Indian J. Plant Physiol., Vol. 13, No. 3, (N.S.) pp. 307-311 (July-Sept., 2008)

SHORT COMMUNICATION

MORPHOPHYSIOLOGICAL TRAITS AS INDEX OF SCREENING WHEAT GENOTYPES FOR THERMOTOLERANCE

N.B. SINGH*, Y.P. SINGH, L.P. TIWARI, JAVED BAHAR, V.P.N. SINGH AND PARVEZ ALAM

Section of Rabi Cereals, C.S. Azad University of Agriculture & Technology, Kanpur-208 002

Received on 24 June, 2008, Revised on 30 Sept., 2008

Wheat genotypes which differed widely in their morpho-physiological characters were grown under two dates of sowing, i.e. normal (25th November) and late (3rd January) in order to have temperature variation which was 25-28 ^{o}C in (normal) and 30-33^{o}C (late) during grain filling period. Results revealed that wheat genotypes with droopy leaf, viz. Raj 3765, K 7903, GW 336, NW 1014 and K 8962 recorded a wider angle of flag leaf from vertical plane, early flowering, greater canopy temperature depression, seed hardness and better performance in respect of yield and grain quality over erect leaf oriented genotypes, viz. PBW 373, K 2008, HTWYT- 9, AP 1064, KYP 0328 under high post-anthesis temperature, i.e. 4 to 5.6^{0}C>28^{0}C (Normal) under late sowing. Further, these traits, viz. higher leaf orientation, early flowering, canopy temperature depression and seed hardness possessed positive correlation with yield under late sowing, thereby, indicating their involvement in process of terminal heat stress. Thus, these traits which are simple and easily measurable can be used as screening techniques to identify thermo-tolerant wheat genotypes under late sown environments of north eastern plain zone of the country.

Key words: **Canopy temperature depression, flowering, leaf orientation, seed hardness, sowing date, wheat.**

High temperature stress is one of the major environmental constraints that limit production and productivity of wheat. With increase in intensive cultivation more than 40 per cent of total area of wheat has been switched over to late sowing practice, i.e. (from mid of November to mid of January) due to paddy-wheat, toria-wheat, sugarcane ratoon-wheat, potato-wheat, cotton-wheat and green chillies-wheat in entire north eastern plain zone of the country. Late sown wheat crop often face a high post anthesis temperature that proved to be detrimental to grain development which results in lower production with poor grain quality. High temperature not only affects grain growth and yield of wheat (Asana and William 1965, Fischer and Maurer 1976, Mc Donald *et al*. 1983, Sharma Natu *et al*. 2006) but also affects phasic development and flour quality of wheat as well (Bagga and Rawson 1977, Slafer and Rawson 1994, Stone and Nicholas 1998, Blum *et al.* 2001). One of the options for success of crop under late sown condition is to have thermo-tolerant wheat genotype that can tolerate high temperature stress. There has been pressing demand of breeders in wheat programme for screening technique which is simple, rapid and realistic for evaluating wheat genotypes for thermotolerance in large segregating populations under field condition. With this view, the present study was undertaken to analyze parameters such as canopy orientation, leaf angle, early flowering, canopy temperature depression and seed hardness as an index for screening thermo-tolerance in wheat genotypes.

*Corresponding author, E-mail: nbsingh2006@yahoo.co.in

A field experiment was conducted with 10 wheat genotypes widely differing in morphophysiological traits such as canopy orientation; Raj 3765, K 7903, GW 336, NW 1014 and K 8962 have droopy canopy and PBW 373, K 2008, HTWYT-9, AP 1064 KYP 0328 are erect canopy type (Table 1). Experiment was laid out in lattice square design with two replication under two date of sowing, i.e. normal (25th Nov.) and late (3rd January) during 2005-06 at experimental research farm of C. S. Azad University of Agriculture & Technology, Kanpur. Temperature was, therefore, varied by date of sowing (Asana and Chinoy 1947 and Asana and Saini 1962). Maximum and minimum temperature were recorded during crop growing season. The plot size was 3m x 0.92m. Seed rate was kept 100 kg/ha. Recommended doses of fertilizers were applied. Soil was sandy loam and slightly alkaline (7.5 pH). Data on flowering was recorded as per Zo dok *et al.* (1974). Canopy temperature depression (CTD) was measured by infra-red thermometer (Teletemp AG-42 USA) and seed hardness was measured by seed hardener. Leaf angle was measured by set-square (chanda). Co-efficients of correlation of grain yield with leaf angle, early flowering, CTD and seed hardness were also worked out. Crop was harvested at a physiological maturity.

Table 1. Variation in morphological traits in wheat genotypes used for study.

Genotypes	Traits
Raj 3765	Droopy leaf early & medium height
K 7903 Halna	Droopy leaf early & medium height
GW 336	Droopy leaf early tall height
NW 1014	Droopy leaf early tall in height
K 8962	Droopy leaf early fleshy and tall in height
PBW 373	Erect leaf late & medium height
K 2008	Erect leaf late medium height
HTWYT 9	Erect leaf late medium height
AP 1064	Erect leaf late & medium height
KYP 0320	Erect leaf late medium height

Data on mean maximum and mean minimum temperature during grain development revealed 4.2-5.0 ^{o}C higher temperature under late sowing as compared to normal sowing (Table 2). Temperature, however, remained cool upto boot stage yet late sown crop had higher temperature also during pre-anthesis than normal sowing. Data recorded on flag leaf angle revealed that genotypes differed in degree of leaf angle from vertical plane (Table 3). Droopy genotypes, viz. Raj 3765, K 7903, GW 336, NW 1014 and K 8962 had higher value of leaf angle which ranged from 25 to 30^{0} and 20 to 24^{0} under timely and late sowing. Erect leaf genotypes, viz. PBW 373, K 2008, HTWYT 9, AP 1064 and KYP 0328 showed lower value in leaf angle which ranged from 22 to 24^{0} and 16 to 19^{0}C under timely and late sowing. Results clearly indicated that genotypes with droopy leaves that provide more shading effect enabled such genotypes to cope up heat stress more efficiently by reducing total net-radiation and rate of transpiration over erect leaf genotypes. It also seems that genotypes with droopy leaf are more efficient in dissipating excess net radiation through latent heat via transpiration. Blum (1988) also argued that heat tolerance should evolve in plants that are short in mechanism of heat avoidance. Thus, droopy leaf orientation seems to be very simple trait and can be used in screening programme for identifying thermo-tolerant genotypes under late sown field conditions.

Table 2. Mean minimum and mean maximum temperature (^{0}C) during crop growth stages (pre-anthesis - anthesis and anthesis to physiological maturity) under normal and late sown field conditions.

Growth stage	Mean minimum (^{o}C)	Mean maximum (^{o}C)
	Normal sowing	
Sowing to anthesis	5.8	25.0
Anthesis to physiological maturity	7.4	28.8
	Late sowing	
Sowing to anthesis	7.6	29.5
Anthesis to physiological maturity	12.5	33.4

Data recorded on 75 per cent flowering as per Zo dok *et al.* (1974) revealed a significant genotypic variation under both the sowing conditions (Table 3).

Indian J. Plant Physiol., Vol. 13, No. 3, (N.S.) pp. 307-311 (July-Sept., 2008)

Table 3. Effect of sowing dates on flag leaf angle, days to 75% flowering, canopy temperature depression, seed hardness and grain yield in wheat genotypes.

Genotypes	Leaf angle⁰		Days to 75% flowering		C.T.D. at anthesis (⁰C)		C.T.D. after 15 DAA (⁰C)		Seed hardness		Grain yield (q/ha)		Yield reduction over normal sowing
	Normal	Late	Normal	Late	Normal	Late	Normal	Late	Normal	Late	Normal	Late	(%)
Raj 3765	26	22	75	68	5.4	4.2	4.4	3.6	H	H	44.0	34.5	21.5
K 7903	25	20	68	63	5.7	4.7	4.7	3.9	H	H	34.5	31.0	10.1
GW 336	30	24	73	69	5.3	4.5	4.2	3.3	H	H	42.5	35.5	16.4
NW 1014	30	22	70	64	5.4	4.8	4.0	3.4	H	H	41.5	36.5	12.0
K 8962	30	22	73	60	6.0	5.0	4.2	3.3	H	SH	43.5	34.5	20.0
PBW 373	24	19	88	76	4.8	3.8	3.2	2.4	H	SH	43.5	32.0	26.4
K 2008	24	18	84	78	4.7	3.8	3.1	2.7	H	SH	43.0	30.5	29.0
HTWYT-9	22	15	83	78	4.2	3.6	3.3	2.0	SH	SH	45.0	32.5	27.0
AP 1064	22	18	84	77	4.9	3.4	3.0	2.2	H	SH	42.5	32.0	24.0
KYP 038	22	16	79	76	5.0	3.7	3.0	1.9	SH	SH	43.0	29.0	32.5
Mean	25	19	77	70	5.0	4.5	3.7	3.2	-		42.3	32.8	
CD at 5%	3.1	3.1	4	6	1.4	1.0	1	1.2	-		7.8	4.7	

H = Hard seed DAA = Days after anthesis
SH = Semi hard CTD = Canopy temperature depression

Interestingly all genotypes with droopy leaves, viz. Raj 3765, K 7903 (Halna), GW 336, NW 1011 and K 8962, took shorter duration for flowering which ranged from 68 to 75 and 60-68 days under normal and late sowing. On contrary to this, erect leaf genotypes, viz. PBW 373, K 2008, HTWYT-9, AP 1064 and KYP 0328 took comparatively more days for flowering in the range of 77 to 88 and 76-78 under normal and late sowing, respectively. From the present finding, it appears that early flowering enabled genotypes with droopy leaves to complete their grain development a bit earlier under late sowing. Earliness is supposed to be one of the important traits for success of wheat crop under both drought and high temperature condition. Since heat stress is intimately linked with the energy balance of plant, thus, an early flowering type through its heat avoidance mechanism can be used as a trait for screening of the thermo-tolerant genotypes of wheat under late sown field conditions.

Canopy temperature was measured at anthesis and 15 days after anthesis under both normal and late sowing. Data recorded for this trait was higher in normal than late sowing at both stages. CTD ranged between 4.2 to 5.7 at anthesis and 3.4 to 5.8, 15 days after anthesis under normal planting. It ranged from 3.4-5.8 at anthesis and 1.9-3.9, 15 days after anthesis under late sowing (Table 3). CTD was significantly higher in genotypes that had droopy orientation of leaves over narrow erect oriented genotypes. Lower CTD under later sowing can be attributed to a greater heat stress condition experienced by crop. From the results, it was inferred that a genotypes with droopy leaves having higher CTD keep their canopy more cooler over erect leaf genotypes, hence, performed better under late sown condition. Further, C.T.D. was positively correlated with grain yield, thereby, showing its avoidance mechanism in heat tolerance. Many workers like Idso *et. al.* (1985), Blum *et. al*. (1989), Balota *et. al.* (1993), Reynold *et.*

al. (1994) also reported a positive correlation of CTD with yield under water and heat stress environment. This trait holds a great promise in screening programme for identifying thermo-tolerant wheat genotypes under harsh environmental conditions caused by late sowing.

Genotypes with droopy leaves, viz. Raj 3765, K 7903 (Halna) GW 336, NW 1014 and K 8962 resulted in hard seed and showed a great degree of tolerance to high temperature stress during grain filling stage as compared to erect leaf type which showed forced maturity with greater grain shrivelness (semi-hard). Seed hardness also revealed the ability of genotype for better sink realization under rising ambient high temperature stress caused by late sowing. Jenner *et. al.* (1995) also observed that a thermo-tolerant wheat genotypes had greater sink capacity under water and heat stress conditions. This trait assumes a special significance and can be used in assessing thermo-tolerant wheat genotypes under late sown condition.

Droopy leaves combined with early flowering in wheat genotypes, viz. Raj 3765, Halna, GW 336, NW 1014 and K 8962 performed better in respect of grain yield and quality over erect leaf and delayed flowering types under late sowing. Further, early flowering with droopy leaf genotypes, viz, Halna, NW 1014, GW 336, K 8962 and Raj 3765 showed yield reduction of 10.1-21.5 % under late sowing compared to normal sown condition. The per cent reduction in grain yield was more pronounced (26.4-32.5 %) in erect leaf combined with delayed flowering type. Comparatively lesser reduction in grain yield of genotypes with droopy leaf alongwith early flowering habit seems to be associated with their thermo-tolerance mechamism under late sowing environments. A positive correlation of grain yield with CTD, early sowing, flag leaf angle, and seed hardness under late sowing indicate involvement of these traits in mitigating the effect of high temperature under late sown condition.

ACKNOWLEDGEMENT

The first author is grateful to Late Dr. Ziauddin Ahmad, Professor and Internationally reputed Wheat Breeder for suggesting this problem and also to Dr. D. N. Singh, formerly at IIPR, Kalyanpur for critically going through this manuscript.

REFERENCES

Asana, R.D. and Saini, A.D. (1962). Studies on physiological analysis of yield. Grain development in wheat in relation to temperature, soil moisture, change with age in sugar content of stem, in photosynthetic surface. *Indian J. PIant. Physiol.* **5:** 128-171.

Asana, R.D. and William, R.A. (1965). The effect of temperature stress on grain development in wheat. *Aust. J. Agric. Res.* **16:** 1-3.

Bagga, A.K. and Rawson H.M. (1977). Contrasting responses of morphologically similar wheat cultivars to temperature appropriate to warm temperature climate with hot summer: A study in control environment. *Aust. J. PIant Physiol* **13:** 605-610.

Balota, M., Amani, I., Reynold, M.P. and Acevedo, E. (1993). Evaluation of membrane thermostability and canopy temperature depression as screening traits for heat tolerance in wheat. Wheat Special Report No. 20, CIMMYT, Mexico.

Blum, A., Kluera, N. and Nguyen, H.T. (2001). Wheat cellular thermotolerance is related to yield under heat stress. *Euphytica* **117:** 117-123

Blum, A., Shpiler, L., Gotal, G. and Mayer, J. (1989). Yield stability and canopy temperature of wheat genotypes under drought stress. *Field Crop Res.* **22**: 289-296.

Chinoy, J. (1947). Correlation between yield of wheat and temperature during ripening of grain. *Nature (London)* **159**: 442-444.

Idso, S.B., Reginate, R.J., Hatfield, J.L. and Printer, P.J. Jr. (1981). Measuring yield reducing plant water potential depression in wheat by infrared thermometry. *Irrigation Sci.* **2:** 205-212.

Fischer, R.A. and Maurer, O. (1976). Crop temperature modification and yield potential in dwarf spring wheat. *Crop Sci.* **16:** 855-859.

Jenner, C.F., Ugalda, J.D. and Aspinall, D. (1991). The physiology of starch and protein deposition in the endosperm of wheat. *Aust. J. Plant. Physiol*. **18:** 211-226.

Mc Donald, G.K., Sutton, B.G. and Ellison, F.W. (1983). The effects of time of sowing on the grain yield of irrigated wheat in the Naomi Valley, New South Wales. *Aust. J. Agric. Res.* **34:** 229-240.

Reynold, M.P., Balota, M., Delgado, B.M.I., Amani, I. and Fischer, R.A. (1994). Physiological and morphological traits associated with spring wheat under hot, irrigated conditions. *Aust. J. Plant. Physiol*. **21**: 717-730.

Sharma-Natu, P., Sumesh, K.V., Lohot, V.D. and Ghildiyal, M.C. (2006). High temperature effect on grain growth in wheat cultivars: An evaluation of responses. *Indian J. Plant Physiol* **11:** 239-245.

Slafer, G.A. and Rawson, H.M. (1994). Sensitivity of wheat phasic development to major environmental factors: A re-examination of some assumptions made by physiologist and modellers. *Aust J. Plant Physiol.* **21:** 393-426.

Stones, P.J. and Nicholas, M.E. (1998). The effect of duration of heat stress during grain filling on two wheat varieties differing in heat tolerance, grain growth and fractional protein accumulation. *Aust. J. Plant Physiol* **26:** 453-458.

Zadoks, J.C., Chang, T.T. and Kon Zak, C.F. (1974). A decimal code for growth stages of cereals. *Weed Res*. **14:** 415-421.