GAU Res. J. 2000. 26 (1) : 16-22

Studies on Heat Tolerance in Wheat Genotypes

Sandeep Kumar, Mahendra Singh and R. S. Verma**

Department of Agronomy, G. B. Pant University of Agriculture & Technology, Pantnagar

ABSTRACT

In a field experiment, 10 wheat genotypes were sown timely (Nov. 19) and Late (Dec. 20) to study some of the physiological parameters related to terminal heat stress tolerance. Genotypes and sowing dates had significant influence on memberane thermostability, specific leaf weight, flag leaf chlorophyll content, canopy temperature depression and grain as well as biological yield. Memberane thermostability and specific leaf weight both recorded at anthesis showed negative and positive correlation respectively with both grain or biomass yields. Canopy temperature depression and flag leaf chlorophyll did not show significant association with grain or biological yield.

(Received on 27th July, 1999)

INTRODUCTION

In the present era of intensive agriculture, the increased cropping intensity has pushed more and more area under late sown wheat, which ultimately results in the exposure of plants to high temperature at grain development stage. So the crop is forced to mature without getting its sink demand fulfilled, leading to subnormal grain size. This results in heavy yield losses because of heat stress during grain filling period.

Wheat genotypes show variation in their heat stress tolerance, which may be attributed to the difference in various physiological traits. Therefore, the present investigation was aimed to studying some of the physiological parameters, which may have bearing on terminal heat stress tolerance of wheat genotypes.

MATERIALS AND METHODS

A field experiment was conducted with 10 wheat genotypes (HD 2501, K 8962, K 9329, NIAW 34, PBW 226, PBW 373, UP 2338, UP 2425, Raj 3765 and Sonalika) during the *rabi* season of 1997-98 in split plot design with three replications. The treatments comprised of two dates of sowing (Nov. 19 & Dec. 20) as main plot and varieties as sub plot treatment.

Memberane thermostability in terms of relative injury (RI%) was recorded by the method described by Saadalla *et al.*, (1990). Flag leaf chlorophyll content was extracted in dimethyl sulphoxide (DMSO) by the method given by Hiscox and Israelstam (1979). Canopy temperature depression was recorded using infrared thermometer (Telatemp AG-42) during grain growth period. Specific flag leaf weight was determined by dividing flag leaf dry weight

** Present address : Professor, Deptt. of Agronomy, G. B. Pant Uni. of Agri. & Technology, Pantnagar - 263 145, U. S. Nagar (U.P.).

by its area recorded with the help of automatic area meter.

The field was prepared after pre-sowing irrigation. The crop was manually sown in rows opened 23 cm apart with 300 seeds per square metre. The crop was adequately fertilized with 120 kg nitrogen and 60 kg P_2O_5 per ha through urea and DAP. Half dose of nitrogen and full dose of phosphorus were applied at the time of sowing and remaining half dose of nitrogen was top dressed at crown root initiation stage i.e. 25 days after sowing. The crop was harvested at maturity and the grain as well as biological yield was reported on the basis of net plot (3.68 m^2) harvested. The coefficient of correlation (r) between yield and different physiological parameters was computed on the basis of mean values for varieties.

RESULTS AND DISCUSSION

Significant increase in the relative injury (RI%) was noticed with delay in sowing after Nov. 19 (Table 1). The highest and lowest memberane injury was recorded in variety K 9329 and NIAW 34, respectively at anthesis in Nov. 19 sown crop, while variety Sonalika and PBW 373 showed the highest and lowest relative injury at anthesis under late sown conditions. Under late sown crop, variety Sonalika at 15 days after anthesis also showed the highest relative injury. The reason for highest relative injury in case of Sonalika than other varieties may be the heavy rust incidence which might have damaged cell memberane leading to solute leakage from its cell than that of all other varieties. Saadalla *et al.* (1990) found considerable genetic variation in relative injury. Relative injury increased during a fortnight after anthesis. Porter *et al.* (1994) also made similar observations. Membrane injury at the time of anthesis showed significant and negative correlation with grain as well as biological yield, indicating that the genotypes in which cell memberane can tolerate high temperature stress and show less injury, yielded more than those

TABLE 1

Effect of sowing dates, genotypes and their interaction on memberane thermostability (Relative injury %) and specific leaf weight (mg cm^{-2}) at anthesis.

Sr. No.	Genotypes	Memberane thermostability (RI %)						Specific leaf weight		
		0 DAA			15 DAA					
		Nov.19	Dec.20	Mean	Nov.19	Dec.20	Mean	Nov.19	Dec.20	Mean
1.	HD 2501	5.87	7.18	6.53	20.57	29.79	25.18	3.59	4.83	4.21
2.	K 8962	6.00	9.21	7.61	21.06	38.70	29.88	4.04	5.12	4.58
3.	K 9329	9.07	5.10	7.08	26.66	29.85	28.26	4.29	4.99	4.64
4.	NIAW 34	2.00	4.31	3.16	15.76	35.58	25.67	6.42	5.08	5.75
5.	PBW 226	6.48	9.28	7.88	25.81	38.17	31.99	3.72	6.42	5.07
6.	PBW 373	2.37	3.07	2.72	16.07	20.50	18.29	6.67	5.80	6.23
7.	UP 2338	2.42	4.52	3.47	15.57	30.80	33.18	3.93	5.99	4.96
8.	UP 2425	5.61	4.22	4.92	20.83	26.10	23.47	3.89	5.02	4.46
9.	Raj 3765	3.36	3.47	3.67	18.50	27.72	23.11	4.24	4.91	4.58
10.	Sonalika	4.12	10.44	7.28	22.04	47.15	34.60	3.97	5.04	4.51
	Mean	4.73	6.13	5.43	20.29	32.44	26.36	4.48	5.32	4.90

Table 1 (contd.)

	SEM ±	CD(5%)	SEM ±	CD(5%)	SEM ±	CD(5%)
Dates	0.01	0.07	0.02	0.14	0.02	0.14
Genotypes	0.05	0.12	0.11	0.30	0.05	0.16
For comparing two genotypes at same sowing date	0.07	0.19	0.15	0.43	0.08	0.22
For comparing two dates for same or different genotypes	0.06	0.19	0.14	0.42	0.08	0.24

DAA - Days after anthesis

which were susceptible to heat stress at anthesis. Coefficient of correlation between yield and memberane injury at 15 days after anthesis was also negative but it was not up to the level of significance.

Significantly higher specific leaf weight was recorded in Dec. 20 sown crop as compared to Nov. 19 sown crop(Table-1). Although delay in sowing resulted in the reduction in both the area and dry weight of flag leaf but due to more reduction in flag leaf area as compared to flag leaf dry weight, Dec. 20 sown crop showed significantly higher specific leaf weight than Nov. 19 sown crop. PBW 373 and PBW 226 produced the highest specific leaf weight under normal and late sown conditions respectively, while variety HD 2501 showed the lowest specific leaf weight under both the showings.

Highly significant positive correlation was found between specific leaf weight and grain as well as biomass yield (Table-2). Considerable differences in the specific leaf weight of different cultivars have been reported by Zhu. *et al.*, (1982).

TABLE 2

Effect of sowing dates, genotypes and their interaction on flag leaf chlorophyll content (mg g^{-1} fresh weight) at anthesis and 15 days after anthesis and canopy temperature depression (°C) during grain growth period.

Sr. No.	*Genotypes*	*Chlorophyll content*						*Canopy temperature depression*		
		0 DAA			*15 DAA*					
		Nov.19	*Dec.20*	*Mean*	*Nov.19*	*Dec.20*	*Mean*	*Nov.19*	*Dec.20*	*Mean*
1.	HD 2501	0.83	1.86	1.34	2.76	1.81	2.29	1.97	3.17	2.56
2.	K 8962	1.23	2.05	1.64	1.69	1.62	1.66	0.97	1.23	1.10
3.	K 9329	1.67	2.00	1.83	2.38	1.48	1.93	1.93	3.40	2.67
4.	NIAW 34	1.20	1.81	1.51	2.28	1.73	2.00	1.93	4.37	3.15
5.	PBW 226	1.39	2.06	1.72	2.03	1.95	1.99	2.37	4.20	3.28
6.	PBW 373	1.28	1.55	1.41	3.12	1.58	2.35	2.67	3.43	3.05
7.	UP 2338	1.27	1.71	1.49	2.15	1.88	2.02	2.07	3.53	2.80
8.	UP 2425	1.00	1.95	1.48	2.00	2.03	2.01	2.47	3.60	3.03
9.	Raj 3765	1.10	2.00	1.55	3.16	1.89	2.52	1.67	2.27	1.97
10.	Sonalika	1.10	1.98	1.54	2.07	1.11	1.59	1.10	3.40	2.25
	Mean	1.21	1.90	1.55	2.36	1.71	2.04	1.91	3.26	2.59

Table - 2 (contd.)

	SEM ±	CD(5%)	SEM ±	CD(5%)	SEM ±	CD(5%)
Dates	0.01	0.08	0.01	0.07	0.03	0.15
Genotypes	0.02	0.05	0.02	0.05	0.09	0.26
For comparing two genotypes at same sowing dates	0.02	0.06	0.02	0.07	0.13	0.36
For comparing two dates for same or different genotypes	0.03	0.10	0.02	0.09	0.12	0.37

DAA - Days after anthesis

At the time of anthesis, the chlorophyll content was significantly higher in Dec. 20 sown crop than Nov. 19 sown crop but 15 days after anthesis the pattern was just opposite (Table-2). It appears that temperature played an important role in the synthesis of chlorophyll. At the time of anthesis temperature was more favourable for chlorophyll synthesis in Dec. 20 sown crop and was low in case of Nov. 19 sown crop. But rising temperature during a fortnight after anthesis became more favourable in case of Nov. 19 sown crop than in Dec. 20 sown crop. At the time of anthesis, the other possible reason may be its higher specific leaf weight. Variety K 9329 and PBW 226 produced the highest chlorophyll content under normal and late sown conditions, respectively, while variety HD 2501 and PBW 373 produced the lowest chlorophyll content in their flag leaf under normal and late sown crop, respectively. Hari Kumar (1989) also found variation in the chlorophyll content of different wheat varieties. The lower chlorophyll content of variety K 8962 and Sonalika can be attributed to the heavy incidence of brown rust. Flag leaf chlorophyll content did not show significant correlation with grain or biological yield indicating that the leaf chlorophyll was not a limiting factor. According to Kasanga and Monsi (1954) most higher plants contain atleast the level of chlorophyll required for carbon dioxide assimilation and excess chlorophyll is not related to production.

Significantly higher canopy temperature depression (CTD) was found under late sown conditions as compared to normal sown conditions (Table-2). Under normal sown conditions (Nov. 19) variety PBW 373 and under late sown conditions, variety NIAW 34 showed the highest canopy temperature depression. The lowest canopy temperature depression was recorded in variety K 8962 under both the dates of sowing. The canopy temperature depression did not show any relation with grain or straw yield. Canopy temperature depression varies with change in the number of external variables, like, soil moisture, wind velocity and its turbulence and cloud cover in field conditions. Frequent rainfall during grain growth period when CTD was recorded on a bright day, might be the reason for non-significant correlations between CTD and grain for biological yield. Amani *et al.*, (1996) reported a significant positive correlation between canopy temperature depression (CTD) and yield.

The grain yield was significantly affected by sowing dates. The highest mean grain yield was obtained in Nov. 19 sown crop. Delay in sowing (Dec. 20) resulted in significant reduction in mean grain yield (Table-3). On an average, variety PBW 373 significantly out yielded all other varieties. It was followed by NIAW 34, Raj 3765 which statistically did not differ in their grain yield. The lowest grain producing variety K 8962 was followed by HD 2501 and UP 2425.

In Nov. 19 sowing variety NIAW 34 and in Dec. 20 sowing PBW 373 yielded significantly higher than all other varieties. In Dec. 20 sowing variety K 8962 and in Nov. 19 sowing UP 2425 produced significantly lower grain yield than all other varieties. Higher grain yield from timely than late sown crop has also been reported by Naik *et al.*, (1991) and Singh (1988).

TABLE 3

Effect of sowing dates, genotypes and their interaction on grain yield and biological yield (t ha^{-1}).

Sr. No.	*Genotypes*	*Grain yield*			*Biological yield*		
		Nov.19	*Dec.20*	*Mean*	*Nov.19*	*Dec.20*	*Mean*
1.	HD 2501	3.71	3.12	3.42	11.62	9.78	10.70
2.	K 8962	3.75	2.91	3.33	11.67	9.51	10.59
3.	K 9329	3.69	3.73	3.71	11.65	9.05	10.35
4.	NIAW 34	4.71	3.68	4.20	13.51	9.35	11.43
5.	PBW 226	4.51	3.71	4.11	11.44	9.53	10.49
6.	PBW 373	4.59	4.28	4.43	13.11	11.92	12.51
7.	UP 2338	4.28	3.49	3.88	11.53	9.86	10.70
8.	UP 2425	3.57	3.72	3.65	10.76	9.93	10.35
9.	Raj 3765	4.53	3.78	4.16	11.97	9.47	10.72
10.	Sonalika	4.32	3.19	3.76	11.96	9.29	10.63
	Mean	4.17	3.56	3.86	11.92	9.77	10.85
			SEM ±	CD(5%)		SEM ±	CD (5%)
Dates			0.01	0.07		0.04	0.24
Genotypes			0.02	0.06		0.06	0.17
For comparing two genotypes at same sowing date			0.02	0.08		0.08	0.24
For comparing two dates for same or different genotypes			0.02	0.10		0.09	0.31

DAA - Days after anthesis

TABLE 4

Correlation coefficients between yield and different physiological parameters.

Sr. No.	Parameters	'r' value	
		Grain yield	Biological yield
1.	Memberane thermostability (RI%)		
	0 DAA	-0.644*	-0.649*
	15 DAA	-0.374	-0.606
2.	Canopy temperature depression	0.552	0.279
3.	Specific leaf weight	0.805**	0.877**
4.	Chlorophyll content		
	0 DAA	-0.073	-0.468
	15 DAA	0.489	0.397

RI % : Relative injury per cent.

There was significantly lower biological yield in Dec. 20 sowing than in Nov. 19 sowing (Table-3). The late sown crop was forced to mature earlier without fulfilling its requirements during vagetative and reproductive period due to rise in temperature in the month of February resulting lower grain as well as straw yield than timely sown crop. Tewari (1990) and Rao (1986) also reported that late sowing resulting in reduction in biological yield.

The highest biological yield was recorded in NIAW 34 followed by PBW 373 and lowest by of 2425 under normal sown conditions (Nov. 19). Varieties PBW 373 and K 9329, respectively produced the highest and lowest biological yield than all other varieties under late sown conditions.

REFERENCES

Amani, I; Fischer, R. A. and M. P. Reynalds. 1996. Canopy temperature depression associated with yield of irrigated spring wheat cultivars in a hot climate. *J. Agron. and Crop Sci.* **176** (2) : 119-129.

Hari Kumar, S. J. 1989. Studies on growth, photosynthetic characteristics, grain development and yield of wheat genotypes under normal and late sowing. Thesis, M. Sc. Ag. (Agron.) G. B. Pant Univ. of Agri. & Tech., Pantnagar, (Nainital).

Hiscox, J. D. and G. F. Israelstam, 1979. A method for extraction of chlorophyll from leaf tissue without maceration. *Cand. J. Bot.* **57** : 1332-1334.

Kasanga, H. and M. Monsi, 1954. On the light transmission of leaves and its meaning for the production of dry matter in plant communities. *Japan J. Bot.*, **14** : 304-324.

Naik, P. L., Patel, R. A. and K. K. Kalaria, 1991. Response of wheat *(Triticum aestivum)* varieties to sowing date and seed rate, *Indian J. Agron.*, **36** : 225 - 226.

Porter, D. R.; Nguven, H. T. and J. J. Bruke, 1994. Quantifying acquired thermal tolerence in winter wheat. *Crop Sci.*, **34** : 1686-1989.

Rao, Y. H., 1986. Influence of sowing dates on growth, grain, development and yield of wheat genotypes. Thesis, Ph. D. (Agron.) G. B. Pant Univ. of Agric. & Tech., Pantnagar (Nainital).

Saadalla, M. M. : Shanahan, J. F. and J. S. Quick, 1990. Heat tolerance in winter wheat I. Hardening and genetic effect on membrane thermostability. *Crop Sci.*, **30** : 1243-1247.

Singh, Dharam Pal, 1988. Studies on photosynthesis, growth, development and yield of wheat genotypes under different sowing dates. Thesis, M.Sc. Ag. (Agron.) G. B. Pant Univ. of Agri. & Tech., Pantnagar, (Nainital).

Tewari, shree Krishna. 1990. Evaluation of productivity constraints of wheat *(Triticum aestivum* L.) under late sown conditions. Thesis, Ph. D. (Agron.) G. B. Pant Univ. of Agric. & Tech., Pantnagar (Nainital).

Zhu, D. Q.: Zhu, X. L.; Zhan, ZH. and B. Z. Qi, 1982. The relationship between photosynthetic characters of main shoot flag leaf in winter wheat c.f. *Field Crop Abs.* (1983). **36** : 4150.