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EFFECT OF TEMPERATURE ON DEVELOPMENT AND GRAIN FORMATION IN SPRING WHEAT

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Abstract

Ten wheat genotypes viz., Inqilab-91, AS-2002, GA-2002, Manthar, Ufaq-2002, 00125, 00055, 01180, 00183 and 99022 were planted on November 10, 2003 (normal planting) and January 10, 2004 (late planting) at Wheat Research Institute, Faisalabad to study the effect of temperature on development and formation of grain. Significant genotypic differences were observed for all traits studied indicating considerable amount of variation among genotypes for each character under normal and late planting conditions. The maximum reduction of 53.75% was noted for grain yield while tillers m^{-2} showed less reduction (15.38%) under late planting conditions. Heat stress intensity was high (0.538), which ultimately lowered the grain yield under late planting conditions. Variety AS-2002 showed a low (0.86) heat susceptibility index for grain yield. However, Inqilab-91, 00125, 00180, and 00183 were better yielder under normal planting conditions. High genotypic coefficient of variability (GCV), phenotypic coefficient of variability (PCV), heritability in broad sense (h^2), genetic advance as percentage of mean (GA%) were observed for grain filling duration, grains per spike, 1000-grain weight and grain yield per plot under normal and late planting conditions. Genotypic correlation coefficients were generally in the same direction as phenotypic correlation coefficients but higher in magnitude under both planting conditions. 1000-grain weight was significantly and positively associated with harvest index at genotypic level. Under late planting conditions, grain yield per plot showed significant and positive genotypic correlation coefficients with biomass per plot and harvest index. Characters showing strong association with grain yield indicating selection for these traits are expected to result in yield improvement under normal and late planting conditions.

Introduction

Temperature and water are the important factors for better production of wheat especially during the grain filling period in many parts of the world. In Punjab, the optimum wheat sowing time is from 1$^{st.}$ November to 25$^{th.}$ November. However, wheat sowing is often delayed, under cotton-wheat, sugarcane-wheat and rice-wheat cropping pattern due to late picking of cotton, late start of sugarcane mills and late harvest of basmati rice, respectively. These delayed wheat sowing even after 25$^{th.}$ December or even some times 10$^{th.}$ January (due to erratic rainfall in 2nd fortnight of December) in around 40 % of the 6.379 million hectares of Punjab causes the great loss of yield due to high temperature during its grain filling period. Consequently, it curtailed the total production of Punjab to 17.375 million tones with an average of 2724 kg ha^{-1} during 2004-05 (Anon., 2007). The reduction in the duration of emergence to double ridge (GS1) and double ridge to anthesis (GS2) is associated with reduced spike number per plant and grain number per spike. The reduction in duration of anthesis to physiological maturity (GS3) is often associated with a reduction in grain weight (Warrington *et al.*, 1977). Similarly, Hanchinal *et al.*, (1994) reported the reduction in the duration of GS2 and GS3 growth phases under late planting. They also observed that spikelets per spike and grains per spike under normal planting and spikes m^{-2} under late planting conditions may serve as valuable selection criteria. Delayed planting reduced the plant height, days to heading, days to maturity and grain filling duration and ultimately showed the reduction in yield and yield components (Shpiler & Blum, 1991; Din & Singh, 2005; Mahboob *et al.*, 2005).

The information of certain genetic parameters is essential for crop improvement. In wheat, researchers studied the different genetic parameters and used the genotypic correlations for crop improvement. Subhani & Alam, (1988), Chowdhry *et al.*, (1997), Sachan and Singh, (2003) and Ali *et al.*, (2008) reported the high heritability estimates coupled with high genetic advance for plant height, tillers per plant, grains per spike, 1000-grain weight and grain yield per plant. Similarly, Subhani & Chowdhry (2000b) recorded high heritability estimates for days to heading and 1000-grain weight under irrigated as well as drought conditions. Asif *et al.*, (2004) reported that days to heading and plant height showed relatively higher heritability. While Yagdi & Sozen (2009) reported heritability values of 6.35%, 9.38%, 6.13%, 5.26%, 9.45% and 3.12% for plant height, number of spikelet per spike, seed number per spike, seed weight per spike, thousand kernel weight and seed yield, respectively.

Subhani & Chowdhry (2000b) reported high genotypic coefficient of variability under both environments for tillers/plant, 1000-grain weight, biomass per plant and grain yield per plant. They also observed maximum reduction of 68% in grain yield per plant followed by biomass per plant, tiller per plant and plant height under drought stress conditions compared to irrigated ones, respectively. Similarly, Sachan & Singh (2003) observed high estimates of GCV and PCV for grain yield, number of seeds per ear, plant height, 1000-grain weight and number of tillers per plant. Little variability was noted for number of days to flowering and maturity. While Ali *et al.*, (2008) reported the considerable amount of variation among genotypes for each character. The estimates of genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were high for yield per plant, number of productive tillers per plant and number of grains per spike. The remaining traits recorded moderate to low PCV and GCV estimates.

Singh *et al.*, (1990) reported that significant and positive correlation of total biomass with grain yield; number of tillers per plant and grains per spike were recorded. Similarly Sharma & Singh (1991) revealed that harvest index, biomass yield and tillers per plant were the most important contributors to yield. Whereas, Ahmad *et al.*, (1994), Ali *et al.*, (2008), Jamali *et al.*, (2008) and Yagdi & Sozen (2009) reported positive and significant genotypic correlation among productive tillers m^{-2}, plant height, spike length, spikelets per spike, grains per spike and grain yield. Subhani & Chowdhry (2000a) reported the positive and significant correlations between grain yield and plant height, tillers per plant, grains per spike, 1000-grain weight, biomass per plant and harvest index under irrigated and drought conditions. While negative and significant correlation was noted between days to heading and grain yield. Whereas Kumar *et al.*, (2004) reported that grain yield had positive and significant correlations with days taken to maturity, test weight and number of spikes per meter row length.

The present study aims to assess the variability and relative importance of different characters with the help of genetic parameters like GCV, heritability (b.s.), genetic advance as percentage of mean and interrelationships among different characters and of wheat under normal and late planting (high temperature during later growth stages) conditions.

Materials and Methods

Ten spring wheat varieties/promising lines viz., Inqilab-91, AS-2002, GA-2002, Manthar, Ufaq-2002, 00125, 00055, 01180, 00183 and 99022 were grown in two field experiments at Wheat Research Institute, Faisalabad on November 10, 2003 (Normal planting) and January 10, 2004 (Late planting). Genotypes in each experiment were planted in a randomized complete block design with four replications. Plots consisted of six rows, 6 meters long and 27 cm apart, seeded at an average rate of 100 kg ha^{-1} with Norvaigean drill and maintained 5 meters length of the plot. The full dose of nutrients i.e. nitrogen 100 kg ha^{-1} and P_2O_5 85 kg ha^{-1} was applied at the time of seedbed preparation. Standard agronomic practices were adopted for both experiments. The crop characters recorded were: (i) days to heading, (ii) days to maturity, (iii) grain filling duration, (iv) plant height (cm), (v) tillers m^{-2}, (vi) grains per spike, (vii) 1000-grain weight (g), (viii) biomass per plot (kg), (ix) harvest index (%) and (x) grain yield per plot (kg).

Individual analysis of variance (Steel & Torrie, 1980) was conducted for each character. Phenotypic and genotypic coefficient of variation was estimated as per Burton (1951). Heritability (b.s.) and genetic advance as percentage of mean were calculated according to Allard (1960). Genotypic and phenotypic correlations were determined by the method of Jonhson *et al*., (1955).

Results and Discussion

Variability and genetic parameters: Analysis of variance showed that genotypic differences were significant for all traits under normal and late planting indicating the presence of genetic variation for selection of superior genotypes under both conditions. A wide range of variation was observed for all traits under both conditions. The temperatures from November to March are relatively suitable for wheat crop planted in November while low and high temperature during emergence and grain formation stage, respectively are not suitable for crop planted in late December and in early January (Fig. 1). It is obvious from the Table 1 that high temperature significantly reduced the growth and development stages of the wheat plant. Maximum reduction of 53.75% was noted for grain yield per plot on overall mean basis followed by biomass per plot (38.3%), while tillers/m^2 was suppressed less by high temperature and a minimum reduction of 15.38% was observed. It is also observed from the Fig. 2 that a timely planted experiment completed their growth and reproductive stages under normal climatic conditions and late planted experiment passed through hotter period in the later (stem elongation to maturity) stages of crop growth. The yield was reduced due to the reduced tillers m^{-2} and 1000-grain weight and shortened period of heading and maturity and ultimately grain filling due to high temperature. These results are in good agreement with the findings of Warrington *et al*., (1977); Shpiler & Blum (1991); Hanchinal *et al*., (1994); Subhani & Chowdhry (2000b); Din & Singh (2005) and Mahboob *et al*., (2005).

In case of varieties, Ufaq-2002 and Manthar were badly affected by high temperature during their growth period. Variety AS-2002 showed better performance than other varieties/lines under late planting by maintaining the tillering ability, number of grains per spike, biomass and grain yield per plot (Table 1). Similarly an advanced line 00183 also showed better performance through plant height, days to maturity, grain filling duration and biomass per plot. Ten approved and advanced lines of wheat planted under two temperature regimes (Table 1), clearly indicated lower yield under late planting conditions as evident from the high heat stress intensity (relative yield loss) 0.538. Variety AS-2002 showed a low heat susceptibility index (0.86) for yield under late planting conditions, indicating the heat tolerance for tillers m^{-2}, grains per spike and biomass per plot as clearly evident from low reduction in these traits. However, other genotypes like Inqilab-91, 00125, 00180 and 00183 were better yielder under normal planting conditions.

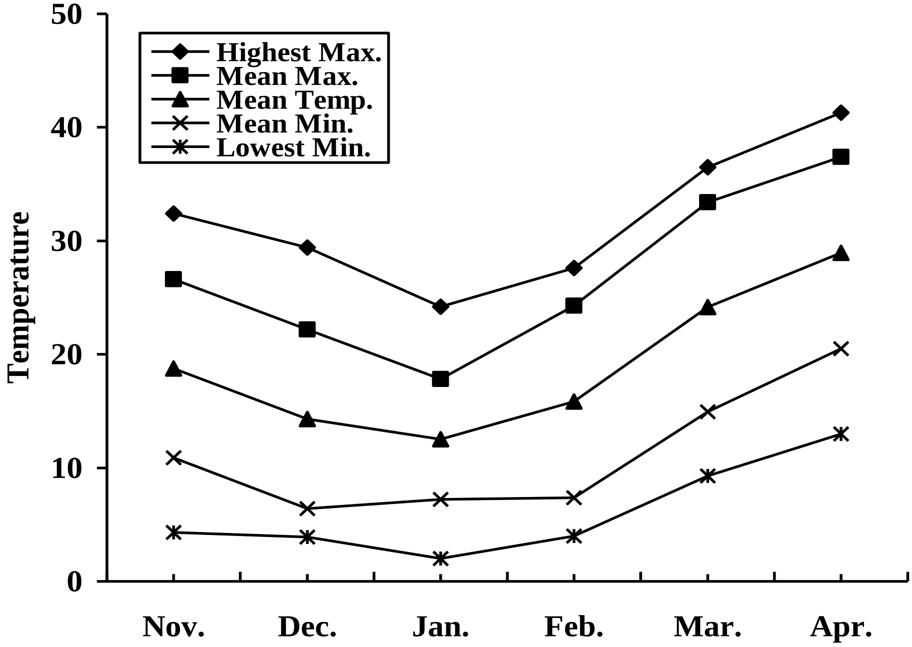

Fig. 1. Monthly temperature (°C) during the wheat growing season.

Genotypic coefficient of variability (GCV), phenotypic coefficient of variability (PCV), heritability in broad sense (h^2), genetic advance as percentage of mean (GA%) were high for plant height, grain filling duration, grains per spike, 1000-grain weight, harvest index and grain yield under normal sowing conditions (Table 2). Relatively high GCV and PCV, h^2 and GA as percentage of mean were noted for grain filling duration, tillers m^{-2}, grains per spike, 1000-grain weight and grain yield under late sowing conditions (Table 2). Hence considerable improvement in these five traits may be achieved through selection in high temperature. These findings are corroborated with the results of Subhani & Alam (1988); Chowdhry *et al.*, (1997); Subhani & Chowdhry (2000b); Sachan & Singh (2003); Asif *et al.*, (2004); Ali *et al.*, 2008; Jamali *et al.*, (2008) and Yagdi & Sozen (2009).

Correlation coefficient: Plant height was negatively and significantly correlated with harvest index at genotypic and phenotypic levels, while positive and significant phenotypic correlations were observed between plant height and grains per spike and biomass per plot (Table 3). Days to heading was negatively and significantly correlated with grain filling duration, 1000-grain weight and harvest index at genotypic and phenotypic levels. Similarly days to maturity had also negative and significant correlation with harvest index. Grain filling duration was positively and significantly correlated with 1000-grain weight and harvest index at phenotypic levels. Grains per spike was negatively and significantly associated with 1000-grain weight and harvest index. 1000-grain weight was negatively and significantly correlated with harvest index at genotypic and phenotypic levels. Grain yield was positively and significantly correlated at phenotypic level with 1000-grain weight, biomass per plot and harvest index under normal planting conditions. In case of late planting, days to heading had positive and significant association with days to maturity and negatively and significantly with grain filling duration, 1000-grain weight at genotypic and phenotypic levels. Similarly days to maturity was negatively and significantly correlated with biomass per plot and grain yield at genotypic level. But grain filling duration had positive and significant correlation with 1000-grain weight at genotypic and phenotypic levels. While grains per spike had negative and significant association with 1000-grain weight at both levels. Grain yield was positively and significantly correlated with biomass per plot and harvest index at genotypic and phenotypic levels under late planting. Biomass per plot and harvest index is the important traits for selecting high yielding genotypes under normal and late planting (Singh *et al.*, 1990 and Sharma & Singh, 1991).

The present study clearly indicated that under normal planting conditions plant height, grain filing duration, grains per spike, 1000-grain weight, harvest index and grain yield per plot while in late planting conditions grain filling duration, tillers/m^2, grains per spike, 1000-grain weight and grain yield per plot would serve as valuable selection criteria as considerable variation was observed for these traits with limited material studied. It would therefore, suggest that there could be great chance for improving yield under normal and late planting conditions.

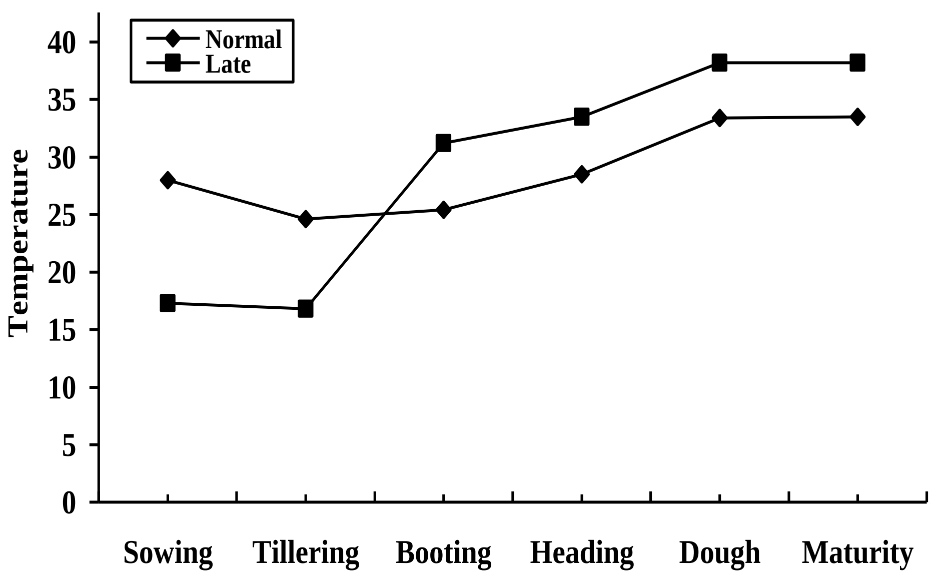

Fig. 2. Maximum temperatures (ºC) during wheat growth stages under normal and late planted conditions.

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