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SHORT COMMUNICATION

VARIATION IN PHYSIOLOGICAL TRAITS IN PROMISING WHEAT VARIETIES UNDER LATE SOWN CONDITION

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A field experiment was conducted to study the physiological traits associated with terminal temperature tolerance under late sown irrigated wheat. Results revealed a significant differential genotypic variation for physiological traits with respect to grain yield and its determining attributes under high post anthesis temperature i.e. ± 4.5-6.8 ºC > 28ºC in late sowing. Genotypes, Halna, K8962, GW 173, HD2189, HD2402 and AKW381 exhibited earliness in their flowering, higher canopy temperature depression (CTD), low membrane thermo-stability index (MTI), greater seed size (1000-grain weight), longer grain growth duration and higher grain yield, thereby showed a greater degree of high temperature tolerance as compared to long duration wheat genotypes. These traits are relatively simple and easily observable and can, therefore, be used to screen large number of wheat germplasm for high temperature tolerance. Based on yielding ability, these genotypes are proposed as suitable donor for crossing programme to develop ideal plant type suitable for late sown conditions.

Key words: **Canopy temperature depression, membrane thermostability index, temperature, wheat**

High temperature (>28ºC) during grain development is the single most important factor that limits productivity of wheat in India. Due to intensive cropping system farmers by and large delay wheat sowing, particularly, in wheat grown belt of northern India which ultimately results in exposure of plants to extreme high temperature. This increased temperature hastens the phenological development of crop, reduces total duration of crop growth, grain filling and finally lowering the grain yield and its quality (Monteith 1981, Alkhatib and Paulsen, 1984 Wang *et al.* 1992). The extent and magnitude of growth and yield reduction in crops largely depend on their adaptability to changed climate. A lot of work has been done on the effect of high temperature on growth and yield parameters mostly with old wheat genotypes. Information on high temperature effect on physiological traits associated with heat tolerance in advance wheat genotypes under field condition, however, is still inadequate. Keeping in view the significance of genetic diversity for high temperature tolerance, a field experiment with 12-advanced wheat genotypes was conducted to identify the physiological traits imparting heat tolerance with respect to grain yield under irrigated late sown conditions.

A field experiment with 12 promising wheat genotypes GW 173, GW 190, AKW 381, HD 2189, HD 2428, HD 2402, Halna (K 7903), K 8962, UP 2338, Raj 3765, Nicozari and Tepoca widely differing in their physiological maturity was conducted to findout physiological traits associated with heat tolerance with respect to grain yield under irrigated late sown condition, i.e. by 28th December. The experiment was laid out in RBD with four replications during rabi season at experimental research farm of C.S. Azad University of Agriculture and Technology, Kanpur. The soil of

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experimental field was sandy loam with slightly alkaline (pH 7.5) in reaction. Temperature was regulated by late sowing (Chinoy 1947, Asana and Saini 1962). Data on maximum and minimum temperature were recorded during crop season. The plot size was 5m×0.92m. Seed rate was kept 100 kg/ha. Recommended does of N, P and K @ 12, 60 and 40 kg/ha respectively was given. Physiological traits were recorded as per Zodok *et al.* (1974). The canopy temperature depression (CTD) was measured by infrared thermometer (Teletamp AG 42). Membrane thermostability index was determined by the method described by Deshmukh *et al.* (1991). Total chlorophyll was determined following Arnon (1949). Flag leaf photosynthetic rate was measured by using IRGA LCA-2 (ADC UK). Biomass accumulation rate was determined during grain growth period and value was expressed as mg/plant/day. Grain growth duration was recorded as a total duration taken from anthesis to physiological maturity. Physiological maturity was determined as and when rachis losses its greenish colour. Grain yield and its attributes were recorded at maturity. The statistical analysis for different parameters were worked out as per standard procedure. Correlation coefficients between physiological parameters and yield were also determined.

Data on mean maximum and minimum temperature revealed ±4.5 to 6.8ºC higher temperature during grain development under late sowing. However, temperature remained cooler upto booting stage.

Data recorded on 75 per cent flowering revealed a significant genotypic variation ranged from 69 to 85 DAS under late sowing (Table 1). Among the genotypes, Halna (K 7903) took shorter duration, i.e. 69 DAS for flowering followed by K 8962 and AKW 381 (72 DAS). The maximum duration for 75 per cent flowering was noticed in GW 190 (85 DAS). The maximum temperature during anthesis to grain development were 26.2 to 32.3ºC respectively. Genotypes maintained their inherent

Table 1. Effect of late sowing on phenological and physiological traits associated with heat tolerance in wheat.

Genotypes	Day to anthesis	Days to maturity	Rate of photosynthesis µmol $CO_2/m^2/s^{-1}$	Biomass accumulation rate mg/plant/day	Total chlorophyll mg/g/fw	Membrane thermo stability index (%)	Canopy temperature depression (ºC)
GW 173	74	101	18.19	0.38	1.08	28.50	6.3
GW 190	85	108	20.63	0.32	1.33	38.10	6.2
AKW 381	72	101	20.09	0.37	1.06	29.40	5.8
HD 2189	77	105	21.15	0.33	1.10	34.33	6.3
HD 2428	76	104	18.93	0.36	1.01	31.00	5.8
HD 2402	74	104	22.33	0.40	1.26	30.30	6.9
Halna (K7903)	69	98	17.99	0.35	1.31	27.70	6.8
K 8962	72	100	19.25	0.41	1.40	27.30	6.9
UP 2338	80	106	18.48	0.33	1.42	36.55	6.4
RAJ 3765	76	104	18.88	0.34	1.14	30.83	6.3
NECOZARI	79	107	22.85	0.41	1.37	32.35	6.2
TEPOCA	81	107	21.20	0.31	1.40	33.30	5.8
Mean	76.2	103.7	19.99	0.33	1.24	31.7	6.3
CD at 5%	0.67	0.66	0.04	0.03	0.06	0.12	1.47

characteristics for flowering against high temperature under late sowing.

Seed maturity also varied significantly among genotypes ranging from 98 to 108 days under late sowing (Table 1). Genotypes, Halna (98 DAS). K 8962 (100 DAS) and AKW 381 (100 DAS) took shorter duration for seed maturity compared with other genotypes. GW 190 took longer duration, i.e. 108 DAS for its physiological seed maturity. From the results it was deduced that genotypes with early physiological maturity mostly escaped from the effect of high post anthesis temperature thus proved to be more heat tolerant compared to longer duration genotypes.

The flat leaf photosynthetic rate measured at anthesis varied significantly among genotypes under late sowing (Table 1). The data revealed that longer duration wheat genotypes, viz. Nicozari, Tepoca and GW 190 had relatively higher values of photosynthetic rate ranging from 20.0 to 22.8 µmol CO_2 m^{-2} s^{-1} compared to short duration wheat genotypes except K 8962 and AKW 381 which recorded photosynthetic rate of 19.25 and 20.09 µmol CO_2 m^{-2} s^{-1} respectively. The high photosynthetic rate especially in longer duration wheat genotypes did not reflect any relationship with grain yield. It seems that longer duration genotypes suffer a lot in respect of grain development under rising temperature compared to short duration genotypes.

The data on membrane thermostability index (MT1) in 12 promising wheat genotypes, viz. GW 173, GW 190, AKW 381, HD 2189, HD 2428, HD 2402, Halna (K 7903), K 8962, UP 2338, Raj 3765, Nicozari and Tepoca recorded during anthesis (69-85 DAS) showed significant variation ranging from 27.30 to 38.10 per cent (Table 1). Genotypes Halna (27.3%), K 8962 (27.7%), GW 173 (28.5%), AKW 381 (29.4%) and Raj 3765 (30.8%) had relatively lower values of MTI as compared to other genotypes. From the results it was inferred that the genotypes with lower MTI seems to be associated with heat tolerance positively through maintaining their cellular membrane integrity from damage of high temperature. Results also revealed a positive correlation between MTI and grain yield (=0.378). A significant positive correlation between MTI and grain yield was also reported by Blum and Ebrercon (1981 and Shanahan *et al.* (1990).

Data recorded on canopy temperature depression (CTD) at anthesis stage revealed genotypic variation ranging from 5.8 to 6.8 under late sowing (Table 1). Among the genotypes Halna and K 8962 exhibited higher CTD difference over other genotypes. Genotypes with larger variation in CTD can keep their canopy cooler more efficiently under high temperature and are expected to perform better under late sown environment. Reynold *et al.* (1994) also found a significant positive correlation of yield and CTD in wheat under hot conditions.

A perusal of data (Table 1) revealed a significant genotypic variation in total chlorophyll content ranging from 1.01 to 1.42 mg/g/fresh leaf tissue under late sowing. Maximum and minimum values were noticed in UP 2338 and HD 2428. In general, long duration wheat genotypes, i.e. Nicozari, Tepoca and GW 190 had relatively higher value over early maturity genotypes. Higher chlorophyll did not show any significant relationship with grain yield but maintained their stay green colour for longer time under late sowing.

Genotypes showed a differential trend in their biomass accumulation rate during grain growth after anthesis (Table 1). Significantly maximum and minimum biomass accumulation rate were noticed in K 8962 (0.41) and in Tepoca (0.31) respectively. The other genotypes such as HD 2402, AKW 381 and GW 173 proved to be more efficient in their biomass accumulation compared to other genotypes. This finding revealed the ability of these genotypes for greater transfer of their photosynthates form source to sink site under rising temperature caused by late sowing.

The number of grains per ear showed a significant variation among genotypes under late sown condition (Table 2). Maximum and minimum number of grain per ear were observed in K 8962 (62) and GW 173 (37). From the results it is evident that K 8962 did not show any negative effect of rising temperature on its grain formation thereby proved to be tolerant to high temperature.

Table 2. Effect of late sowing on grain yield and its determining attributes associated with heat tolerance in wheat genotypes.

Genotypes	Productive ears/m^2	Grain number/ ear	1000-grain weight (g)	Grain growth rate (g/m^2/day)	Grain growth rate per heat degree day g/m^2/heat degree day	Grain growth duration (days)	Grain yield g/m^2
GW 173	425	37	36	12.36	0.625	27	337
GW 190	385	52	37	14.18	0.677	23	323
AKW 381	318	39	35	11.55	0.595	29	335
HD 2189	428	55	36	12.17	0.980	28	344
HD 2428	330	39	39	10.98	0.544	28	305
HD 2402	422	53	35	11.67	0.586	30	350
Halna (K7903)	318	43	41	11.73	0.617	29	343
K 8962	352	62	36	13.07	0.674	28	362
UP 2338	340	45	37	11.01	0.532	28	286
RAJ 3765	330	48	34	11.73	0.583	26	331
NECOZARI	413	55	34	10.04	0.486	28	281
TEPOCA	347	56	38	14.23	0.681	26	363
Mean	3.67	48.6	36.5	-	-	27.5	330
CD at 5%	14	2.45	1.8	-	-	0.96	21

Genotypes also exhibited significant variation in their 1000-grain weight (Table 2). Results revealed that K 8962, Halna, HD 2189, GW 190, recorded higher test weight thereby showed a greater degree of tolerance to high post anthesis temperature. The better performance of these genotypes revealed the existence of sink tolerance mechanism. A similar result was also reported by Jenner *et al.* (1991).

Productive ears also varied significantly among genotypes ranging from 318/m^2 to 428/m^2. The maximum and minimum value were obtained in HD 2189 (428/m^2) and Halna (318/m^2) respectively.

The genotypes, viz. Tepoca, GW 190 and K 8962 had higher grain growth rate per day ranging from 13.073 to 14.235 g/m^2/day over rest of genotypes (Table 2). As regards grain growth rates per heat degree K 8962, GW 10 and Halna had relatively high value ranging from 0.617 to 0.677 g/m^2/heat degree. The better performance of K 8962, Halna, HD 2189, HD 2402 and GW 173 may, therefore, be attributed to greater tolerance of their grain development to high post anthesis temperature caused by late sowing.

Grain yield also varied significantly among genotypes under late sowing (Table 2). Genotypes, viz. Tepoca, K 8962, HD 2189 and Halna out yielded in grain yield over rest of genotypes. The higher yield/m^2 in Tepoca and K8962 my be attributed to higher grain number/ear and that of HD 2189 and HD 2402 may be due to their higher productive ears/m^2. The adverse effect of high

temperature on grain yield was also reported by Fisher and Mauser (1976 and Warrington *et al.* (1977).

Data on correlation coefficient revealed positive correlation of grain yield with membrane thermo stability index (r=0.3785) and negative correlation with days to anthesis (r=-0.4220). Thus, this finding revealed involvement of these traits with heat tolerance under late sown conditions.

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REFERENCES

Al-khatib, K. and Paulsen, G.M. (1984). Mode of high temperature injury to wheat during grain development. *Plant Physiol.* **61:** 363-368.

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

Blum, A. and Ebercon, A. (1981). Cell membrane stability as a measure of drought and heat tolerance in wheat. *Crop Sci.* **21:** 43-47.

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

Deshmukh, P.S., Sai Ram, R.K. and Shukla, D.S. (1991). Measurement of ion leakage as a screening technique for drought resistance in wheat genotypes. *Indian J. Plant Physiol.* **34:** 89-91.

Fisher, R.A. and Mauser, O. (1976). Crop temperature modification and yield potential in dwarf spring wheat. *Crop Sci.* **16:** 855-899.

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

Monteith, J.L. 1981). Climate variation and growth of plants. *J. Royal Meteorological Society* **107:** 749-774.

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

Shanahan, J.F., Edwards, I.B., Quick, J.S. and Fenwick, R.J. (1990). Membrane thermo stability in heat tolerance of spring wheat *Crop Sci.* **30:** 247-251.

Wang, Y.P., Handoko, Jr. and Rimmington, G.M. (1992). Sensitivity of wheat growth to increased air temperature for different scenarios of ambient CO_2 concentration and rainfall in Victoria - a simulation study. *Climate Research* **2:** 131-149.

Warrington, I.J., Dunstone, R.I. and Green, L.M. (1977). Temperature effects at three developmental stages on the yield of wheat ear. *Australian J. Agric. Res.* **28:** 11-27.

Zadok, J.C., Chang T.T. and Konzak, C.F. (1974). Weed Res. **14:** 415-421.