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YIELD AND QUALITY PARAMETERS OF WHEAT GENOTYPES AS AFFECTED BY SOWING DATES AND HIGH TEMPERATURE STRESS

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Abstract

Twelve wheat genotypes bred at this Institute were assessed for yield and quality parameters at two levels of sowing dates i.e., normal (18th November) and late sowing (11th December). The normal temperature persisted from December to February after which there was consistent rise in the temperature with heat shocks of 35°C in the end of March. With delayed planting, the development of plant organs and transfer from source to sink were remarkably affected, which was reflected by overall shortening of plant height, reduction in number of internodes, days to heading, days to maturity and grain filling period and ultimately in the reduction of yield and yield components. The protein content of the genotypes was higher in late condition, possibly due to low grain weight. Genotypic responses were almost similar and in the same direction, however, the intensity varied.

Introduction

Wheat (*Triticum aestivum* L.) is an important food crop cultivated over an area of about 8 million hectares with an annual production of nearly 20 million tonnes in Pakistan. It provides more than 50% of the total calories and 60% of the total protein consumed by the population as a whole. To feed the ever-increasing population in the country, the need for more wheat will continue. There are enough possibilities to increase wheat yields in Pakistan through developing new high yielding varieties and by adoption of proper package of technology (Sial *et al.,* 2000; Arain *et al.,* 2002). Yield is the function of many components which when modified have direct influence on the productivity. For instance, higher grain yields in wheat have been obtained by early sowing (Darwinkel *et al.,* 1977; Arain *et al.,* 1999; 2001; Sial *et al.,* 2000; 2001).

Temperatures above normal alter plant functions and productivity. Short heat stresses (≥ 35°C) in the post-anthesis period can significantly reduce grain weight in wheat and barley (Wardlaw & Wrigley, 1994), decrease grain quality (Randall & Moss, 1990; Savin *et al*., 1996). Stephens & Lyons (1998) suggested that the sowing dates in terms of changed temperatures are critical for determining appropriate crop yields. The present study was conducted to determine the effects of time of sowing and heat shocks during grain filling on different yield, yield components and quality traits of new wheat cultivars.

Materials and Methods

Ten advanced wheat (*Triticum aestivum* L.) genotypes viz., SD-4085/3, SD-4047, SD-66, SD-1200/11, SD-1200/19/1, SD-1200/51, 7-03, 15-10, RWM-9313, ESW-9525 alongwith two check cultivars viz., Kiran 95 and Sarsabz were sown at two sowing dates viz., 18 November (normal) and 11 December (late) during the year 1999-2000 at the Experimental Farm of Nuclear Institute of Agriculture (NIA), Tando Jam, Pakistan. The experiments were conducted in four replicates in randomized complete block design (RCBD) with six rows, 5m long and 30 cm inter-row spacing. The seeding rate was 100 kg/ha at each sowing date and the soil was clay loam with a pH of 7.4. Daily minimum and maximum temperatures (meteorological data) were recorded throughout the season.

The traits measured on plot basis at each sowing date were: (i) days to heading, (ii) days to maturity, (iii) grain filling period. Besides, five random plants from each genotype were selected for agronomic studies i.e., plant height, number of internodes per plant, spike length, number of spikelets per spike, number of kernels in a spike, main spike yield (g), grain yield per plot ($6m^2$). The quality characters examined were; 100 grain weight (g), protein (%), and lysine content (%). Means were compared using Duncan's Multiple Range Test (DMRT) and student's t statistic.

Results and Discussion

High temperatures beyond 35^0C persisted in October and first week of November. The temperatures became favourable by the beginning of December and continued (below 30^0C) up to 3rd week of February (occurring at 15 days after anthesis). Moderately high temperatures (27^0C- 32^0C) were recorded during 4th week of February. The linear increase in temperature continued in the month of March and by the end it reached to about 39^0C. Disastrous temperature to wheat crop (>40^0C) happened to be in the month of April. Overall, high temperatures in the range of 31^0C to 45^0C prevailed from 3rd week of March to second week of April (Table 1).

Mean values of different traits were compared under normal and late planting using t-statistic. Except protein content, there was decline in the mean values under late planting. This decline was significant for days to heading, days to maturity, grain filling period, plant height, spikelets per spike, grains per spike and grain yield (Table 2). There was an overall decline in grain yield of 635 kg/ha under late planting, a yield loss of 26 kg/ha per day over the normal harvest of 2902 kg/ha. The reduction in yield may be more severe, when planting is still delayed as reported by Arain *et al*., (1999), where the intensity of yield depression was found to the extent of 38 kg/ha/day. Studies have shown that moderately high temperatures (25-32^0C) and short periods of very high temperatures (33-40^0C and above) during grain filling severely affect the yield, yield components and grain quality in wheat and barley (Chowdhry & Wardlaw, 1978, Wardlaw *et al.*, 1989, Stone & Nicolas, 1994, Reynolds *et al.*, 2001).

The response of genotypes to sowing dates varied for different yield contributing characters studied. The number of days required for heading under normal sowing ranged between 68 and 90. This span was reduced to 80 days (upper limit) under late planting. This reduction was more pronounced in the genotypes which required higher number of days for heading under normal planting. The phenomenon is almost universal as time to heading shortens, in a curvilinear fashion as temperature increases (Tashiro & Wardlaw, 1999; Slafer & Whitechurch, 2001). Similarly, the genotypes matured 4 to 10 days earlier when planted late, indicating forced maturity due to high temperatures. The transfer of assimilates from source to sink, determines the grain filling period. When the genotypes were provided the optimum conditions (normal), the grain filling period was higher (42 to 55.5 days) than under stress of late planting (42 to 49 days). At least one genotype, Kiran 95 was identified which possessed inherent earliness for heading and maturity under normal and late planting and seems to have tolerance capability to high temperature (Table 3a).

Table 1. Summary of meteorological data (1999-2000).

Month	Week	Temperature			
		Min. Temp. (^{0}C)		Max. Temp. (^{0}C)	
		Range	Mean	Range	Mean
r 99	2nd	21-25	23.16	31-41	35.50
	3rd	21-27	23.33	34-37	35.66
	4th	21-21	21.00	36-37	36.20
ber 99	1st	18-23	20.83	33-37	35.16
	2nd	15-23	17.75	31-33	32.25
	3rd	14-19	16.40	34-34	33.60
	4th	12-17	13.66	25-32	29.50
ber 99	1st	11-15	13.16	22-31	26.50
	2nd	09-13	11.42	23-29	26.00
	3rd	08-12	15.25	24-27	25.75
	4th	05-14	08.50	20-24	22.16
/ 2000	1st	09-12	10.33	22-24	23.00
	2nd	05-11	08.40	19-27	22.40
	3rd	04-12	07.00	18-28	21.16
	4th	07-13	10.50	21-30	26.00
ry 2000	1st	05-12	09.00	19-27	23.00
	2nd	05-15	11.20	22-26	24.00
	3rd	08-11	09.60	22-27	25.20
	4th	10-12	10.83	22-32	26.50
2000	1st	18-22	20.00	32-35	33.00
	2nd	09-18	12.40	26-32	29.40
	3rd	12-17	14.25	31-34	32.25
	4th	11-17	13.40	30-35	33.20
000	1st	15-19	17.00	38-40	39.60
	2nd	19-25	23.00	39-45	41.60
	3rd	23-25	24.20	38-42	40.40
	4th	24-29	25.85	39-43	40.71

Table 2. Comparison of agronomic and quality traits of wheat genotypes under normal and late sowing using mean standard error and t-value.

Characters	Mean values ± standard error		t-value	
	Normal sown	Late sown		
Days to heading	80.33± 2.15	76.48± 0.89	2.94	*
Days to maturity	128.37± 1.12	121.72± 0.57	7.36	*
Grain filling period	48.02± 1.49	45.21± 0.54	2.21	*
Plant height (cm)	103.60± 1.77	92.77±1.66	6.49	***
Spike length (cm)	12.18± 0.39	11.91± 0.42	0.47	n.s
Spikelets per spike	22.62± 0.79	20.64± 0.45	3.01	*
No. of grains per spike	60.94± 2.18	53.33± 1.58	3.88	**
No. of internodes per plant	3.95± 0.09	3.90± 0.05	0.50	n.s
Spike yield (g)	2.04± 0.11	2.10± 0.07	-0.55	n.s
100 grain wt. (g)	4.35± 0.10	4.21± 0.10	1.75	n.s
Grain yield (kg/plot)	1.74± 0.04	1.37± 0.05	8.05	***
Protein (%)	10.01± 0.21	10.37± 0.18	-4.23	**
Lysine content (%)	3.06± <.01	3.06± <.01	-0.27	n.s
Grain yield (kg/ha)	2902± 60.0	2287± 78.0	8.05	***

Under favourable temperatures, the genotypes which were relatively late in heading possessed better vegetative growth, reflected by increased plant height and more number of internodes. The yield components such as spike length, number of spikelets per spike and number of grains per spike were also found associated with the vegetative growth period (Table 3b). The development rate of plant organs is generally accelerated due to increased temperatures. The late planting reduced plant height in all the genotypes, the maximum to the extent of 19.5 cm in genotype SD-1200/11. The spike length, number of spikelets per spike and number of grains per spike were also reduced under late planting in almost all the genotypes, except SD-4085/3, where there was a substantial increase for these characters. When growth resources are limited by heat stress, the size of plant organs such as leaves, tillers and spikes are reported to be reduced (Fischer, 1984).

Yield of a genotype is the most integrative trait, because it is influenced by all known and unknown factors (Araus *et al*., 2001). The genotypes produced higher grain yield, when planted on 18th November as compared to the 11th December. Genotypes 7-03, SD-4085/3. ESW-9525, SD-4047 and SD-1200/51 were promising in yield in November sowing, while genotypes RWM-9313 and SD-4047 produced higher grain yield than other entries under late planting. The phenomenon of yield depression due to late planting was also computed in each genotype. As high as 33% and 31% yield reduction was observed in genotypes SD-1200/11 and SD-1200/51, respectively (Table 3c). The genotype RWM-9313 did not show any remarkable reduction in yield, when planted late and seems to possess tolerance to high temperature to some extent. The other genotype having less yield depression was SD-4047 (12%). Higher yields from early sown wheat crop is almost universal (Darwinkel *et al*., 1977; Arain *et al*., 1999).

Taking quality parameters into consideration, it was observed that percent protein was significantly influenced by changing planting time; whereas, 100 grain weight (g) and lysine content (%) did not show any significant effects of sowing time (Table 3d). Protein percent was significantly higher in late sown wheat grains as compared to early (normal) sown, as heat shock proteins are synthesized at very high rates under high

Table 3a. Response of wheat genotypes to different sowing dates.

Genotypes	Days to heading			Days to maturity			Grain filling period (Days)		
	Normal	late	Difference	Normal	late	Difference	Normal	late	Difference
SD 4085/3	68.75 g	71.25 g	-2.50	121.80 d	117.80 d	4.00	53.05 a	46.55	6.50
SD 4047	74.25 e	74.25 e	-	127.00 c	120.80 c	6.20	52.75 a	46.55	6.20
SD 66	80.50 c	78.75 bc	1.75	128.30 bc	121.00 c	7.30	47.75 b	42.25	5.50
SD 1200/11	89.50 a	79.75 a	9.75	131.50 a	123.50 ab	8.00	42.00 cd	43.75	-1.75
SD1200/19/1	88.75 a	79.00 b	9.75	129.30 abc	123.30 ab	6.00	40.50 d	44.30	-3.80
SD1200/51	85.25 b	78.25 c	7.00	129.80 abc	121.80 bc	8.00	44.50 c	43.55	0.95
7-03	78.75 d	76.50 d	2.25	131.80 a	123.00 ab	8.80	53.00 a	46.50	6.50
15-10	88.75 a	79.75 a	9.00	131.50 a	124.00 a	7.50	42.75 cd	44.25	-1.50
RWM 9313	86.50 b	79.00 b	7.50	130.50 ab	123.30ab	7.20	44.00 c	44.30	-0.30
ESW 9525	79.50 cd	76.00 d	3.50	131.50 a	121.80 bc	9.70	52.00 a	45.80	6.20
Kiran 95	71.50 f	72.75 f	-1.25	120.00 d	122.00 bc	-2.00	48.50 b	49.25	-0.75
Sarsabz	72.00 f	72.50 f	-0.50	127.50 bc	118.30 d	9.20	55.50 a	45.80	9.70

Means denoted by the same letters in a column are not significantly different.

Table 3b. Response of wheat genotypes to different sowing dates.

Genotypes	Plant height (cm)			No. of internodes/plant			Spike length (cm)		
	Normal	late	Difference	Normal	late	Difference	Normal	late	Difference
SD-4085/3	104.55 d	99.85 b	4.70	3.60 de	3.85 bcd	-0.25	11.00 c	11.25 ab	-0.25
SD-4047	113.55 a	103.95a	9.60	3.80 cd	3.90 bcd	-0.10	11.10 c	12.32 ab	-1.22
SD-66	103.15 d	93.30c	9.85	4.05 abc	3.90 bcd	0.15	13.80 a	12.68 ab	1.12
SD-1200/11	108.25 c	88.70d	19.55	4.25 a	3.65 d	0.60	13.65 a	11.52 ab	2.13
S-1200/19/1	112.35 ab	94.70c	17.65	4.35 a	4.00 abc	0.35	13.90 a	11.65 ab	2.25
SD-1200/51	109.20 bc	94.10c	15.10	4.35 a	3.85 bcd	0.50	14.30 a	11.35 ab	2.95
7-03	98.60 ef	87.00d	11.60	3.85 bcd	3.85 bcd	-	10.50 c	09.50 b	1.00
15-10	101.75 de	94.10c	7.65	4.05 abc	4.25 a	-0.20	11.10 c	12.43 ab	-1.33
RWM-9313	101.50 de	83.20e	18.30	4.05 abc	3.70 cd	0.35	11.80 b	10.30 b	1.50
ESW-9525	94.35 g	88.05d	6.30	4.15 ab	4.10 ab	0.05	11.00 c	15.40 a	-4.40
Kiran-95	98.75 ef	90.15d	8.60	3.45 e	3.80 bcd	-0.35	12.15 b	12.35 ab	-0.20
Sarsabz	97.25 fg	96.15c	1.10	3.45 e	3.95 bcd	-0.50	11.85 b	12.15 ab	-0.30

Means denoted by the same letters in a column are not significantly different.

Table 3c. Response of wheat genotypes to different sowing dates.

Genotypes	No. of spikelets/spike			No. of grains/spike			Grain yield (kg/ha)		
	Normal	late	Difference	Normal	late	Difference	Normal	late	Difference
SD-4085/3	18.55 f	19.65 de	-1.10	47.15 f	53.35 bc	-6.20	3115	2292	823
SD-4047	20.15 de	20.25 cd	-0.10	58.05 c	54.30 bc	3.75	3063	2698	365
SD-66	22.70 c	21.10 bc	1.60	57.40 c	48.15 cd	9.25	2802	2125	677
SD-1200/11	25.45 ab	22.10 b	3.35	71.55 a	55.85 b	15.70	2615	1744	871
SD-1200/19/1	26.40 a	21.20 bc	5.20	69.15 a	52.55 bc	16.60	2906	2417	489
SD-1200/51	26.30 a	20.30 cd	6.00	68.30 a	53.45 bc	14.85	3063	2104	959
7-03	21.10 d	18.00 f	3.10	48.65 d	44.55 d	4.10	3156	2354	802
15-10	25.25 b	23.95 a	1.30	66.45 ab	67.05 a	-0.60	2677	2146	531
RWM-9313	22.40 c	18.85 ef	3.85	60.25 bc	48.35 cd	11.90	2740	2740	-
ESW-9525	23.10 c	21.70 b	1.40	62.05 bc	55.50 b	6.55	3083	2375	708
Kiran-95	19.90 e	19.90 d	-	61.75 bc	53.20 bc	8.55	3010	2313	697
Sarsabz	20.10 de	20.65 cd	-0.55	60.30 bc	53.65 bc	6.65	2594	2135	459

Means denoted by the same letters in a column are not significantly different.

Table 3d. Response of wheat genotypes to different sowing dates.

Genotypes	100 grain weight (g)			Protein content (%)			lysine content (%)		
	Normal	late	Difference	Normal	late	Difference	Normal	late	Difference
SD-4085/3	4.320 cd	3.965 e	0.355	8.300 g	10.510cd	-2.210	3.023 g	3.082	-0.059
SD-4047	4.355 cd	4.250 cd	0.105	9.400 c	10.740b	-1.340	3.043 efg	3.067	-0.024
SD-66	4.870 b	4.750 a	0.120	9.855 b	10.740b	-0.885	3.072 bc	3.072	-
SD-1200/11	4.385 cd	4.580 ab	-0.195	8.005 h	10.580c	-2.575	3.043 efg	3.050	-0.007
SD-1200/19/1	4.445 c	4.405 bc	0.040	8.775 e	10.740b	-1.965	3.063 cde	3.072	-0.009
SD1200/51	4.450 c	4.715 a	-0.265	9.040 d	11.360a	-2.320	3.060 cde	3.082	-0.022
7-03	4.265 d	3.950 e	0.315	8.500 f	09.950f	-1.450	3.033 fg	3.055	-0.022
15-10	3.855 e	3.960 e	-0.105	9.765 b	09.125h	0.640	3.088 ab	3.028	0.060
RWM-9313	3.935 e	3.910 e	0.025	8.300 g	10.390d	-2.090	3.045 def	3.060	-0.015
ESW-9525	3.885 e	3.680 f	0.205	8.685 e	10.110e	-1.425	3.065 cd	3.065	-
Kiran-95	5.050 a	4.310 c	0.740	9.125 d	10.740b	-1.615	3.092 ab	3.102	-0.010
Sarsabz	4.405 cd	4.065 de	0.340	10.430 a	09.495g	0.935	3.102 a	3.028	0.074

Means denoted by the same letters in a column are not significantly different.

temperature stress and are believed to have a protective role under environmental stress (Reynolds *et al.*, 2001). Since, there was a decline in the overall grain yield under late planting, therefore, it is obvious that higher temperatures have been the main cause of higher protein content in the late sown wheat crops. Earlier studies have also shown a negative correlation between grain yield and protein content (Randall & Moss, 1990). The local check variety Kiran-95 had the highest 100-grain weight and Sarsabz gave significantly higher protein and lysine contents at normal sowing date (Table 3d); whereas, at late sowing SD-66, SD1200/51, SD1200/19/1 had high 100-grain weight, protein and lysine contents. Kiran 95 had also higher protein % at late sowing (Table 3d).

Our studies support the use of early seeding dates for obtaining maximum yield. However, the wheat yields in warm environments can be raised significantly by modifying agronomic practices, such as adding farm yard manure to improve soil physical and chemical conditions and to increase the conservation of soil moisture (Reynolds *et al*., 2001).

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