigation water and machinery at proper time, sowing of wheat after sugarcane and rice crop etc.) which prevent timely sowing of the crop. Apart from other biotic and abiotic stresses responsible for low wheat productivity in the province, terminal or late heat stress during the grain filling period of the normal as well as late planted wheat is also considered one of the major environmental factors drastically reducing wheat production in most of the wheat growing areas under different agro-ecologies of the country including NWFP (Subhan *et al.,* 2004). This situation is definitely responsible for low yield per hectare. Any delay in wheat sowing beyond third week of November has been reported to result in a yield reduction of 35-45kg/ha per day. A loss up to 10 million tones per annum has been reported because of late sowing of the crop. High temperatures during the later phases of wheat development and particularly since the beginning of heading and after anthesis (terminal or late heat stress) are thus considered as an important factor limiting wheat production in different wheat growing areas of Pakistan. Increased heat tolerance in late planted wheat is very essential to enhance and stabilize wheat productivity in the country. Breeding for selecting genotypes with increased heat tolerance is therefore, one of the most vital objectives in wheat improvement programme.

In order to compensate yield losses in wheat caused by late sowing, breeders are searching wheat genotypes that have increased heat tolerance under late planting condition (Reynolds *et al*., 1998; Irfaq *et al*., 2005). The present study was carried out in order to select genotypes among the existing wheat germplasm with in built resistance/tolerance to terminal heat stress associated with late planting so as to utilize them for development of high yielding, widely adapted and good quality varieties suitable for cultivation under late planting conditions in NWFP and elsewhere in the country.

Materials and Methods

Field experiment was conducted at experimental field of Nuclear Institute for food and Agriculture (NIFA), Tarnab Peshawar during 2002-2003 in order to study the effect of early and late sowing on the performance of wheat genotypes. The objectives of the study was to select genotypes with tolerance to possible terminal heat stress caused by late sowing in the wheat growing regions of NWFP, Pakistan. Based on high yield performance and other agronomic characters viz., days to maturity, Plant height (cm), Biological yield, (kg ha^{-1}), Spikes / m^2, 1000 Grain weight (g) and Grain yield (kg ha^{-1}), out of 134 nineteen promising wheat genotypes were selected from NIFA wheat observation nursery during 2001-2002 including Bakhtawar-92 as check cultivar (Table 1). The nursery was initially introduced as International Bread Wheat Screening Nursery (IBWSN) from CIMMYT, Mexico in 2000-2001. Table 1 represents yield performance and other agronomic traits of 18 different wheat genotypes selected from 134 lines of NIFA Wheat Observation Nursery during 2001-2002. The selected genotypes were re-evaluated in the replicated yield trial with a plot size of 3 m^2 per entry for the confirmation of their desired traits during 2002-2003. Using randomized complete block design the material was planted in three replications on two different sowing dates with a gap of 33 days i.e., 17-11-2002 and 20-12-2002. The sowing dates were used as a factor.

The test genotypes, viz., CT-01001, CT01004, CT01008, CT-01030, CT-01073, CT-01079, CT-01084, CT-01085, CT-01163, CT-01183, CT-01217, CT-01222, CT-01239, CT-01244, CT-01250, CT-01264, CT-01354 and CT-01382 were used as a second factor. The meteorological data regarding average rain fall (mm), monthly minimum and maximum temperature and intensity of solar radiation (Ca m^{-2}) were obtained from Agriculture Research Institute Tarnab, Peshawar.

Table 1. Yield performance and other agronomic characters of top 18 genotypes under normal (N) and late (L) sowing condition during 2001-2002 in comparison to Bakhtawar-92 (check).

S.No.	Genotype	Days to heading			Days to maturity			Plant height (cm)			Biological yield (g/plot)			Harvest index			1000-Grain weight			Spikes/m^2			Grain yield (kg/ha)			Hectolitre weight (kg)		
		N	L	Mean	N	L	Mean	N	L	Mean	N	L	Mean	N	L	Mean	N	L	Mean	N	L	Mean	N	L	Mean	N	L	Mean
1.	CT-01073	120	105	112	159	142	151	75	68	71	2.3	1.3	75	28.7	30.6	29.7	37	38	37	456	211	333	6022	2133	4078	71	72	71
2.	CT-01264	123	108	116	161	141	151	82	75	79	2.1	1.5	82	15.9	29.8	22.9	43	36	39	273	198	236	4311	2356	3333	71	73	72
3.	CT-01084	122	105	114	160	141	151	99	92	96	2.9	1.3	99	31.3	52.2	41.8	38	33	36	506	273	390	5956	2711	4333	70	73	72
4.	CT-01085	121	104	113	159	143	151	96	89	93	2.8	1.1	96	22.6	37.8	30.2	41	40	40	466	231	349	5778	3044	4411	73	67	70
5.	CT01008	118	104	111	159	143	151	81	74	77	2.5	1.4	81	31.9	37.3	34.6	35	33	34	527	216	371	5956	2267	4111	74	75	74
6.	CT-01244	122	107	115	162	142	152	84	82	83	2.7	1.1	84	29.2	39.7	36.5	35	30	32	501	268	384	5911	2267	4089	73	70	72
7.	Bakhtawar-92	127	108	118	163	143	153	89	82	85	3.1	1.3	89	31.4	52.8	42.1	35	32	34	577	261	419	5867	2422	4144	73	75	74
8.	CT-01079	121	105	113	159	144	151	96	89	92	2.7	1.7	96	29.2	39.7	34.5	38	40	39	417	211	314	5778	1978	3878	68	69	69
9.	CT-01239	122	104	113	158	141	149	75	74	75	1.7	1.3	75	29.2	33	31.8	37	30	34	312	307	310	5667	3311	4489	73	75	74
10.	CT01004	121	105	113	159	143	151	85	78	81	2.8	1.2	85	30.6	28	27.5	33	33	33	452	197	325	5644	2267	3956	73	75	74
11.	CT-01183	122	105	114	160	142	151	88	81	85	2.5	1.3	88	26.9	33.3	33.1	32	37	35	446	261	353	5111	2933	4022	73	74	73
12.	CT-01163	120	105	113	159	144	151	77	70	74	2.5	1.1	77	32.9	34.6	31.6	40	29	35	566	341	453	5644	2867	4256	74	77	76
13.	CT-01001	120	106	113	161	142	152	86	79	82	2.5	1.3	86	28.8	46.7	38.5	38	37	38	420	198	309	5578	2067	3822	71	73	72
14.	CT-01354	123	106	114	160	143	152	84	77	81	2.5	1.6	84	30.3	30.7	29	31	33	32	477	316	396	5644	5644	5644	69	72	70
15.	CT-01030	118	104	111	157	143	150	79	72	75	2.4	1.4	79	27.2	33.7	29.6	40	31	35	421	236	329	5600	2489	4044	72	73	73
16.	CT-01250	123	104	114	163	142	153	86	79	83	2.5	1.4	86	25.5	29.5	25.6	34	32	33	558	267	413	5756	3133	4444	72	73	72
17.	CT-01217	125	108	117	163	143	153	79	72	75	2.4	1.1	79	21.8	44.7	37.6	35	41	38	449	171	310	5111	2600	3856	70	73	71
18.	CT-01382	125	105	115	162	142	152	89	75	82	2.6	1.6	89	30.5	31.1	27.1	32	33	33	543	316	430	5689	5689	5689	71	75	73
19.	CT-01222	119	103	111	159	143	151	68	61	64	2.2	1.0	68	23	27.4	26.3	35	33	34	469	158	314	4800	1778	3289	74	76	75

Mean values of different characters under normal (N) and late (L) sowing condition and their averages: the basis of selection of the genotypes from NIFA observation Nursery (2001-2002).

Data regarding days to heading, days to maturity, plant height (cm), biological yield, (kg ha^{-1}), spikes m^{-2}, 1000 grain weight (g), grain yield (kg ha^{-1}) and hectolitre weight (kg) were recorded and statistically analyzed using MSTATE-C software. For significant F-ratios, New Duncan's multiple range test (DMRT) was applied for comparison among the treatment means.

Results and Discussion

Figures 1, 2 and 3 represent meteorological data regarding average rain fall (mm), monthly maximum and minimum temperature and intensity of solar radiation (Ca m^{-2}). It is evident from Fig. 2 that the average minimum and maximum monthly temperatures are approximately in the same range in both the cropping seasons. However, maximum rain fall was recorded for 2002-2003 especially in the month of Feb, 2003 (Fig. 1). As a result the intensity of solar radiation remained slightly low during 2002-2003 as compared to rabi 2001-2002 (Fig. 1).

Days to heading: Highly significant differences in the mean values were observed for all the genotypes under the influence of different sowing dates, within the same dates as well as among different genotypes. The average values of both normal and late sowing conditions, Table 1 and Table 2 reveal that minimum days to heading were recorded for CT-01222, CT-01217 and CT-01008 (110, 111 and 111 respectively) representing earliness of the genotypes where as maximum days to heading were recorded for the genotypes CT-01250, CT-01030 and CT-01079 (118, 117 and 116 respectively). The data of the previous year regarding the character under consideration are in harmony to those of the final year (Table 1)

Highly significant differences in the mean values were observed for all the genotypes as a result of the interaction between genotypes and sowing dates (Table 2). The present findings are in agreement to Irfaq *et al*., (2005) which ratify the result that reduction in days to maturity in association with late sowing is the cause of terminal heat stress. In general all the genotypes took more days to heading under normal sowing as compared to those of late sowing.

Days to maturity: The mean values for all the genotypes with respect to days to maturity differed from one another under the influence of both the sowing dates (Table 1 and Table 2). Highly significant difference in the mean values for the character under consideration was observed as a result of the genotypes, different sowing dates and interaction between genotypes and dates (Table 2). Differences in the mean values for the genotypes were highly significant under the influence of normal sowing date (Table 3), whereas non-significant differences in the mean values were there under late sowing condition. Based on the average values of normal and late sowing, Table 1 and Table 2 reveal that minimum days to maturity were recorded for CT-01264, CT-01008 and CT-01382 (147, 149 and 150 respectively) representing earliness of the genotypes where as maximum days to maturity were recorded for the genotypes CT-01250, CT-01079 and CT-01183 (153, 153 and 152 respectively). The data of both the years regarding the character under consideration again reveal harmony for all the genotypes (Table 1 and 2). Generally, the duration required for days to maturity was reduced for all genotypes under late sowing condition as compared to that of normal sowing. The results coincide with those of Jain *et al*., (1992) who also recorded short duration to maturity for different wheat genotypes in response to late sowing under irrigated condition.

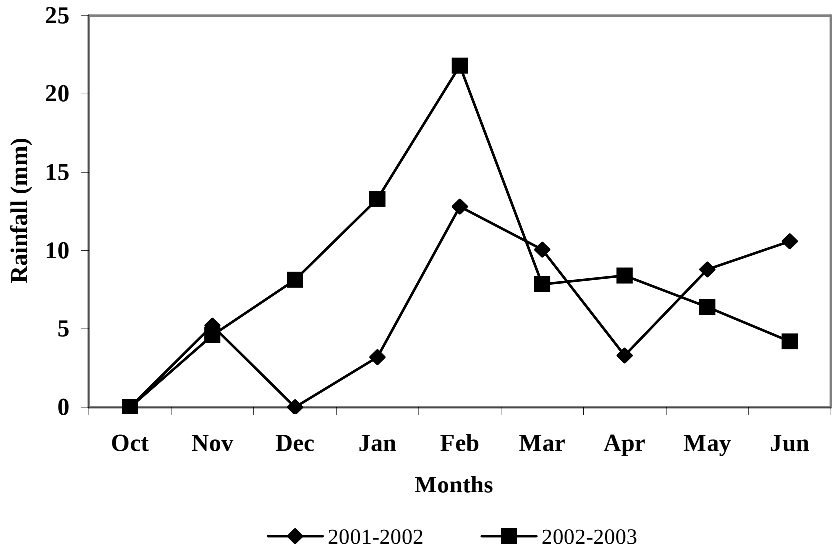

Fig. 1. Average rainfall during 2001- 2002 and 2002–2003.

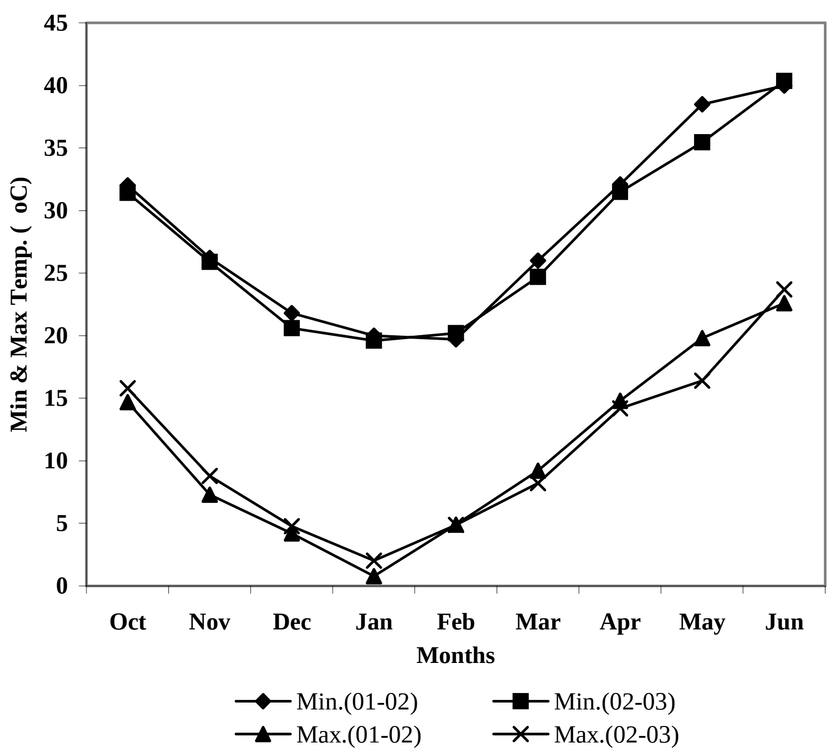

Fig. 2. Average minimum and maximum temperature during 2001- 2002 and 2002 – 2003.

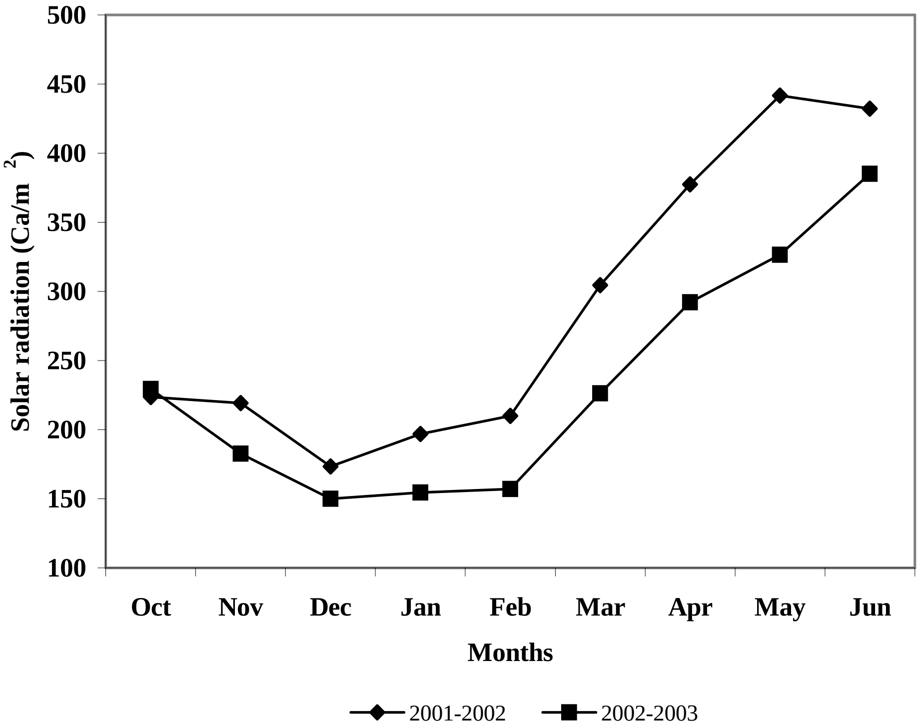

Fig. 3. Average monthly intensity (Ca/ m^2) of solar radiation during 2001-2002 and 2002–2003.

Plant height (cm): The genotypes CT-01163, CT-01073 and CT-01085 showed maximum plant height of 91, 92 and 93 cm whereas minimum plant height of 147, 149 and 151 cm was recorded for genotypes CT-01264, CT-01008 and CT-01222 respectively (Table 2). The character under consideration was adversely affected by late sowing (Table 1). Highly significant differences in the mean values for plant height were observed as a result of genotypes as well as interaction of different sowing dates (Table 3). Non-significant differences in the mean values were observed as a result of the interaction between genotypes and dates. However, it is evident from Table 1 and Table 2 that genotypes with tall stature took more time to heading as well as maturity. It is a clue towards the fact that there exist genetic relationship between plant height and duration to heading and maturity. The present results are in agreement with those of Shazad *et al*., (2002) and Irfaq *et al*., (2005) who also observed reduction in plant height of different wheat genotypes as a result of late sowing. The decrease in plant height must have been occurred due to shortness in growth period as well as photosynthetic period because of terminal heat stress in association with late sowing.

Biological yield: Maximum biological yield of 2.3, 2.13 and 2.18 kg/plot was recorded for Ct-01001, CT-01163 and CT-01073 whereas minimum biological yield of 1.65, 1.6 and 1.7 kg/plot was recorded for CT-01079, CT-01264 and CT-01239 respectively (Table 2). The average values regarding biological yield (Tables 1 and 2) indicate that reduction in the Biological yield occurred for all the cultivars as a result of late sowing (Subhan *et al*., 2004). Non-significant differences in the mean values were observed for all the genotypes under same date of sowing (Tables 1, 2). Based on combined analysis for both normal and late planting conditions, the differences in the mean values for biological yield were non-significant because of the genotypes as well as interaction between genotypes and dates. However, significant differences were observed as a result of different sowing dates (Table 3). Maximum and minimum biological yield was observed by genotypes CT-01073 and CT-01079 respectively (Table 2). In general, biological yield of all the genotypes was decreased under late sowing conditions. The results are in agreement with those of Gibson & Paulsen, (1999).

Spikes/m^2: Reduced number of tillers of 280, 290, 309 and 324 was recorded for CT-01079, CT-01001, CT-01008 and CT-01239 whereas maximum number of tillers of 400, 398 and 392 was recorded for genotypes CT-01183, CT-01222 and CT-01004 respectively (Table 2). Pronounced negative effect of late sowing was observed on number of spikes/m^2 for all the genotypes (Table 1 and Table 2). Increased numbers of spikes were observed for genotype CT-01183 whereas very small number of spikes was observed for genotype CT-01001 under late planting condition (Table 2). The present results with respect to No. of spikes/m^2 are in ratification to those presented by Ansary *et al*., (1989) and Shahzad *et al*., (2002) who also found reduction in spikes/m^2 with delay in sowing. According to combined analysis under both normal and late sowing conditions, non-significant differences in the mean values for the character was observed because of the genotypes and interaction b/w genotypes and sowing dates (Table 2). The combined analysis as well as both normal and late sowing showed highly significant differences in the mean values because of different genotypes (Tables 2 and Table 3). Generally late sowing was observed to be associated with reduced number of spikes/m^2

Harvest index (%): In general, mean values regarding harvest indices were gradually increased for all the genotypes as a results of late sowing. Maximum harvest index of 44.1, 43.8 and 40.5% was recorded for the Genotypes CT-01354, CT-01382 and CT-01217 respectively. The results with respect to harvest index of the previous year are in harmony to those of the last year (Tables 1 and Table 2) and according to those of Irfaq *et al.*, 2005. Non-significant differences in the mean values were observed as a result of genotypes and sowing dates whereas significant differences were found due to interaction between dates and genotypes (Table 3).

1000 grain weight (gm): All the genotypes were negatively affected as a result of late sowing regarding 1000-grain wt. (Tables 1 and 2). Genotypes CT-1085, CT-01244, CT-01163 and CT-01183 showed highest 1000 wt. of 39, 38, 36 and 35 grams respectively than check variety B-92 (34 grams) under normal sowing condition as well as under average between normal and late sowing dates (Tables 1 and 2). However, all the cultivars showed decrease in 1000 grain weight as a result of late sowing. It is evidente from the first two tables that all the genotypes responded in similar way for 1000- grain weight in both years. Al-Khatib & Paulsen (1984) urged that loss in grain weight occurs as a result of the injury caused by high temperature during the grain development period. Calderini *et al.*, (1999) & Wardlaw. 2002 have suggested that reduction in grain weight is caused by high temperature during pre and post anthesis under field condition.

Table 2. Effects of different sowing dates days to heading, days to maturity, plant height, biological yield, spikes per meter^2, number of tillers/plant, 1000 grain weight, grain yield kg/ha and hectoliter weight (kg) on different wheat genotypes (2002-2003).

Characters		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
		CT-01244	CT-01079	CT-01382	CT-01073	CT-01163	CT-01084	CT-01354	CT-01085	CT-01030	CT-01004	CT-01250	CT-01183	CT-01217	CT-01222	CT-01008	CT-01264	CT-01239	CT-01001	B-92
Days to heading	Normal	120hij	125.3abc	120.7fgh	121fgh	123.7cde	122efgh	118.3ijk	122.3 efg	125.3abc	124.7bc	127.3a	120ghi	118jk	117k	117.3k	118k	122efg	123def	126ab
	Late	106bc	108.3a	106bc	105bcd	106.3 b	106bc	104.3cd	105.3bcd	109a	108.7a	109.3a	106b	104cd	104d	105bcd	111e	105bcd	105bcd	108a
	Average	113i	116.8 l	113.4fg	113fg	115i	114j	111.3fg	113.8	117.15k	116.7 l	118.3lm	113i	111fg	110.5ef	111.15g	114.5jk	113.5hi	114j	117kl
Days to maturity	Normal	161abc	163a	158fgh	159def	162.3ab	158.3efg	159def	160cdef	160.7bc	161.3ab	163.3 a	160cde	160cde	158ghi	156i	143abc	160cde	161bcd	163a
	Late	142bcd	142bcd	141cd	143abc	144.3a	143.7abc	142.7abc	143.3abc	144ab	142abc	142.7abc	143abc	142abc	143abc	141d	150efg	143abc	143abc	143abc
	Average	152bcd	153cde	150ab	151abc	153cde	151abc	151abc	152 bcd	152bcd	152bcd	153cde	152bcd	151abc	151abc	149ab	147a	152bcd	152bcd	153cde
Plant height (cm)	Normal	95cdef	96bcd	95bcde	98abcd	99.80ab	92.93efg	92.67efg	96.9bcd	90.9fgh	81.47i	89.27gh	95def	95cdef	99abc	94def	79fgh	87gh	86.67h	101a
	Late	86abcd	86abcd	86abcd	85bcde	87.13ab	80.20cde	80.87bcd	85.27abc	76.80gh	78.80efg	79.4def	83abc	82abcd	85abc	80cdef	87defg	85abc	74h	88a
	Average	91ijk	91ijk	91ijk	92klm	93lmn	87def	87def	91ijk	84bcd	80a	84bcd	89fgh	89fgh	92jkl	87def	83abc	86de	80a	95opq
Bio. yield (kg ha^{-1})	Normal	2.53bcd	2.13de	2.36bcd	2.83ab	2.46bcd	2.16de	2.50bcde	2.60abc	2.20cde	2.60abc	2.36bcd	2.7ab	2.83ab	2.6abcd	2.5bcd	1.3abc	2.1e	2.6bcd	3.06a
	Late	1.36abc	1.16bc	1.20bc	1.53abc	1.80a	1.36abc	1.20bc	1.50abc	1.40abc	1.43abc	1.36abc	1.3abc	1.16bc	1.4abc	1.5abc	1.9abc	1.3abc	2.0ab	1.13c
	Average	1.95	1.65	1. 8abc	2.18bcd	2.13bcd	1.76abc	1.85abc	2.05bcd	1.8abc	2.02	1.9abc	2bcd	2bcd	2bcd	2bcd	1.6abc	1.7abc	2.3bcd	2.0bcd
Spikes / m^2	Normal	420.0bcd	346.7d	450.3abcd	451.7abcd	533ab	483.7abc	527ab	507abc	444abc	496abc	464abc	445abc	476abc	497abc	404bcd	421bcd	380cd	430bcd	577a
	Late	197.7bc	214bc	268.7abc	197.3bc	185bc	298.3ab	215.7bc	218.3bc	241bc	288ab	240bc	374a	263abc	298ab	214bc	236bc	268abc	149c	294ab
	Average	309cd	280a	360efg	325def	359defg	391gh	371efg	363gh	343def	392de	352efg	410hij	370efg	398gh	309cd	329de	324efg	290ab	436ijk
Harvest index	Normal	30.7ef	17.9	33.3hij	24.6a	33.9hij	31.2fgh	33.4 hij	31.2fgh	32.6hi	28.9cde	34.9ij	30.8ef	32.3hi	29.2cde	27.5bc	23.8a	32.5hi	25.0ab	27.1gh
	Late	32.6hi	31.9fgh	54.2st	39.8de	39.3de	41.7kl	54.8st	41.7kl	35.0jk	30.0ef	35.3jk	36.6ki	48.7pq	32.7hi	35.7ij	31.5fgh	46.7no	33.1hij	29.4cde
	Average	31.7fg	24.9a	43.8lm	32.2ghi	36.6kl	36.5kl	44.1lm	36.5kl	33.8hij	29.5cde	35.1jk	33.6hij	40.5ki	31.0fg	31.6fg	27.6bc	39.6de	29.1cde	28.3cd
1000 Grain weight (g)	Normal	38.27b	38.0 bc	32.67ghi	33cde	38bcd	31.47hi	34.7efg	41.33a	33fgh	30.27i	33fgh	35efg	35def	37cd	38bcd	40ab	35defg	32hi	35efg
	Late	37.33a	32.20cde	29.73f	33cde	34bc	31ef	33cde	37ab	27gh	26h	30f	34bcd	32 cde	33cde	31def	31ef	32cdef	29fg	32cdef
	Average	38ghi	35def	31bc	33cde	36efg	31bc	34de	39hij	30ab	28a	32bcd	35def	34de	35def	35def	36efg	34de	31bc	34de
Grain yield (kg ha^{-1})	Normal	5578abc	5000def	5022cdef	5644abcd	5089cd	4756efg	5956abc	6089ab	4134g	4356fg	4978def	5111cde	6600a	6600a	5178de	5600de	4489fg	4845ef	5867bcd
	Late	1867ghi	2355bcd	3289a	2000fgh	1600hi	2711bcd	2311defg	2578cde	2133fgh	2134fgh	2400efg	2866bc	2889ab	2800bcd	2422ef	2267efg	2266defg	1311i	2533def
	Average	3723f	3678i	4156c	3822de	3345gh	3734f	4134c	4334b	3134k	3245j	3689i	3989d	4745a	4700a	3800de	3934d	3378gh	3078 l	4200bc
Hectolitre weight (kg)	Normal	69.5fgh	70.8efg	70.3gh	73.3b	69bc	72de	73b	73cde	66j	66j	71cde	75a	74bcd	68cde	69cde	72ef	69 l	69hi	73bcd
	Late	71.0efg	70.7cdef	70.5cde	74.6a	74.2fh	72 bc	74ab	73ab	68h	69efg	73def	76a	70def	73gh	71g	68gh	71cde	72bcd	71cdef
	Average	70def	71cde	70def	74b	72ef	72ef	74b	73ab	67h	68gh	72ef	76a	72ef	71cde	70def	70def	70def	71cde	72ef

Mean values sharing same alphabets show no significant difference among them

Table 3. Mean square values of analysis of variance (ANOVA) for various plant characters in wheat cultivars affected by different sowing dates during rabi 2002-2003.

SOV	Df	Days to heading	Days to maturity	Plant height (cm)	Biological yield	Grain yield (kg/ha)	No. of spikes/ m2	Harvest index	1000 grain weight (g)	Hectolitre weight (kg/HL)
Replications	2	8.633 (H.S) (0.0069)	6.608(N.S) (0.0714)	94.42 (H.S) 0.0000	1.297 (H.S) (0.0000)	8141826.67(H.S) (0.0000)	61534.31(H.S) (0.0002)	260.745 (S) (0.0303)	27.65 (H.S) (0.0001)	0.453 (H.S) (0.0000)
Genotypes (Factor A)	19	35.464 (H.S) (0.0000)	9.158 (H.S) (0.0000)	98.573 (N.S) (0.2217)	0.139 (0.2217)	1267883.66 (H.S) (0.0000)	9941.82 (N.S) (0.1063)	108.618 (N.S) (0.1007)	41.034 (H.S) (0.0000)	416.53 (H.S) (0.0000)
Sowing dates (Factor B)	1	7130.208 (H.S) (0.0000)	9013.33(H.S) (0.0000)	3901.080 (H.S) (0.0000)	38.42 (H.S) (0.0000)	259325640.30 (H.S) (0.0000)	1391268.67 (H.S) (0.0000)	245.388 (N.S) (0.0674)	390.96 (H.S) (0.0000)	197.37 (H.S) (0.0000)
AxB interaction	19	4.629 (H.S) (0.0006)	6.281 (H.S) (0.0017)	19.310 (N.S) (0.1939)	0.144 (N.S) (0.1939)	675487.26 (H.S) (0.0004)	6726.65 (N.S) (0.4491)	69.034 (S) (0.04533)	7.89 (H.S) (0.0004)	385.33 (H.S) (0.0000)
Error	78	1.625	2.420	12.104	0.109	229176.76 (H.S)	6594.14	31.307	2.69	0.827
Total	119	7180.6	9037.8	125.5	40.1	269640014.7	1476065.6	714.092	470.2	1000.5

Values in brackets represent probability values

Probability value less than 0.05 represent significance (S) at 1 percent level of probability

Probability value greater than 0.05 represent Non- significance (N.S) at 1 percent level of probability

Probability value less than 0.01 represent High significance (H.S.)at 1 percent level of probability

Significant differences in the mean values for 1000 grain weight was observed between different genotypes, dates and interaction b/w dates and genotypes under both normal and late sowing conditions (Table 3), where as non-significant differences between the mean values for different genotypes were observed and both normal and late planting conditions

Grain yield (kg/ha): The mean values regarding grain yield (kg/ha) reveal that both the planting dates (Normal and Late) had differently affected the grain yield of all the genotypes. All the genotypes produced lower grain yield as a result of late sowing (Tables 1 and 2). However, the genotype CT-01217, CT-o1222 and CT-01085 produced maximum grain yield of 4745, 4700 and 4334 kg/ha under late sowing condition representing that the line was less affected by terminal heat stress under late sowing condition. Similar was the response of these genotypes in the previous year (Table 1). The results with respect to the afore-mentioned genotypes are in agreement with the finding of Sun & Quick (1991) who advocate that some lines may have built-in resistance against terminal heat stress.

Significant differences in the mean values for grain yield were observed due to effect of genotypes, dates and interaction between genotypes and dates under both normal and late sowing conditions (Tables 2, 3 and 4).

In general the present results are in agreement to those of Okuyama *et al.*, (2005) Darwinkel *et al*., (1977), Kirby (1967), Jain *et al*., (1992) and Kumar *et al*., (1994) who found that delay in sowing is directly associated with consistent reduction in grain yield.

Hectolitre weight (HLW kg): The number of kilograms contained in volume of one hectolitre (100 litters), the property of wheat seeds that refers to the compactness and density of the seed. Greater is the hectolitre weight higher will be the density and more compact will be the seeds. Rodriguez *et al*., (1978). This property is required during the storage, shipping and transportation of the dry seeds. It is evident from Table 1 and Table 2 that the character under consideration was positively affected by late sowing. It is because reduced seed size is associated with late sowing therefore more number of seeds are accommodated per unit volume. CT-01073, CT-01354 and CT-01250 were the leading genotypes in connection to hectolitre weight on late normal average basis (74, 74 and 72 kg per 100 litters respectively (Table 2). Same results are achieved from the data of previous year (Table 1) the mean square values represent that difference for HLW among the genotype, sowing dates and as a result of interaction between genotypes and sowing dates were highly significant (Table 3). The character under consideration is negatively correlated with yield (Rharrabti *et al*., 2001) and positively correlated with protein content (Schuler *et al*., 1994) of the seed.

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