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EFFECT OF HEAT STRESS ON BIOPHYSICAL AND BIOCHEMICAL PARAMETERS IN DIFFERENT WHEAT SPECIES

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Introduction

Wheat (*Triticum* spp.) is one of the most important cereal crops of the world. Wheat is a winter season crop grown in the tropics and subtropics despite the relatively high temperature that occur during the growth cycle. Heat stress is an important constraint to wheat productivity affecting growth stages specially anthesis and grain filling. It has already been established that heat stress can be a significant factor in reducing the yield and quality of wheat and is a major challenge to wheat productivity in India (Joshi *et al*., 2007).

Methods

A field experiment was conducted to evaluate the effect of heat stress on biophysical and biochemical parameters in different wheat species under normal irrigated conditions. The experiment consisted of 12 genotypes belonging to the cultivated species; *Triticum aestivum*, *Triticum durum* and *Triticum dicoccum* and were arranged in a factorial randomized block design (FRBD) with three replications. The low temperature regimes was maintained by early or normal sowing and high temperature regime was maintained by late sowing and also daily maximum and minimum temperature recorded under both the temperature regimes of crop growth. The biophysical parameters like membrane thermostability, relative water content,canopy temperature and heat stress index and biochemical parameters like chlorophyll stability index, wax deposition were studied.

Results and Discussion

The data on the grain yield (tables 1 and 2) indicated that it was significantly influenced by temperature regimes, genotypes and their interaction. In general, there was reduction in grain yield due to high growth temperature. Among the genotypes, UAS-439 (5566.79 kg ha^{-1}) recorded significantly higher grain yield and HI-1571 (4125.08 kg ha^{-1}) recorded the lowest yield under low temperature regime. The genotype, NIAW-1415 had the lowest per cent reduction in grain yield (9.4%) followed by HW-1098 (9.8%) and DDK-1029 (9.9%). Among the genotypes, UAS-439 had significantly higher HI (54.13%) and HI-1571 (38.53%) had lowest HI under low temperature regime. Acevedo *et al*. (1990) reported that heat stress during anthesis to maturity affects mainly assimilate availability, translocation of photosynthates to grain and the synthesis and deposition of starch in the developing grain. The maximum 1000-grain weight was recorded in UAS-439 in both the temperature regimes followed by UAS-415. The 1000-grain weight was reduced due to high growth temperature in all the genotypes. The lowest weight was recorded in HI-1571 under both temperature regimes. The reduction in the total grain weight due to elevated growth temperatures was mainly attributed to a reduction in individual grain weight and a small reduction in grain number (Bhullar and Jenner, 1983).

Maximum RWC (table 3) was observed in UAS-439 (75.6%) and UAS-415 (51.6%) at low and high growth temperature and the minimum RWC was observed in UAS-320 (57.6%) and NIAW-34 (30.7%) at low and high growth temperature, respectively at 90 DAS. The RWC varied from 8.2 per cent (MACS-2971) to 27 per cent (UAS-415) at low temperature regime and at high temperature regime, 7.7 per cent (DDK-1025) to 25.4 per cent (UAS-415).The membrane thermo stability (MTS) varied from 11.4 (NIAW-1415) to 23.5 per cent (DDK-1029) at low temperature regime and at high temperature regime (table 3). The MTS varied from 10.2(UAS-320) to 21.3 per cent (DDK-1029). Blum (1988) reported that cell membrane thermo stability is a

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Table 1 : Influence of temperature regimes on grain yield (kg ha^{-1}) and harvest index (%) in wheat genotypes.

Genotypes	Grain yield (kg ha^{-1})			Harvest index (%)		
	Temperature regimes					
	Low	High	Mean	Low	High	Mean
UAS-320	4700.00	4194.43 (10.8)*	4447.22	43.92	39.97	41.95
NIAW-1415	4505.55	4083.33 (9.4)	4294.44	41.66	39.70	40.68
NIAW-34	4416.68	3777.78 (14.5)	4022.22	41.42	36.73	39.08
HI-1571	4125.08	3627.76 (12.1)	3951.43	38.53	35.27	36.90
DWR-1006	4611.13	4119.45 (10.7)	4365.29	44.84	40.78	42.81
UAS-415	5277.76	4416.00 (16.3)	4846.88	51.32	42.94	47.13
UAS-428	5261.12	4366.00 (17.0)	4813.56	51.16	42.45	46.80
UAS-439	5566.79	4416.66 (20.7)	4991.72	54.13	42.95	48.54
DDK-1025	4716.66	4250.03 (9.9)	4483.35	45.86	41.33	43.59
DDK-1029	4855.55	4283.00 (11.8)	4569.27	47.21	41.65	44.43
MACS-2971	4921.55	4344.43 (11.7)	4632.99	47.85	42.24	45.05
HW-1098	4555.55	4111.12 (9.8)	4333.33	44.30	40.06	42.18
Mean	**4792.78**	**4165.83**		**46.02**	**40.51**	

	S.Em.±	C.D. at 5%	S.Em.±	C.D. at 5%
Temperature regimes	68.03	258.50	0.44	1.65
Genotypes	166.63	633.20	1.06	4.05
Interaction	235.65	895.48	1.51	5.72

* Figures in the parentheses indicate per cent decrease over low temperature regimes.

Table 2 : Influence of temperature regimes on 1000-grain weight (gm), number of spikes per hill, spike length (cm) and spike weight per spike (gm) at harvest in wheat genotypes.

Genotypes	1000-grain weight (gm)			Number of spikes per hill			Spike length (cm)			Spike weight (gm)		
	Temperature regimes											
	Low	High	Mean	Low	High	Mean	Low	High	Mean	Low	High	Mean
UAS-320	49.44	46.32	47.88	6.0	5.2	5.6	16.19	15.28	15.74	2.58	2.49	2.54
NIAW-1415	47.44	43.92	45.68	5.3	4.7	5.0	13.73	13.22	13.47	2.33	2.22	2.28
NIAW-34	47.39	43.83	45.61	5.0	4.6	4.8	13.21	12.77	12.99	2.19	2.09	2.14
HI-1571	47.04	43.20	45.12	5.0	4.1	4.6	12.80	12.13	12.47	2.14	1.91	2.03
DWR-1006	48.36	45.73	47.04	6.0	5.0	5.5	15.21	15.10	15.16	2.37	2.32	2.35
UAS-415	52.54	51.74	52.14	8.0	6.3	7.2	18.37	17.73	18.05	3.26	3.03	3.15
UAS-428	52.28	49.78	51.03	8.0	6.0	7.0	17.50	16.51	17.00	3.05	2.98	3.01
UAS-439	57.46	53.28	55.37	8.0	7.3	7.7	18.91	18.28	18.60	3.65	3.57	3.61
DDK-1025	49.86	46.82	48.34	6.5	5.4	6.0	16.37	15.48	15.93	2.61	2.51	2.56
DDK-1029	51.18	47.18	49.18	7.0	5.6	6.3	16.88	16.15	16.52	2.81	2.70	2.76
MACS-2971	51.35	48.50	49.93	7.1	5.8	6.5	17.40	16.31	16.85	3.05	2.83	2.94
HW-1098	48.21	45.51	46.86	6.0	4.8	5.4	14.53	13.53	14.03	2.36	2.29	2.33
Mean	**50.21**	**47.15**		**6.49**	**5.41**		**15.92**	**15.21**		**2.70**	**2.58**	

	S.Em.±	C.D. at 5%	S.Em.±	C.D. at 5%	S.Em.±	C.D. at 5%	S.Em.±	C.D. at 5%
Temperature regimes	0.27	1.02	0.09	0.35	0.21	0.81	0.04	0.15
Genotypes	0.66	2.50	0.22	0.85	0.52	1.99	0.10	0.37
Interaction	0.93	3.53	0.32	1.20	0.74	NS	0.138	NS

Table 3 : Influence of temperature regimes on relative water content (%), membrane thermo stability index (%) and canopy temperature (^{0}C) in wheat genotypes.

Genotypes	Relative water content (%)			Membrane thermo stability index (%)			Canopy temperature (^{0}C)		
				Temperature regimes					
	Low	High	Mean	Low	High	Mean	Low	High	Mean
UAS-320	57.6	31.7	44.7	16.8	10.2	13.5	40.19	36.48	38.33
NIAW-1415	69.0	37.3	53.1	11.4	10.4	10.9	39.35	39.03	39.19
NIAW-34	67.2	30.7	49.0	16.3	15.2	15.7	39.53	39.40	39.47
HI-1571	68.0	49.7	58.9	19.4	18.4	18.9	38.79	37.70	38.25
DWR-1006	69.4	41.3	55.4	21.5	19.3	20.4	40.80	39.25	40.03
UAS-415	59.7	51.6	55.7	19.4	18.6	19.0	39.46	38.55	39.01
UAS-428	58.2	44.2	51.2	18.5	14.3	16.4	39.94	39.87	39.91
UAS-439	75.6	46.3	60.9	18.5	16.3	17.4	39.59	39.07	39.33
DDK-1025	64.1	41.5	52.8	22.8	20.1	21.5	40.28	36.27	38.27
DDK-1029	58.9	47.5	53.2	23.5	21.3	22.4	38.44	36.59	37.52
MACS-2971	70.1	45.5	57.8	16.0	14.3	15.2	38.96	38.54	38.75
HW-1098	64.7	42.8	53.7	16.7	14.2	15.4	40.44	35.29	37.87
Mean	**65.2**	**42.5**		**18.4**	**16.1**		**39.65**	**38.00**	

	S.Em.±	C.D. at 5%	S.Em.±	C.D. at 5%	S.Em.±	C.D. at 5%
Temperature regimes	1.1	4.0	0.6	2.2	0.11	0.37
Genotypes	2.6	9.7	1.4	5.4	0.24	0.92
Interaction	3.6	13.8	2.0	NS	0.34	1.29

Table 4 : Influence of temperature regimes on heat stress index in high and low temperature regimes in wheat genotypes.

Genotypes	Heat stress index
UAS-320	0.60
NIAW-1415	0.83
NIAW-34	0.62
HI-1571	0.67
DWR-1006	0.66
UAS-415	0.70
UAS-428	0.74
UAS-439	0.74
DDK-1025	0.66
DDK-1029	0.81
MACS-2971	0.74
HW-1098	0.66
Mean	**0.70**

The 'S' was used to characterize the relative heat stress tolerance of the various species ($S \leq 0.50$ highly stress tolerant, $S>0.5 \leq 1.00$ moderately stress tolerant and $S>1.00$ susceptible).

fair index of genetic variation in heat tolerance that bears a reasonable relationship to plant performance under heat stress. The canopy temperature (table 3) varied from 38.44°C (DDK-1029) to 40.44°C (HW-1098) at low temperature regime and at high temperature regimes, 35.29°C (HW-1098) to 39.87°C (UAS-428). The heat stress index (table 4) was more in NIAW-1415 (0.83) followed by DDK-1029 (0.81), the minimum heat stress index was observed in UAS-320 (0.60).

The maximum chlorophyll stability index (table 5) was observed in DWR-1006 (85.5%) followed by UAS-428 (79.2%) and the minimum chlorophyll stability index was noticed in DDK-1025 (58.4%)and UAS-439 (58.8%) at low and high temperature regimes, respectively. The differences in the chlorophyll stability index due to temperature regimes, irrespective of genotypes indicated a significant reduction due to increase in the growth temperature. Highest wax deposition (table 5) was observed in UAS-439, lowest was observed in DWR-1006 in low temperature regime. Glaucosness, which is the visible manifestation of epicuticular wax, has been found to increase the grain yield and dry matter of drought tolerant wheat and the time of development of epicuticular wax is an important factor (Richards, 1984).

Conclusion

Though, the grain yield per hectare was low in HI-1571 and NIAW-34, the reduction due to high temperature was very low in these genotypes thus indicating the high temperature tolerance.

Table 5 : Influence of temperature regimes on chlorophyll stability index (%) and wax deposition (mg dm^{-2}) in wheat genotypes.

Genotypes	Chlorophyll stability index (%)			Wax deposition (mg dm^{-2})		
	Temperature regimes					
	Low	High	Mean	Low	High	Mean
UAS-320	72.7	70.4	71.6	0.68	1.79	1.24
NIAW-1415	74.8	68.1	71.4	0.85	1.82	1.33
NIAW-34	68.0	59.0	63.5	0.39	0.87	0.63
HI-1571	76.8	66.8	71.8	0.51	1.03	0.77
DWR-1006	85.5	80.3	82.9	0.21	1.04	0.63
UAS-415	78.1	71.0	74.6	0.45	0.95	0.70
UAS-428	79.2	78.0	78.6	0.68	1.07	0.87
UAS-439	59.6	58.8	59.2	1.16	1.76	1.46
DDK-1025	58.4	58.4	58.4	0.98	1.11	1.04
DDK-1029	74.9	74.3	74.6	0.91	1.76	1.33
MACS-2971	77.2	75.5	76.3	0.56	1.08	0.82
HW-1098	71.8	67.8	69.8	0.32	1.01	0.67
Mean	**73.1**	**69.0**		**0.64**	**1.27**	

	S.Em.±	C.D. at 5%	S.Em.±	C.D. at 5%
Temperature regimes	1.3	5.0	0.02	0.07
Genotypes	3.2	12.2	0.04	0.17
Interaction	4.5	NS	0.06	0.24

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