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Reaction of elevated temperature on growth and yield at wheat (*Triticum aestivum* L.) genotypes

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Abstract
A field experiment was conducted during *rabi season* of 2012 on the topic entitled "Reaction of elevated temperature on growth and yield at wheat (*Triticum aestivum* L.) 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. 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 14.62^0C ambient temperature) ranged between 8-11% in sequence. Further increase of temperature from 0.5^0C to 1.0^0C 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. Hence, the variety V_2, V_7 & V_8 and variety V_2, V_5 & V_3 are more heat tolerant for 0.5^0C & 1.0^0C elevated temperature over ambient 14.12^0C at vegetative stage (30-50 DAS) & 22.18^0C at reproductive stage (50-70 DAS) respectively.

Keywords: wheat, number of tillers, length of ear, no. of grains, test weight, yield

Introduction
Temperature, one of the most important external forces that drive the climatic process is likely to constitute the most significant changes for terrestrial ecosystem over the coming years (Watson 1995) [7]. The anticipated rise in atmospheric temperature due to global warming effects of green house gases to the extent of 1-4.5°C over the present century can probably lead to substantial reduction in the growth and productivity of crop plants by changing their phenological and physiological processes such as spikelet sterility in rice (Yoshida 1981), loss of pollen viability in sorghum, okra and maize (Decker *et al.* 1986, Singh 1997) [1, 5] and reversal of vernalization and shortening the period of growth phases in wheat (Evans *et al.* 1975) [2] and depression in tuber initiation and bulking in potato (Prange *et al.* 1990) [4]. The negative effect of rising temperature is likely to occur more in those crops which are adapted to temperate climates such as wheat, barley, cauliflower, apples etc. as their thermal requirement for optimum growth and productivity is less as compared to other crops. Increased temperature hastens the phenological development of the crop and reduces the grain filling period thus finally lowering grain yield (Wang *et al.* 1992) [6]. The extent and magnitude of growth and yield reduction in different crops under high temperature depends largely on their adaptability to diverse climates (tropical and temperate) and photosynthetic systems (C3 and C4) (Le Houerou *et al.* 1993) [3]. Though different crop species and varieties within a crop species show marked variation in their optimum temperature range (Watson 1995) [7], identification of variety for greater stability in growth and yield attributes would certainly be of great significance in order to stabi lize and sustain the productivity of wheat in the country by developing the hyper thermal tolerant cultivars through hybridization. Though lot of studies have been done on growth and yield response of wheat cultivars to high temperature stress, but most of them are either confined to controlled conditions or limited to the old genotypes. Thus information on the response of newly developed wheat cultivars to high temperature stress is inadequate. Keeping in view the significance of genetic diversity for heat tolerance in wheat, a field experiment was conducted with eight promising wheat cultivars to study their growth and

yield response to hyper thermal stress so as to identify and further develop wheat cultivars suitable for slightly warmer conditions.

Materials and Methods

The present investigation entitled "Reaction of elevated temperature on growth and yield at wheat (*Triticum aestivum* L.) genotypes" was carried out during *Rabi* 2012 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 Number of tillers/plant, Length of ear (cm), No. of grains/ear, Test weight (g), yield (g)/m^2.

Results

Number of tillers/plant from (Table-1 & 2) it is obvious that no of tillers/plant in all the varieties at initial stage H_1 (30 DAS to 50 DAS) increased under heat stressed condition of 0.5^0C over control (H_0). Maximum no of tillers 4.6 was recorded in variety V_9 followed by V_1, V_3 & V_2, respectively. The varieties are significantly at par among each other for tillers formation under heat stressed condition of 0.5^0C elevation over control. Per cent decrease in tillers was maximum in V_1 (43%) followed by V_9 (40%) but no change in number of tillers was observed in V_5 under elevated temperature. Thus, variety V_1 is more heat tolerant for tiller formation followed by V_9, V_3& V_2. Number of tillers per plant of wheat genotypes at different DAS under heat trapping at second stage (H_2) (50 DAS to 70 DAS) as shown in (Table-3) revealed that all genotypes are significant at par among each other for formation of no. of tillers at 1^0C elevated canopy temperature over control (H_2). Genotypes V_7, V_8& V_9 followed by V_2, V_3, V_6, V_{10}, V_{10} & V_1 produced more no. of tillers under heat stressed condition of 1^0C elevated temperature over other varieties V_4, V_5, V_1 may be due to better heat utilization efficiency in variety V_9, V_2, V_7, V_5, V_8, V_6& V_{10}. The more per cent of tillers formation after trapping during 50 DAS to 70 DAS was recorded in V_3, V_9 (56%) followed by V_3, V_5, V_8& V_{10}. Lowest per cent of tillers change was recorded in V_1 (15%) followed by V_2 (20%), V_4 (20%) & V_{10} (40%) thus these varieties are highly sensitive to elevated temperature at reproductive stage.

Length of ear (cm) from (Table-4) it is obvious that length of ear in all the varieties at vegetative stage *i.e.* under heat stressed condition of 0.5^0C (H_1) over ambient (H_0) all varieties are significant by differ among each other in respect of length of ear under elevated temperature condition. Variety V_2 followed by V_5, V_6, V_7, V_8, V_1& V_{10} recorded higher ear length in H_1 condition. In H_2 condition *i.e.* elevated temperature of 1^0C at reproductive stage over H_0, variety V_2 recorded highest ear length followed by V_5, V_6, V_3, V_7, V_{10} & V_9. But ear length under H_2 condition is smaller than H_1 condition may be due to less energy translocation is ear & spike formation.

No. of grains/ear from (Table-5) it is obvious that no of grains per ear in all the varieties at (H_1) heat trapping under heat stressed condition of 0.5^0C over control (H_0) are significantly differ among each other. In both elevation of 0.5^0C & 1.0^0C temperature at vegetative stage (H_1) & reproductive stage (H_2) the varieties are significantly at par among each other. Maximum number of grains formed in variety V_2 in both H_1& H_2 condition *i.e.* 43.50 & 24.26 grains/ear respectively. In H_1, variety V_2 is followed by V_7, V_{10}, V_8, V_5, V_3, V_1, V_4, & V_9. Similarly in H_2 number of grains/ear in V_2 is maximum followed by V_7, V_5, V_3, V_8, V_4, & V_{10} etc. Number of grains per ear at higher elevation temperature of 1.0^0C at reproductive stage (H_2) is quite less in comparison to elevation of 0.5^0C at vegetative stage might be due to less utilization of heat & radiation use efficiency. This ultimately confirms that reproductive stage, is more sensitive for grain formation as compare to vegetative stage at elevated temperature over ambient.

Test weight (g) from (Table-6) it is observed that test weight (g) in all the varieties at 1st stage heat trapping (H_1) decreased over control (H_0) and in the stage (H_2) also it decreases as compare to (H_1). All varieties at both stages of elevation of temperature are significantly at par. At vegetative stage elevation of 0.5^0C over control (H_1) the variety V_4 recorded highest test weight (45.00) followed by V_2, V_{10}, V_1, V_7, V_6, V_8 & V_9. Similarly, 1^0C elevation over ambient at vegetative stage reported the maximum test weight in variety V_2 followed by V_1, V_5, V_{10}, V_8, V_4, V_6, V_7& V_9. Less test weight in H_2 was recorded under H_2 heat trapping condition in comparison to H_1 trapping condition.

Yield (g)/m^2 from (Table-7) it is observed that yield (g)/m^2 in all the varieties at 1st stage heat trapping (H_1) decreased over control (H_0) & at 2nd stage heat trapping (H_2) also it decreased over (H_1). In first stage trapping (H_1) grain yield in variety V_2 reduced to 282.33 gm^{-2} from 310.00 gm^{-2}*i.e.* only 8.61% reduced followed by variety V_7 (10.69%) & V_8 (11.42%). Reduction in yield per cent in other varieties are quite large ranging between 27.28 to 36.18%. All varieties under test are significant or at par among each other in respect of yield under heat stressed condition and are in the order of V_{10}< V_9< V_6 < V_4< V_5< V_1< V_3. In second stage of heat trapping (H_2) the variety V_2, V_5, V_1, & V_3 responded well to sustain the yield as yield reduction ranged between 5.2% to 16% and in the order of V_2 (5.2%), V_5 (10.0%), V_1 (13.8%) & V_3 (16%) as compare to yield reduction of other varieties which is quite large ranging between 26 to 48%. In H_2 also the yield of all varieties are significantly at par among each other. Hence variety V_2, V_7& V_8 is more heat tolerant at vegetative stage elevated temperature of 0.5^0C as compare to other varieties while under reproductive stage heat stressed condition of 1.0^0C over ambient, the variety V_2, V_5, V_1& V_3 are better heat tolerant in comparison to other varieties.

Table 1: Number of tillers/plant of wheat genotypes at different DAS under heat trapping (H_0).

DAS\ Variety		30	50	70
V_1	(PBW-502)	3.07	4.67	6.47
V_2	(PBW-343)	3.53	4.80	7.07
V_3	(PBW-443)	2.60	3.40	4.80
V_4	(PBW-154)	3.00	3.67	5.60
V_5	(K-7903)	2.20	2.67	4.40
V_6	(HUW-234)	2.87	3.47	4.73
V_7	(UP-262)	3.00	3.47	4.93
V_8	(RAJ-3077)	2.87	4.00	6.00
V_9	(HD-2733)	3.13	4.20	5.00
V_{10}	(Kundan)	2.80	3.47	5.47
SE (Mean)		0.244	0.35	0.435
CD at 5%		0.727	1.04	1.294

Table 2: Number of tillers/plant of wheat genotypes at different DAS under heat trapping at vegetative stage (H_1).

DAS\ Variety		30	50	70
V_1	(PBW-502)	2.93	4.20 (43.00)*	5.27
V_2	(PBW-343)	3.07	4.00 (30.00)	5.33
V_3	(PBW-443)	2.93	4.00 (36.00)	6.27
V_4	(PBW-154)	2.67	3.20 (19.00)	4.53
V_5	(K-7903)	3.00	3.00 (2.20)	4.07
V_6	(HUW-234)	2.60	3.40 (30.00)	5.53
V_7	(UP-262)	3.20	3.80 (18.00)	5.80
V_8	(RAJ-3077)	2.73	2.80 (2.50)	4.67
V_9	(HD-2733)	3.27	4.60 (40.00)	5.53
V_{10}	(Kundan)	3.13	4.00 (27.00)	6.67
SE (Mean)		0.297	0.38	0.54
CD at 5%		0.884	1.14	1.61

*Figure in bracket indicates the % change over control.

Table 3: Number of tillers/ plant of wheat genotypes at different DAS under heat trapping at reproductive stage (H_2).

DAS\ Variety		30	50	70
V_1	(PBW-502)	3.20	3.93	5.53 (15.00)*
V_2	(PBW-343)	2.93	4.67	5.87 (20.00)
V_3	(PBW-443)	3.07	3.73	5.80 (56.00)
V_4	(PBW-154)	3.13	4.00	5.20 (20.00)
V_5	(K-7903)	2.40	3.40	5.27 (53.00)
V_6	(HUW-234)	2.73	3.87	5.73 (50.00)
V_7	(UP-262)	3.00	4.27	6.53 (54.00)
V_8	(RAJ-3077)	3.07	4.27	6.40 (52.00)
V_9	(HD-2733)	3.07	4.13	6.40 (56.00)
V_{10}	(Kundan)	3.00	4.00	5.67 (40.00)
SE (Mean)		0.27	0.30	0.446
CD at 5%		0.80	0.89	1.327

*Figure in parenthesis represents % change over before trapping.

Table 4: Length of ear (cm) of wheat genotypes at under control (H_0) and Heat trapping H_1& H_2.

Variety		H_0	H_1	H_2
V_1	(PBW-502)	8.87	7.83	7.50
V_2	(PBW-343)	9.13	8.57	8.20
V_3	(PBW-443)	8.03	7.80	7.50
V_4	(PBW-154)	8.73	7.73	6.50
V_5	(K-7903)	7.39	8.27	7.90
V_6	(HUW-234)	8.77	8.27	7.60
V_7	(UP-262)	9.13	8.27	6.90
V_8	(RAJ-3077)	8.53	8.10	6.30
V_9	(HD-2733)	7.50	7.23	6.73
V_{10}	(Kundan)	8.23	7.67	6.80
SE (Mean)		0.503	0.122	0.132
CD at 5%		1.495	0.363	0.394

Table 5: Number of grains/ear 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)	38.00	31.40	18.10
V_2	(PBW-343)	46.00	43.50	24.26
V_3	(PBW-443)	37.06	33.40	22.63
V_4	(PBW-154)	32.00	30.20	16.76
V_5	(K-7903)	42.50	36.73	23.50
V_6	(HUW-234)	51.66	30.96	12.50
V_7	(UP-262)	39.80	43.00	24.30
V_8	(RAJ-3077)	32.93	39.13	16.60
V_9	(HD-2733)	34.23	28.93	11.43
V_{10}	(Kundan)	40.76	39.13	13.36
SE (Mean)		3.72	0.41	0.33
CD at 5%		11.06	1.22	0.98

Table 6: Test weight (g) of wheat genotypes at under control (H_0) and Heat trapping H_1& H_2.

Variety		H_0	H_1	H_2
V_1	(PBW-502)	45.00	43.33	40.00
V_2	(PBW-343)	48.33	45.00	40.10
V_3	(PBW-443)	45.00	43.33	35.00
V_4	(PBW-154)	48.33	46.33	38.20
V_5	(K-7903)	42.33	41.00	40.00
V_6	(HUW-234)	45.00	41.66	36.40
V_7	(UP-262)	43.00	42.00	35.70
V_8	(RAJ-3077)	45.00	40.00	37.50
V_9	(HD-2733)	40.00	38.00	35.50
V_{10}	(Kundan)	46.61	45.00	38.33
SE (Mean)		1.95	2.28	2.27
CD at 5%		5.81	6.78	6.74

Table 7: Yield (g/m^2) of wheat genotypes under control (H_0) and Heat trapping H_1& H_2 condition.

Variety		H_0	H_1	H_2
V_1	(PBW-502)	338.33	216.67 (35.96)*	186.67 (13.8)*
V_2	(PBW-343)	310.00	282.33 (8.61)	268.33 (5.2)
V_3	(PBW-443)	391.67	250.00 (36.18)	210.00 (16.00)
V_4	(PBW-154)	351.67	250.00 (29.00)	136.67 (45.00)
V_5	(K-7903)	3.15.33	213.33 (32.35)	190.33 (10.00)
V_6	(HUW-234)	3.46.67	246.67 (28.85)	150.00 (39.00)
V_7	(UP-262)	383.33	341.67 (10.69)	250.00 (26.00)
V_8	(RAJ-3077)	305.00	270.00 (11.42)	140.00 (48.00)
V_9	(HD-2733)	316.67	226.67 (28.43)	190.00 (36.67)
V_{10}	(Kundan)	366.60	266.60 (27.28)	170.00 (36.20)
SE (Mean)		54.15	42.29	8.20
CD at 5%		160.72	125.66	24.38

*Figure in parenthesis indicates the % reduction over before trapping.

Conclusion

It is concluded that present study in, the variety V_2, V_7 & V_8 and variety V_2, V_5 & V_3 are more heat tolerant for 0.5^0C & 1.0^0C elevated temperature over ambient 14.12^0C at vegetative stage (30-50 DAS) & 22.18^0C at reproductive stage (50-70 DAS) respectively. Finally, it may also be concluded that elevated temperature at reproductive stage is more sensitive as compare to vegetative stage for these varieties for sustainable yield.

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