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PATTERN OF GENETIC VARIABILITY FOR MORPHOLOGICAL AND PRODUCTIVE TRAITS IN WHEAT GENOTYPES HAVING DIFFERENTIAL PHOTOTHERMO RESPONSE

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ABSTRACT

Forty wheat (*Triticum aestivum*) genotypes were classified on the basis of their photothermal response into five groups. In the high temperature- and photoperiod-responsive genotypes, sowing under high temperature and long days of October caused reduction in number of days to heading, tillers/plant, plant height, spikelets/spike, grains/spike, and grain yield/plant, but such reduction was not observed in the photothermo-nonresponsive genotypes. Maximum resolution of variability for tiller number and plant height was recorded in December sowing among all the genotypes. However, maximum variability for other traits was expressed differently among genotypes of different groups in different environments. The genotypes possessing high degree of thermotolerance may be used by plant breeders in hybridization to develop heat tolerant strains or may be directly promoted as cultivar.

Key words: Wheat, photothermo-responsive, vernalization, photoperiod, genetic variability.

The wheat crop sown at different dates witnesses vast differences with respect to abiotic factors like temperature, light and humidity. The genotypes interact differently to abiotic factors, especially temperature and light in accordance with their photothermal responses, and several morphological and productivity traits are affected. Therefore, there is need to develop varieties capable of facing the vagaries of environment effectively. The progress of breeding efforts in this direction will depend on the amount of variability present in the germplasm. The present study has been undertaken to know the genetic variability for photothermo-response and other morphological and productivity traits under different natural photothermal environments.

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MATERIALS AND METHODS

Forty genotypes of wheat (*Triticum aestivum*) were grown under three natural photothermal environments created by adopting different dates of sowing, i.e. 5.10.1987, 2.11.1987 and 5.12.1987. Separate experiments were laid out in randomized block design with three replications in each of the three photothermal environments. Single-row plots of 2 m length with 23 cm spacing between and 10 cm within rows were planted in each experiment for each genotype. Days to ear emergence was taken as the key diagnostic characteristic to determine photothermal responsiveness of different genotypes. Data on nine other quantitative characters were also recorded on 10 plants per replication of each genotype. Plot means were used for statistical analysis. Genotypic and phenotypic coefficients of variation (GCV, PCV) were calculated by the formula suggested by Burton [1].

RESULTS AND DISCUSSION

The environmental factors, viz., temperature and day length were distinct at the time of sowing and during crop growth under different natural photothermal environments. During October, 1987, the minimum temperature dropped at a faster rate from 19.8°C to 12.5°C while the maximum temperature (37.6°C) started falling only in November 1987. The minimum temperature was below 10°C from November, 1987 to March, 1988. The mean temperature varied from 30°C in the beginning to 23°C at the end of October, 1987. In the beginning of October, the day length was 12 h which decreased in the subsequent months to 10.5 h in November–December. In February, the day length started increasing and reached 12.5 h in April. Thus, the temperature and day length were above normal during October and early November, optimum in November, and below normal in December. Temperature and day length increased in March.

Both high or low temperature and photoperiod in different natural photothermal environments affected the phenophases of different genotypes which was reflected in their flowering pattern. The vernalization responsive and relatively late varieties sown under high temperatures of October took 108 days to heading, while in December sowing heading occurred in 85 days because October sown crop witnessed high temperatures in the early phases of development and the transformation from vegetative phase to reproductive phase of these genotypes occurred only when temperatures dropped below 10°C in December–January. However, when they were sown in December, their low temperature requirement was met immediately and they entered heading phase earlier than the nonresponsive varieties [2]. The varieties responding to supraoptimal temperature and long photoperiod headed within 60–65 days when sown under high-temperature and long-day conditions of October as phenophases of such genotypes were hastened by high temperature, resulting in early heading. The relatively early maturing genotypes took 72 days if sown in October and 91 days in December sowing. Wheat is basically a long-day plant, its long-day requirement is met soon after germination in October sowing, resulting in early heading, but the short days and cooler days of December delay heading [3]. Thus, differential heading behaviour in October and December sowings was indicative of photoperiod and low temperature responsiveness of the genotypes.

The differential behaviour of the genotypes with respect to heading under different photothermal environments was taken as the key diagnostic characteristic to determine the temperature and photoperiodic responsiveness. The 40 genotypes of the present study were classified into five different photothermal groups (Table 1): (i) high temperature responsive, (ii) low temperature responsive, (iii) high temperature and photoperiod responsive, (iv) high temperature and photoperiod tolerant, and (v) temperature and photoperiod nonresponsive.

Table 1. Classification of 40 wheat genotypes based on their photothermo-response

High temperature responsive	Low temperature responsive	High temperature and photoperiod responsive	High temperature and photoperiod tolerant	Temperature and photoperiod nonresponsive
WH 283	HD 2009	AP 337	C 306 (M10)	Harrier S
Sonalika	Girija	Alondra S	HI 1011	NI 5439
S 948 A_1	Kharchia 65	WL 410	P 20080	Veery S
Raj 939	Triple Dirk R	C 591	P 20089	P 20252
WH 147	WH 157	K 227	AP 73	P 20282
WL 1562	WL 711	Chat S	C 306	WH 147(M)
K 68	J 445		Hindi 62	
C 281	PBW 175		P 20253	
HD 2285	NP 846		P 20072	
	Pavon S			

In early October sowing when the temperatures were high, the high temperature- and photoperiod-sensitive genotypes about 67.7 to 72.1 days and the low temperature-responsive genotypes took 108 days to heading (Table 2). Under the optimal temperatures of November sowing, the genotypes of three groups, i.e. high temperature responsive, low temperature-responsive, and high temperature- and photoperiod-responsive, took almost similar number of days to heading and maturity and the low temperature-responsive genotypes even headed earlier than the high temperature- and photoperiod-sensitive

Table 2. Mean performance of wheat genotypes with different photothermal responsive in respect of morphological and productivity traits under three natural photothermal environments

Group of genotypes	Environment (sowing date)	Days to emergence	Days to physiological maturity	Flag leaf duration (days)	Tillers per plant	Plant height (cm)	Spikelets per main spike	Grains per spike	Spikelet fertility (No.)	100-grain weight (g)	Grain yield per plant (g)
All genotypes	5.10.87	102.2 ± 0.8	152.8 ± 0.8	56.7 ± 1.1	8.3 ± 0.7	105.8 ± 1.7	19.7 ± 0.7	50.1 ± 2.3	2.6 ± 0.1	3.7 ± 0.1	15.9 ± 1.7
	2.11.87	99.4 ± 0.68	143.1 ± 0.6	48.9 ± 0.7	9.4 ± 0.8	110.6 ± 0.7	22.1 ± 0.5	51.2 ± 1.1	2.3 ± 0.1	3.4 ± 0.1	14.5 ± 1.5
	5.12.87	88.9 ± 0.5	122.5 ± 0.6	35.6 ± 0.7	6.3 ± 0.7	102.3 ± 0.6	21.4 ± 0.3	50.2 ± 0.9	2.4 ± 0.1	3.7 ± 0.1	9.9 ± 1.1
High temperature responsive genotypes	5.10.87	67.7 ± 0.9	122.1 ± 1.1	58.3 ± 1.1	6.8 ± 0.7	84.8 ± 1.2	15.8 ± 0.7	44.4 ± 2.3	2.8 ± 0.1	3.7 ± 0.1	13.8 ± 1.4
	2.11.87	87.6 ± 0.5	141.9 ± 0.5	60.5 ± 0.7	9.7 ± 0.8	97.4 ± 0.6	19.2 ± 0.4	48.6 ± 1.1	2.5 ± 0.1	3.4 ± 0.1	15.2 ± 1.5
	5.12.87	82.6 ± 0.5	119.7 ± 0.4	39.4 ± 0.7	6.7 ± 0.7	91.6 ± 0.5	19.7 ± 0.2	49.7 ± 0.7	2.5 ± 0.1	3.9 ± 0.1	10.4 ± 1.2
Low temperature responsive genotypes	5.10.87	108.5 ± 0.7	164.6 ± 0.8	64.4 ± 1.1	10.4 ± 0.8	111.5 ± 1.2	18.6 ± 0.8	44.9 ± 2.2	2.4 ± 0.1	3.9 ± 0.1	14.3 ± 1.6
	2.11.87	94.3 ± 0.7	138.9 ± 0.6	51.0 ± 0.6	10.0 ± 0.7	116.6 ± 0.7	20.5 ± 0.5	47.1 ± 0.9	2.3 ± 0.1	3.7 ± 0.1	15.3 ± 1.2
	5.12.87	85.7 ± 0.5	120.0 ± 0.7	36.1 ± 0.7	7.3 ± 0.9	106.9 ± 0.4	20.5 ± 0.3	47.8 ± 0.8	2.3 ± 0.1	4.1 ± 0.1	11.6 ± 1.2
High temperature and photoperiod responsive genotypes	5.10.87	72.1 ± 0.9	131.7 ± 0.8	59.3 ± 1.2	7.2 ± 0.5	98.2 ± 1.1	17.8 ± 0.8	51.5 ± 2.3	2.9 ± 0.1	3.4 ± 0.1	14.7 ± 1.4
	2.11.87	101.4 ± 0.7	141.9 ± 0.5	45.2 ± 0.7	8.5 ± 0.9	104.7 ± 0.9	22.6 ± 0.6	50.9 ± 1.2	2.3 ± 0.1	3.3 ± 0.1	12.3 ± 1.2
	5.12.87	91.3 ± 0.6	122.8 ± 0.6	32.5 ± 0.7	5.4 ± 0.7	92.8 ± 0.9	21.9 ± 0.3	51.8 ± 0.8	2.4 ± 0.1	3.2 ± 0.1	7.6 ± 1.1
High temperature and photoperiod tolerant genotypes	5.10.87	121.2 ± 0.7	166.8 ± 0.7	50.8 ± 0.9	10.5 ± 0.6	119.8 ± 1.2	22.9 ± 0.6	55.3 ± 2.1	2.4 ± 0.1	3.8 ± 0.1	18.6 ± 1.9
	2.11.87	105.8 ± 0.7	144.0 ± 0.5	42.4 ± 0.8	9.1 ± 0.8	118.0 ± 0.8	23.7 ± 0.4	56.1 ± 0.9	2.4 ± 0.1	3.3 ± 0.1	14.2 ± 1.4
	5.12.87	90.5 ± 0.5	123.0 ± 0.5	34.5 ± 0.7	6.0 ± 0.8	110.2 ± 0.9	21.8 ± 0.3	49.0 ± 0.9	2.3 ± 0.1	3.7 ± 0.1	9.6 ± 1.3
Temperature and photoperiod nonresponsive genotypes	5.10.87	134.6 ± 0.6	174.5 ± 0.2	47.2 ± 0.7	10.7 ± 0.7	114.1 ± 0.9	24.5 ± 0.6	57.6 ± 2.6	2.3 ± 0.1	3.6 ± 0.1	17.1 ± 1.8
	2.11.87	113.6 ± 0.6	150.9 ± 0.7	41.4 ± 0.5	9.0 ± 0.9	115.4 ± 0.7	25.8 ± 0.3	54.9 ± 1.0	2.1 ± 0.1	3.5 ± 0.1	15.0 ± 2.1
	5.12.87	99.4 ± 0.5	129.8 ± 0.7	33.5 ± 0.5	5.7 ± 0.4	108.3 ± 0.5	24.2 ± 0.3	55.2 ± 1.1	2.3 ± 0.1	3.5 ± 0.1	9.1 ± 0.6

genotypes. The photothermal tolerant or nonresponsive genotypes were always late in heading, which occurred in February and March irrespective of sowing dates. Such genotypes could tolerate high temperature and are suitable for early sowing. This is in agreement with Singh and Behl [4].

The high temperatures of October caused reduction in the mean number of tillers/plant, spikelets/spike, grains/spike, 100-grain weight, and grain yield per plant in the photo-thermo-sensitive genotypes, but the nonresponsive genotypes gave best performance for these traits in this environment. In other environments, their performance was relatively poor. Such adverse effects of high temperature in the unclassified genotypes have been reported earlier also [5–7].

It was observed that the highest number of grains/spike and grain weight was recorded in December-sown photothermo-sensitive genotypes, but the highest number of tillers/plant was recorded in November sowing which decreased in December sowing. At low temperature, number of spikelets/spike and grains/spike was reported to increase [8] but due to quick transition from vegetative to reproductive phase fewer tiller primordia are differentiated [9]. The number of tillers/plant and grains/spike together determine the total number of grains/plant, and due to greater tillering in November sowing, maximum grain yield/plant was obtained in the photothermo-sensitive genotypes.

The magnitude of PCV was greater than that of GCV (Table 3). The maximum resolution of variability for days to ear emergence was obtained in the high temperature environment of October of the high temperature-sensitive genotypes, in November for low temperature- and photoperiod-sensitive genotypes, and in December for photothermo-nonresponsive or tolerant genotypes. Maximum variability for days to physiological maturity was observed in October sowing of the high temperature- and photoperiod-responsive as well as nonresponsive genotypes, in November sowing of the high temperature-sensitive genotypes, and in December sowing of the low temperature-responsive and photothermo-tolerant genotypes. Therefore, best resolution of variability for these traits, which depends on the photothermal response of genotypes, could be obtained for specific groups in specific environments. Maximum variability for spikelets/spike was recorded in October sowing in the low temperature-responsive. and photothermo-responsive genotypes, in November in the high temperature-responsive, and in December in the photothermo-tolerant/nonresponsive genotypes. Almost identical pattern was observed for spikelet fertility. The trend for grains/spike was opposite to that of spikelets/spike and spikelets fertility where maximum variability was recorded in the high temperature-responsive, low temperature-responsive, and temperature- and photoperiod-responsive genotypes sown in December, and in the photothermo-tolerant or nonresponsive genotypes when sown in October. The photothermo-tolerant or nonresponsive genotypes produce a large number of spikelets, but the spikelets in the lower

Table 3. Genotypic and phenotypic coefficients of variation (GCV, PCV) for morphological and productivity traits in various groups of wheat genotypes in different environments

Group of genotypes	Environment (date of sowing)		Days to ear emergence	Days to physiological maturity	Flag leaf duration	Tillers per plant	Plant height	Spikelets per main spike	Grains per spike	Spikelet fertility	100-grain weight	Grain yield per plant
All genotypes	5.10.87	GCV	14.1	4.7	19.0	7.3	22.8	19.2	16.9	16.0	17.1	25.7
		PCV	14.1	4.8	19.1	10.8	22.8	19.7	17.8	16.4	17.4	28.7
	2.11.87	GCV	10.3	5.1	18.7	13.1	20.5	14.8	13.1	12.4	13.9	23.6
		PCV	10.3	5.1	18.8	17.2	20.6	15.1	13.4	12.6	14.2	26.7
	5.12.87	GCV	7.6	4.3	9.8	19.9	22.4	11.5	11.7	12.4	17.4	24.4
		PCV	7.6	4.3	10.1	24.6	22.4	11.7	11.9	12.6	17.6	28.1
High temperature responsive genotypes	5.10.87	GCV	6.6	4.4	13.1	11.5	36.6	12.3	18.9	17.2	25.4	38.8
		PCV	6.7	4.5	13.3	14.4	36.7	13.4	19.9	17.6	25.7	40.4
	2.11.87	GCV	5.3	7.9	15.3	11.7	32.6	15.1	12.6	13.1	21.4	31.8
		PCV	5.4	7.9	15.4	15.8	32.6	15.4	12.9	13.2	21.6	34.1
	5.12.87	GCV	2.8	3.5	4.9	12.7	35.7	9.4	7.3	8.4	21.6	25.0
		PCV	2.9	3.5	5.3	18.6	35.7	9.5	7.5	8.5	21.8	29.0
Low temperature responsive genotypes	5.10.87	GCV	3.8	2.3	9.8	7.5	13.3	12.3	15.0	15.7	15.2	13.0
		PCV	3.9	2.4	10.1	11.8	13.4	13.3	17.0	16.2	15.5	19.2
	2.11.87	GCV	4.5	2.4	8.0	11.9	15.3	11.5	13.1	12.4	10.7	22.0
		PCV	4.6	2.5	8.1	15.0	15.4	11.9	13.3	12.5	10.9	24.0
	5.12.87	GCV	4.0	4.4	8.5	13.9	17.4	11.9	12.7	14.2	10.3	13.5
		PCV	4.1	4.5	8.9	20.7	17.4	12.0	12.9	14.3	10.5	18.7
High temperature and photoperiod responsive genotypes	5.10.87	GCV	7.4	4.3	5.9	7.4	17.6	17.0	13.1	14.3	20.9	35.7
		PCV	7.5	4.4	6.3	9.6	17.7	18.0	14.2	14.4	21.1	37.7
	2.11.87	GCV	7.9	3.9	12.8	16.7	21.6	6.9	10.7	11.8	7.4	26.7
		PCV	8.0	4.0	12.9	21.3	21.7	7.7	11.1	12.0	8.1	29.4
	5.12.87	GCV	4.2	2.3	8.9	25.3	22.8	8.0	15.5	13.7	20.7	24.0
		PCV	4.3	2.4	9.3	29.4	22.8	8.2	15.6	13.8	20.8	29.9
High temperature and photoperiod responsive genotypes	5.10.87	GCV	3.3	2.9	5.9	NS	13.5	7.3	8.5	7.4	11.0	16.3
		PCV	3.4	3.0	6.4	NS	13.6	8.0	9.7	8.0	11.3	20.9
	2.11.87	GCV	4.7	2.9	10.2	13.2	13.6	8.5	10.0	6.1	12.3	18.6
		PCV	4.8	3.0	10.4	16.8	13.7	8.8	10.2	6.2	13.0	22.0
	5.12.87	GCV	4.7	3.4	7.8	22.6	14.5	9.5	10.2	13.3	14.6	27.5
		PCV	4.8	3.5	8.2	28.5	14.6	9.7	10.4	13.4	14.7	31.8
Temperature and photoperiod non-responsive genotypes	5.10.87	GCV	4.2	4.0	10.0	NS	19.4	5.3	11.4	11.2	8.7	14.3
		PCV	4.3	4.1	10.1	NS	19.5	6.2	12.7	11.9	9.3	19.2
	2.11.87	GCV	4.6	2.5	8.7	11.8	16.2	12.2	11.0	13.5	11.4	NS
		PCV	4.7	2.6	8.9	17.3	16.3	12.3	11.3	13.6	11.7	NS
	5.12.87	GCV	6.9	1.9	7.9	19.1	18.3	9.0	10.2	12.3	11.9	18.2
		PCV	7.0	2.0	8.2	21.1	18.3	9.2	10.5	13.0	12.4	19.8

part of the spike develop well only in December sowing, resulting in maximum expression of variability for this trait among the genotypes. For 100-grain weight, the trend was opposite to the variability for spikelet number. The effect of photoperiod and temperature on expression of plant height, spikelet number, grains/spike and grain weight was also reported earlier [9, 10]. Maximum variability for grain yield per plant was recorded in the October sowing in the high temperature- and photoperiod-responsive genotypes, in November for low temperature-responsive genotypes, and in December for the photothermo-tolerant and nonresponsive genotypes. Pathak et al. [11] reported maximum variability in the semidwarf germplasm collection under high temperature environment.

Thus, classification of wheat genotypes into different photothermal groups has provided useful information on the impact of temperature on mean performance and variability of different traits. The results of the present investigation support the previous observations [5, 8, 12] where drastic effects of high temperature were reported for number of tillers/plant, spikelets/spike, grains/spike and grain yield/plant. However, high temperature had no influence in the photothermo-tolerant and nonresponsive genotypes in the present study. Genotypes of this group like Pavon S, Harrier S, Veery S and P 20282 were found to be good yielders in early sowing. These lines had high degree of thermotolerance in early phases of growth and may be released as a cultivar or exploited in hybridization programmes to develop heat resistant varieties. A strategy for exploitation of different Vrn/Ppd genes in different ecological regions of India was proposed by Singh and Behl [4]. The resolution of variability for different traits among the genotypes of a specific photothermal group can be understood better when the crop is raised in specific suboptimal environment. The conflicting reports about the mean performance and variability of different traits by several earlier workers may be due differences in the material used in those studies. Therefore, it would be advisable to assess variability for different traits under appropriate environment.

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