International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(5): 1388-1391
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Received: 14-07-2018
Accepted: 18-08-2018

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Effect of elevated temperature on growth and development at different stages of wheat genotypes

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Abstract
A field experiment was conducted during *rabi season* of 2012-13 on the topic entitled "Effect of elevated temperature on growth and development at different stages of wheat genotypes" viz. PBW-502, PBW-343, PBW-443, PBW-154, K-7903, HUW-234, UP-262, RAJ-3077 HD-2733 and Kundan experiment was conducted at Instructional farm, of Narendra Deva University of Agriculture and Technology, Narendra Nagar, Kumarganj, Faizabad (U.P.) under 0.5^0C elevated temperature at 30-50 DAS and further increase from 0.5-1.0^0C at 50-70 DAS, respectively. The morphology and physiology of all wheat genotypes were studied under heat stress condition.

Keywords: elevated temperature, chlorophyll content, etc.

Introduction
Changes to the global climate, notably to regional spatial and temporal temperature patterns (Houghton *et al.*, 1996) [2], from increased atmospheric concentrations of greenhouse gases are predicted to have important consequences for crop production (Parry, 1990) [6]. Both plant growth and development are affected by temperature (Porter and Moot, 1998) [7]. Investigations of the effects of changes in mean annual temperature on agricultural crops (Kenny *et al.*, 1993) [5] have used crop climate simulation models and experiments (e.g. Wheeler *et al.*, 1996a, b) [11]. Such efforts have advanced understanding of the effects of annual mean climatic changes on crop production to the extent that we can now predict the implications of mean climatic change for wheat production with some confidence. Wheat is a cool–season crop, hence cool weather during vegetative development and warm weather for maturity is deemed ideal for wheat The lowest minimum cordinal temperature for wheat is 4-5^0C & is called the base temperature, The optimum cordinal temperature about 25^0Cand the maximum about 30-32^0C is best temperature in north west India. Warm temperature during the early growth of wheat may retard heading. The impact of even short period of high temperatures during the grain period setting in wheat crop cause to reduce the yield significantly. For the evaluation of the effect of high temperatures on yield in addition the temperature, the planting date is equally important as it influences the developmental stage of the crop especially when the high temperatures occur around flowering period where most annual crops are extremely sensitive to high temperature stress. In South Portugal, as well as in other Mediterranean environments, the rising temperatures of Spring, wheat during the late phases of its development and, particularly, the beginning of heading and after anthesis, was considered as an important factor limiting the yield. High temperatures, above 30 ^{0}C,affect the grain weight by reducing the duration of grain filling, due to the suppression of photosynthesis (Khatib and Paulsen, 1984) [4] and by inhibition of starch synthesis in the endosperm (Jenner, 1994) [3]. Most of the available information is centred on the post-anthesis effects of temperature, there is ample evidence that temperature during pre-anthesis can modify, not only the final grain weight, but also grain number (Wardlaw *et al.*, 1989) [10]. Pre-anthesis effects may be related with reduction in 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) [1]. The optimum temperature range for reaching maximum kernel weight is 15-18ºC; 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) [8].

In addition to temperature water is also an important factor for production of wheat especially during the grain filling period in many parts of the world. In Punjab, the optimum wheat sowing time is from 1st. November to 25th. November. However, wheat sowing is often delayed, under cotton-wheat, sugarcane-wheat and rice-wheat cropping pattern due to late picking of cotton, late start of sugarcane mills and late harvest of paddy in these are increases crop respectively. These delayed wheat sowing even after 25th. December or even some times 10th. January (due to erratic rainfall in 2nd fortnight of December) in around 40 % of the 6.379 million hectares of Punjab causes the great loss of yield due to high temperature during its grain filling period. Consequently, it curtailed the total production of Punjab to 17.375 million tones with an average of 2724 kg ha-1 during 2004-05. Delayed planting reduced the plant height, days to heading, days to maturity and grain filling duration and ultimately showed the reduction in yield.

Materials and Methods

The present investigation entitled "Effect of elevated temperature on growth and development at different stages of wheat genotypes" was carried out during *Rabi* 2012-13 at Instructional farm, of Narendra Deva University of Agriculture and Technology, Narendra Nagar, Kumarganj, Faizabad (U.P.). The experimental site is located at the main campus Narendra Deva University of Agriculture & Technology, Kumarganj, Faizabad at a distance of about 42 km. away from district headquarter on Faizabad – Raibarelly road. The geographical situation of experimental site lies at latitudes 26^0 47' North and longitude 82^0 12' East and altitude of 113 meter from mean sea level in the Indo gangetic alluvium of eastern Uttar Pradesh. The experiment was conducted in Randomized Block Design (RBD). The different growth parameters studied were wheat cultivars as plant height (cm), leaf area index, chlorophyll content (mg/g fresh weight), dry matter(g/m^2).

Results

Presented in table-1 it is observed that plant height in all the varieties under heat trapping at initial stage H_1 (30 DAS to 50 DAS) is higher under heat stressed condition of 0.5^0C over control (H_0). Maximum plant height 55.2 cm. was recorded in variety V_8 followed by V_5 respectively. The varieties V_1, V_2, V_3, V_9, V_{10} are significant among each other under trapping and other varieties are either differ significantly or at par among each other. The maximum reduction growth in plant height was observed in V_3 (-7.69%) followed by V_1(-5.78%) over control. Thus the variety V_3 is least susceptible followed by V_1 for plant growth at elevation of 0.5^0C canopy temperature over ambient at early stages of heat trapping. This implies that varieties V_8& V_5 are highly sensitive in relation to plant height under high thermal environment. V_3& V_1 are more heat tolerant at 0.5^0C elevated temperature over ambient at vegetative stage.

Presented in table-2 the plant height variation under heat trapping of 1^0C elevation over ambient at reproductive stage (50 to 70 DAS), it is revealed that all varieties are significant or at par among each other. The variety V_1, V_2, V_4, V_5, V_6, V_7, V_8, V_9 are significant while V_2 and V_{10} are at par among each other. It is also observed from table that V_5& V_8though attained minimum plant height 60.4 cm. but posses maximum growth rate (42%) and at par with V_4 (40%) as compare to before heat trapping followed by V_3& V_2, hence these varieties are least susceptible at elevated temperature of 1.0^0C as compare to other varieties. Also tolerance of variety V_6, V_1, V_{10}, V_2, V_8, V_9, V_7, V_3 arein decreasing order at 50 to 70 DAS.

Presented in table-3 it is revealed that maximum leaf area index 3.86 was recorded in variety V_7 followed by V_6, V_1, V_4, V_9, V_{10}, V_2, V_8 & V_2 at 0.5^0C elevation over ambient at vegetative stage heat trapping. Except V_6& V_7 all varieties are significantly differ among each other. Higher elevation of temperature from 0.5 to 1.0^0C at reproductive stage (H_2) revealed that leaf area index decreased at 70 DAS as compare to 50 DAS but significant differences were recorded in all varieties among each other. In spite of reduction in leaf area index (LAI), maximum LAI was observed in variety V_7 followed by V_4, V_8, V_5, V_1, V_2, V_3, V_9& V_{10}.

Presented in table-4 for total chlorophyll content of wheat genotypes under elevated temperature of 0.5^0C at vegetative stage (30-50 DAS) and 1.0^0C at reproductive stage (50-70 DAS), revealed that chlorophyll content significantly differ in all varieties under heat trapping of H_1 but no definite trend of variation was recorded over control. Though variety V_2 contained maximum chlorophyll content 3.9 followed by V_4, V_7, V_5, V_8, V_3, V_6& V_1 etc. in H_1 condition of heat trapping under heat trapping condition of H_2 variety V_3 possess maximum (4.6) chlorophyll content followed by V_7, V_5, V_6, V_{10}, V_2, V_9& V_1. In H_2 also no definite trend was recorded for chlorophyll variation hence no conclusion can be sown.

Presented in table-5 for dry matter of wheat genotypes revealed that under elevated temperature of 0.5^0C (H_1) over ambient (H_0) all varieties differ significantly or at par among each other. Maximum dry matter was observed in variety V_9 followed by V_1, V_7, V_2, V_3& V_{10} etc. at 0.5^0C elevation of temperature at vegetative stage. Dry matter of all varieties decreased after heat stressed over control but increased after further elevation of temperature from 0.5^0C to 1.0^0C at reproductive stage. Maximum dry matter 1751.66 g/m^2 was recorded in V_9 in heat stressed condition given at reproductive stage followed by V_1, V_6, V_8, V_7, V_2, V_3, V_{10}, V_4& V_5. Dry matter variation in all varieties was significant among each other.

Table 1: Plant height (cm) of wheat genotypes at different DAS under heat trapping at vegetative stage (H_1).

Variety	DAS	30	50	70	90
V_1	(PBW-502)	14.84	40.20	54.20	82.60
V_2	(PBW-343)	14.00	34.80	53.40	80.60
V_3	(PBW-443)	13.70	33.60	51.40	72.20
V_4	(PBW-154)	22.00	45.40	60.20	83.20
V_5	(K-7903)	20.10	52.60	58.40	72.60
V_6	(HUW-234)	15.60	38.60	46.80	82.40
V_7	(UP-262)	17.80	43.00	52.40	82.80
V_8	(RAJ-3077)	17.40	55.20	57.20	79.60
V_9	(HD-2733)	17.20	37.40	46.60	81.00

V_{10}	(Kundan)	13.80	33.80	46.00	72.80
SE (Mean)		1.28	2.22	2.32	2.32
CD at 5%		3.83	6.60	6.79	6.92

Table 2: Plant height (cm) of wheat genotypes at different DAS under heat trapping at reproductive stage (H_2).

Variety \ DAS		**30**	**50**	**70**	**90**
V_1	(PBW-502)	14.60	23.80	47.40	76.00
V_2	(PBW-343)	14.00	21.20	40.20	76.60
V_3	(PBW-443)	13.40	29.80	47.20	79.00
V_4	(PBW-154)	19.00	37.00	52.20	83.00
V_5	(K-7903)	19.50	42.40	60.40	81.00
V_6	(HUW-234)	12.20	23.20	56.40	87.00
V_7	(UP-262)	12.80	31.60	60.00	83.20
V_8	(RAJ-3077)	13.00	32.80	60.40	86.20
V_9	(HD-2733)	10.80	24.60	40.40	70.80
V_{10}	(Kundan)	9.60	21.80	41.40	68.60
SE (Mean)		1.13	1.30	1.29	1.68
CD at 5%		3.36	3.89	3.83	5.01

Table 3: Leaf area index of wheat genotypes under control (H_0) and Heat trapping H_1& H_2.

Variety		**H_0**	**H_1**	**H_2**
V_1	(PBW-502)	1.83	3.59	2.52
V_2	(PBW-343)	1.38	3.39	2.46
V_3	(PBW-443)	1.63	3.13	2.42
V_4	(PBW-154)	1.97	3.58	2.91
V_5	(K-7903)	1.80	2.69	2.79
V_6	(HUW-234)	1.75	3.83	2.39
V_7	(UP-262)	3.33	3.86	3.02
V_8	(RAJ-3077)	1.73	3.20	2.85
V_9	(HD-2733)	1.66	3.56	2.24
V_{10}	(Kundan)	1.64	3.43	1.62
SE (Mean)		0.035	0.018	0.0041
CD at 5%		0.106	0.053	0.012

Table 4: Total chlorophyll content (mg g^{-1} fresh weight) of wheat genotype under control (H_0) and Heat Trapping H_1& H_2.

Variety		**H_0**	**H_1**	**H_2**
V_1	(PBW-502)	2.4	2.0	2.0
V_2	(PBW-343)	2.5	3.9	3.3
V_3	(PBW-443)	1.8	2.5	4.6
V_4	(PBW-154)	2.7	3.7	3.3
V_5	(K-7903)	3.4	3.0	3.7
V_6	(HUW-234)	2.7	2.2	3.6
V_7	(UP-262)	2.1	3.1	3.9
V_8	(RAJ-3077)	2.1	2.8	2.5
V_9	(HD-2733)	2.3	1.4	3.2
V_{10}	(Kundan)	2.7	1.8	3.5
SE (Mean)		0.10	0.10	0.13
CD at 5%		0.31	0.29	0.40

Table 5: Dry matter (gm/m^2) of wheat genotypes at control (H_0) and Heat trapping H_1& H_2.

Variety		**H_0**	**H_1**	**H_2**
V_1	(PBW-502)	1466.66	1445.00	1483.33
V_2	(PBW-343)	1834.00	1256.66	1350.66
V_3	(PBW-443)	1440.00	1247.66	1339.66
V_4	(PBW-154)	1392.66	1190.00	1283.33
V_5	(K-7903)	1340.00	1050.33	1064.66
V_6	(HUW-234)	1980.00	1080.00	1472.00
V_7	(UP-262)	1888.00	1385.66	1396.66
V_8	(RAJ-3077)	1744.00	1038.33	1463.33
V_9	(HD-2733)	1420.66	1683.33	1751.66
V_{10}	(Kundan)	1702.00	1248.00	1338.66
SE (Mean)		168.42	10.52	3.12
CD at 5%		500.43	31.26	9.29

Conclusion

It is concluded that present study in the ten varieties under lest sown on 15 December the varieties V_2, V_7 & V_8 are better heat tolerant at vegetative stage (30-50 DAS) as the yield reduction under the heat stress condition (0.5 ^{0}C increase from 14.62^{0}C ambient temperature) ranged between 8-11% in sequence. Further increase of temperature from 0.5^{0}C to 1.0^{0}C at reproductive stage (50-70 DAS) the variety V_2, V_5 & V_3 responsed better for sustainability of yield over control as reduction in yield under heat stress condition at this stage was in the order of 5, 10 & 16% respectively.

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