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Effect of Terminal Heat Stress on Yield and Yield Attributes of Wheat

KEYWORDS: Grain weight, grain filling duration, Yield

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ABSTRACT *High temperature is a major determinant of wheat development and growth and causes yield loss in many regions of the world. This study was conducted to assess heat stress effects on yield and yield related traits of wheat. Three wheat genotypes C 273 (heat tolerant) and PBW 343, PBW 550 (susceptible) under normal and heat stress (late sowing) conditions. Grain yield, no of grain per kerenel, plant height, grain filling duration, peduncle length, peduncle weight and 1000 kernels weight were measured. High temperature significantly decreased all traits specially grain yield (26% and 54.2%), 1000-kernel weight (24% and 31%) and grain filling duration (3% and 9%) in tolerant and susceptible genotypes, respectively. Grain yield (54%) was most affected and grain filling duration (9%) was least affected by heat stress. These traits could be used as reliable screening tools for development of heat-tolerant genotypes.*

Introduction

Wheat is traditionally grown as a cool-season crop, but with the increased availability of more widely adapted semi-dwarf cultivars, wheat production has expanded into warmer regions of countries, where production had previously been restricted to higher altitudes or cooler latitudes (Badrruuddin et al. 1999). Terminal heat stress is a problem in 40% of temperate environments, which cover 36 million ha (Reynolds et al. 2001). Under Mediterranean conditions heat stress after anthesis is the major grain yield limiting factor in winter sown wheat genotypes. High temperatures, above 30°C, affect final grain weight by reducing the duration of grain filling, due to the suppression of current photosynthesis and by inhibition of starch synthesis in the endosperm. Most of the available information is centered on the post-anthesis effects of temperature, there is ample evidence that temperature during pre-anthesis can modify, not only final grain weight, but also grain number (Wardlaw et al. 1989). Pre-anthesis effects may be related with reduction on grain number due to problems during meiosis and the growth of the ovaries which may, in turn, impose an upper limit for potential grain weight (Calderini et al. 1999). The optimum temperature range for reaching maximum kernel weight is 15-18°C; higher temperatures reduce the duration of grain filling and this reduction is not balanced by the increase in rate of assimilates accumulation (Stone et al. 1995). To sustain wheat productivity under late planting, research emphasis has been given to develop heat tolerant genotypes. There is an average yield loss 1.7% per day, when sown beyond optimum time (Mohammadi, 2002). Similarly, Hanchinal et al. (1994) reported the reduction in the duration grain growth phases under late planting. 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 (Din & Singh, 2005). Assessment of genetic variability has important implications in breeding and conservation of genetic resources. Therefore, it is important to have this information for germplasm collections, to determine the range of diversity in genotypes and during long-term maintenance of collections.

Materials and Methods

Three wheat cultivars C 273 (heat tolerant) and PBW 343, PBW 550 (susceptible) and were evaluated under normal and late sowing conditions. The crop was sown in middle of November (optimum planting date) and middle of december (late planting date). The experiments were carried out through a randomized block design with three replications in Research Field of Punjab Agricultural University, Ludhiana India. Soil type was sandy loam and the experiment was optimally managed to avoid unwanted nutrient or water stress. Materials were seeded with hand (4 rows by 1.0 m long, spaced 25 cm apart and 2 cm intrarow space). Grain dry weight, head length, kernels per spike, spiklets per spike, 1000-kernel weight, plant height and peduncle length were measured. The grain filling duration (GFD) was also calculated as the number of days from anthesis to ripeness (approximately 90% of spikes devoid of green color). Data were analyzed statistically by CPCS1 software analysis of variance.

Results and Discussion

Combined analysis of variance for grain yield, peduncle length, peduncle weight, grain filling duration, kernels per spike, 1000 grain weight and plant height are presented in Table about here. Comparison of tolerant and susceptible genotypes on the basis of percent reduction in yield demonstrated that genotypes were significantly different in their response to heat stress. For example, tolerant genotypes had longer grain filling duration than susceptible genotypes under both control and stress conditions. Yield parameters of susceptible genotypes were more affected by high temperature. Greater than 3-fold differences in yield between susceptible and tolerant genotypes were observed similar results have been reported by Zhong-hu & Rajaram, (1994).

It is notable that susceptible genotypes had the highest reduction in grain yield (66.2%). According to Hays et al. (2007) stress occurring after anthesis often has detrimental effects on wheat grain yield by hastening maturity, triggering premature senescence, shortening grain filling duration and reducing net assimilates and 1000 kernels weight. As shown in Table about here, the reduction of yield under stress was due to decline both in number of grain per ear and 1000 grain weight. The results showed that high temperature begun in start of grain filling and continued until ripening had a negative impact on yield as measured by kernel weight (39.85% reduction). Similar results have been reported by Modhe et al. (2008). High temperature during grain-filling period decreased grain filling duration significantly. The duration of grain growth in the post-anthesis period is considered the most significant determinant of yield in wheat (Mitra & Bhatia, 2008). Grain filling duration contribute to the final yield of a plant that is a product of rate of grain filling and du-

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ration of the grain filling period. High temperature during grain-filling period may be with a degree of plant heat escape due to shortening of the grain filling duration by 0.4 day for each 1 °C increase in mean temperature from optimum temperature. Shortening of the grain filling duration generally decreases yield by decreasing kernel weight (Tahir & Nakata, 2005). Asseng & van Herwaarden, (2003) reported that length of the uppermost internode, called peduncle, and its role in stem reserve remobilization was correlated with high grain yield under heat stress. Similarly, peduncle length was highly sensitive to heat stress and decreased by 10.62%. The role of peduncle in heat and drought resistance was already proved due to its role in photosynthesis and stem reserve remobilization (Villegas et al. 2007).

Conclusion

Peduncle length, peduncle weight, soluble sugars and grain filling duration showed the highest correlation with yield under both normal and heat stress conditions. It was concluded that these traits could be used as reliable screening tools for development of heat-tolerant genotypes.

Table. Yield and yield characteristics of wheat under normal (NS) and late sowing (LS) conditions.

Traits	Yield		1000Grain weight		Grain no/ spike		Peduncle length		Peduncle weight		Plant height		Grain filling duration	
	NS	LS	NS	LS	NS	LS	Post anthesis	Maturity	Post anthesis	Maturity	NS	LS	NS	LS
C 273	0.27	0.20	40.08	27.4	47.01	37.20	47.97	45.15	1.64	0.849	114.5	103.5	46.25	43.0
PBW 343	0.61	0.28	44.95	33.4	54.5	43.7	32	30	1.36	0.54	88.5	73	41.7	40.2
PBW 550	0.53	0.26	45.7	34.5	56.5	45.5	34	34	1.24	0.47	77	68	47.5	43.3

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