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Variability studies for morpho-physiological traits in wheat (*Triticum aestivum* L. emend. Fiori & Paol) to post anthesis high temperature stress

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ABSTRACT

A study was conducted during crop season 2004-05 and 2005-06 to work out the phenotypic and genotypic variance, heritability, genetic advance, correlation coefficients and path analysis for yield and yield contributing traits under three sowing conditions namely timely sown(15th November), late sown (15th December) and very late sown (7th January). High heritability estimates were found for characters days to flowering, canopy temperature depression, grain growth duration, biological yield and harvest index under all the sowing conditions. High value of heritability in broad sense was observed for plant height, peduncle length, ear length, spikelets per spike, canopy temperature depression, grain growth duration, tillers per meter, grain yield and harvest index. Positive and significant correlation thousand kernel weight (0.653), grains per spike (0.643), tillers per meter (0.698), grain growth duration (0.563), canopy temperature depression (0.569), spikelets per spike (0.833), ear length (0.667) and peduncle length (0.369). The path coefficients were studied for all the traits under three environments viz., optimum condition, late sown condition and very late sown condition. Harvest index biological yield per meter, canopy temperature depression, number of spikes per spike let, ear length, number of grains per spike had direct positive effect on yield both at genotypic and phenotypic levels across the three environments.

Key words: Wheat, Grain yield, Genetic variability, High temperature stress

Wheat is the most widely consumed cereal crop of the world in a variety of forms. Globally, demand for wheat by the year 2020 is forecast around 950 million tons. This target will be achieved only, if global wheat production is increased by 2.5% per annum. In India, wheat is the second most important crop after rice in terms of both the area and production. With an area of nearly 11% under wheat, India contributes 12% to the world wheat pool. The major wheat producing states in India, Punjab, Haryana, Uttar Pradesh, Bihar and Rajasthan are located in the Indo-Gangetic plains and account for nearly 85% of total wheat production in the country. Wheat is best adopted to cool growing conditions. However, this crop is being increasingly grown in South East Asia including India, Pakistan, Bangladesh and Nepal where the ambient temperatures exceed the optimum temperature. The optimum temperature for wheat is 15°C (Chowdhury and Wardlaw 1978), while moderately high temperatures (25-32°C) for longer duration and very high temperatures (33-40°C) for a shorter period are very common in subtropical environments of these south East Asian countries particularly during grain filling (Stone and Nicholas 1994, Paulsen 1994).Therefore heat stress is one of the major constraints of wheat production in many areas of the world. Heat stress at late growth stages is a problem in 40% of wheat areas in the temperate environments (Reynolds *et al.* 2001).Studies conducted under controlled environments have revealed that long hours of exposure to moderately high temperature as well as short exposure to very high temperature reduces wheat yield. Even a brief period of exposure to high ambient temperature (>35°C) can drastically reduce the grain yield in wheat (Hawker and Jenner 1993). Gradual rise in daily maximum temperature inflicts relatively less damage in comparison to the severe damage caused by sudden temperature build up. Such situations arise under Indian wheat growing environments due to the proximity to the desert and delayed planting. When the crop is exposed to high temperature before anthesis, reduction in grains number occurs via reduction in spike/m2 and grains per spike (Shipler and Blum 1991). The reduction in grain weight results from reduction in the grain filling duration and rate (Shipler and Blum 1991; He and Rajaram 1994).

The ideal genotype for high temperature stress conditions must combine a reasonably high yield potential with specific plant characters which could buffer yield against sever temperature stress (Blum 1983). Yield components and plant trait contributing to grain yield are important for breeding strategies. Simple correlations studies relate grain yield to a single variable and may not provide a complete understanding of the importance of each components in determining grain yield. (Dewey and Lu 1959). Phenotypic and genotypic variance, heritability and genetic advance have been used to assess the magnitude of variance in wheat breeding material (Jhonson *et al.* 1956, Khan 1990, Zaheer *et al.* 1987). Path coefficient analysis allows an effective means of partitioning correlation coefficient in to unidirectional pathway and alternate pathway. This analysis also permits a critical examination of specific factors and produces a given correlation and can be successfully employed in formulating an effective selection strategy.

The objective of this study were to evaluate degree of association between yield components and plant traits with grain yield and to determine direct and indirect effects of yield components and plant traits on grain yield in wheat genotypes grown under temperature stress conditions.

MATERIALS AND METHODS

Field experiments were conducted at Experimental Farm, Division of Genetics, Indian Agricultural Research

Institute, New Delhi, India (28° 41 North latitude and 77°13' East latitude, 228 m above mean sea level). The area is semi arid, sub tropical climate with alluvial soil which is slightly alkaline with clay loam texture and low organic matter. The experiment was sown in two planting seasons during 2004-05 and 2005-06.

The experimental material comprised of 49 diverse wheat lines which represents a range of phenotypic variation in maturity, date to heading, adaptation zone, yield potential and tolerance to terminal heat stress etc. The material was planted in simple lattice with two replications and three dates of sowing i.e., normal sowing in 2nd week of November and late sowing in the 2nd week of December and very late sowing in the first week of January. Six, 5m row were planted by keeping a distance of 23 cms between the row. Normal cultural practices were followed. The data were recorded for plant height (cms), days to heading, peduncle length PL (cms), ear length EL (cms), spikelets per spike, tillers per meter, tillers per plant, grain number per spike, grain weight per spike, 1000 kernel weight, grain growth duration, biological yield per meter, biological yield per plant, grain yield per plant, grain yield per meter and harvest index and canopy temperature depression. The canopy temperature depression is measured at the anthesis with the help of Infra Red Thermometer. Variance analysis was done as per Panse and Sukhatme 1967; coefficients of variability (Burton and Devane 1953); heritability in broad sense (Allard 1960); genetic advance (Robinson *et al.* 1951); phenotypic and genotypic correlation (Al-Jibouri *et al.* 1958); and path coefficient analysis (Dewey and Lu 1959) were carried out. Correlated response was calculated as per Falconer (1981).

RESULTS AND DISCUSSION

The pooled analysis of variance showed highly significant differences among genotypes for all the traits (Table 1). The phenotypic and genotypic coefficients of variability (PCV and GCV) were computed according to the method suggested by Burton and Devane (1953). The absolute variation in different traits does enable identification as to which character shows the highest degree of variation. Hence the estimation of genotypic and phenotypic coefficients of variation (GCV & PCV) becomes necessary.

Higher values for GCV were shown for days to flowering, canopy temperature depression, grain growth rate, grain weight per spike, thousand kernel weight, biological yield and harvest index. This may be due to different parentage background of the genotypes. In some cases like those of phenotypic and genotypic coefficient of variation were almost similar in most of the cases and indicative for presence of very low environmental effects. These results indicate that the above traits offer a better opportunity for improvement for selection. Burton (1951) suggested that higher GCV together with higher values of heritability estimates would give the best results.

High value of heritability in broad sense was observed for plant height, peduncle length, ear length,

Table 1 Estimation of selection parameters for different quantitative traits in wheat

	Characters	Heritability			Genetic Advance	GCV (%)	PCV (%)
		Normal Sowing	Late Sowing	Very late Sowing			
1.	Days to flowering	56.2	91.4	93.6	21.26	19.92	20.83
2.	Plant height	72.1	31.6	44.0	11.62	10.01	17.82
3.	Peduncle length	58.7	65.3	88.1	6.12	9.26	11.46
4.	Lower plant height	55.6	45.3	44.0	10.3	8.60	8.00
5.	Ear length	59.3	74.8	77.7	1.82	9.94	11.50
6.	Spikelets per spike	60.3	68.1	85.0	6.29	9.64	11.68
7.	Canopy Temp Depression	52.9	55.6	89.8	28.19	17.68	23.21
8.	Grain growth duration	54.9	72.1	83.2	24.21	18.17	21.40
9.	Tillers/meter	75.9	89.5	91.1	8.40	4.89	5.17
10.	Grain weight per spike	44.4	54.8	59.6	9.55	16.54	22.34
11.	Grains per spike	56.2	59.3	59.0	22.3	11.34	16.33
12.	1000 kernel weight	44.4	54.8	58.2	8.18	12.63	15.72
13.	Biological yield	45.7	64.6	59.4	87.71	17.29	22.14
14.	Grain yield per meter	66.3	77.2	85.9	8.52	9.14	10.40
15.	Harvest index	91.6	96.4	96.1	25.79	12.24	12.46

spikelets per spike, canopy temperature depression, grain growth duration, tillers per meter, grain yield and harvest index. The comparison of heritability for all the traits was done under optimum sowing conditions, late sowing and very late sowing. This indicates that except for plant height, heritability estimates increases with delay in the sowing dates. This may be due to influence of environment on genotypes under temperature stress environment.

Higher genetic advance was observed for biological yield (87.71%) and for days to flowering, canopy temperature depression, grain growth duration and harvest index, moderate genetic advance was found in the range of 25-30%. This indicates that in respect of these traits, selection is effective and the material present may be useful for enhancing the productivity in wheat under different temperature regimes. Higher genetic advance for some traits also indicates for additive gene action and hence these can be effectively used for selection of better genotypes. Heritable variations can be estimated with greater degree of accuracy when heritability is studied along with genetic advance. A high heritability coupled with high genetic advance gives the most effective criteria for selection.

The estimates of the correlation coefficient between 10 characters revealed that phenotypic coefficient are higher in the magnitude than the genotypic correlation coefficients under all the environments on pooled data basis and are presented in Table 2. Grain yield showed significant positive correlation with thousand kernel weight (0.653), grains per spike (0.643), tillers per meter (0.698), grain growth duration (0.563), canopy temperature depression (0.569), spikelets per spike (0.833), ear length (0.667) and peduncle length (0.369). These characters can be effectively used as selection criteria for grain yield under high temperature regime. If the selection is made for one of these traits, simultaneous selection of other traits is achieved which will help in improving the grain yield. Spike length and canopy temperature depression possessed significant positive correlation with days to flowering and peduncle length. Spikelets/spike showed significant positive correlation with ear length. Other characters like peduncle length were significantly correlated with ear length, spikelets per spike with canopy temperature depression.

The path coefficients were studied for all the traits under three environments viz., optimum condition, late sown condition and very late sown condition. A close perusal of Table 3a, 3b and 3c showing direct effects of on grain yield reflects that harvest index biological yield per meter, canopy temperature depression, number of spikes per spike let, ear length, number of grains per spike had direct positive effect on yield both at genotypic and phenotypic levels across the three environments. This result is similar to the findings of Shamsuddin (1987) and Singh and Sharma (1994). This indicates that selection for harvest index and biological yield and other traits can be practiced under all the environments for improving yield.

Plant height has direct negative effects at genotypic level in all the three sowing conditions. This indicates that selection of semi dwarf plant height is good under irrigated condition but under stress environment selection for medium tall plant height is effective for increasing the grain yield.

Late sowing and very late sowing conditions most of the components of plant height namely peduncle length, and lower plant height is having direct negative effect on yield both at genotypic and phenotypic level, but value of direct negative effect of plant height components are very small as compared to value of positive direct effect of other traits towards yield. The findings of present study with regard to peduncle length are not in conformity with observations of Nachit and Jorrah (1986).

Peduncle length had positive direct effect under optimum sowing conditions which indicated that plant with long peduncle yielded significantly higher under timely sown. However, long peduncle contributed to yield through harvest index, biological yield per meter and 1000 kernel weight because they also have direct positive effect on yield under irrigated high fertility conditions.

Most of the components of plant height have shown negative direct effect on grain yield whereas, most of the yield traits showed positive direct effect under irrigated high fertility late sown condition. This indicate that yield and its component like tillers per meter, 1000 grain weight, biological yield per meter and harvest index can be better utilized as selection criteria both for optimum and temperature stress conditions, whereas plant height component have little use particularly for irrigated environments.

Plant breeder also argues that selection for yield components is more effective than that for yield per se (Graffius 1956). So, it can be concluded that factors show significant positive correlation with grain yield should be given priority especially where breeding for varietal improvement for temperature stress condition is concerned.

Correlated response obtained in grain yield and biological yield as a result of selection for different traits (Table 4). Biological yield exerted maximum response to grain yield followed by tillers per meter, grains per spike, spikelets per spike and canopy temperature depression. Therefore selection for grain yield can be done through the tillers per meter, grains per spike, spikelets per spike and harvest index. For stress environments, canopy temperature depression, grains per spike, canopy temperature depression, harvest index can be utilized for making selection for grain yield.

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