Plant Archives Vol. 17 No. 2, 2017 pp. 1257-1261 *ISSN 0972-5210*

EFFECT OF TEMPERATURE REGIMES ON PERFORMANCE OF WHEAT (*TRITICUM* SP.) GENOTYPES

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Abstract

A field experiment was conducted during *Rabi*, 2015-16 to study the effect of temperature on performance of wheat (*Triticum* sp.) genotypes at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad (Karnataka), India. The experiment consisted of two dates of sowing *viz*., 2nd November 2015 (D_1 temperature regime), 15th December 2015 (D_2 temperature regime) and nine wheat genotypes belonging to three species, *viz*., *Triticum aestivum, Triticum durum* and *Triticum dicoccum*. Significant reduction in plant height, dry matter accumulation, yield and yield attributes was observed under D_2 temperature regime. The reason might be prevailing of favorable temperature required for wheat crop for higher photosynthate accumulation consequently resulting in higher yield parameters under D_1 temperature regime. DDK-1045 recorded maximum plant height at harvest under both D_1 (82.87 cm) and D_2 (74.55 cm) temperature regimes. HW-1098 recorded maximum total dry matter accumulation at harvest under both D_1 (18.96 g hill^{-1}) and D_2 (16.41 g hill^{-1}) temperature regimes. HW-1098 recorded maximum grain yield under both D_1 (8102 kg ha^{-1}) and D_2 (6093 kg ha^{-1}) temperature regimes. Under D_1 temperature regime UAS-415 recorded maximum 1000 grain weight (45.95 g) while under D_2 temperature regime HW-1098 recorded maximum 1000 grain weight (40.84 g). The genotype HW-1098 recorded higher harvest index and more number of tillers m^{-2} under both the temperature regimes which might be attributed to higher yield.

Key words : Wheat, dry matter accumulation, temperature regime, yield, harvest index.

Introduction

Wheat is one of the most important cereal crop in the world and the second most important food crop in India after rice in terms of both area and production. Wheat production in India accounts for 12 per cent of global wheat production which made India the 2nd largest wheat producing country with surplus wheat as against deficient country during 1960's (Arya *et al*., 2012). In India, wheat is grown over an area of 31.19 million ha with production of 95.91 million tones with an average productivity of 3075 kg ha^{-1} (Anonymous, 2014). Wheat is one of the most important *Rabi* cereals next to sorghum in Karnataka. Wheat is grown over an area of 0.21 million ha with production of 0.23 million tones with an average productivity of 1075 kg ha^{-1} in Karnataka (Anonymous, 2014).

Sowing period of wheat normally extends from last week of October to third week of November. However, it continues up to December. Wheat requires cool climate for potential productivity during its early growth stages. Higher temperature during early growth stages is unfavorable for tillering and reduces grain filling duration if occurs during later growth stages. Unusual changes in weather parameters, especially an increase in maximum/ minimum temperature from normal at any growth stage of crop adversely affects the growth and ultimately the yield.

Most crop plants of temperate origin do not tolerate prolonged exposure to maximum temperatures above 35^{0}C. Under field conditions, temperatures of 35-38^{0}C are common in many wheat producing areas of the world. However, agronomists and physiologists have found that for planting of wheat, the average temperature should be around 20-22^{0}C, for tillering around 16-20^{0}C and for proper development of wheat plant, the best temperature range is 20-23^{0}C (Tandon and Hanchinal, 1984). At mean daily temperatures higher than 20^{0}C in the early tillering phase, the tillering is poor and heading is accelerated. At temperatures higher than 25^{0}C in the grain development phase, the plant dries up prematurely. These temperature

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limits represent the limits of crop growth duration in these areas (Hanchinal, 1987). Poor yields in Karnataka as compared to national average could be attributed to both environmental and genetic factors.

Hence, the present study was undertaken to know the effects of temperature regimes on morphology, dry matter accumulation, yield and yield attributes, specifically at post-anthesis phase, in wheat genotypes.

Materials and Methods

A field experiment was conducted during *Rabi*, 2015-16 to study the effect of dates of sowing on performance of wheat (*Triticum* sp.) genotypes at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad (Karnataka), India. The experiment consisted of two dates of sowing *viz*., 2nd November 2015 (D_1 temperature regime) and 15th December 2015 (D_2 temperature regime). Nine wheat genotypes (UAS-304, NIAW-34, HD-3090, UAS-415, UAS-458, UAS-459, HW-1098, DDK-1045 and DDK-1046) belonging to three species, *viz*., *Triticum aestivum*, *Triticum durum* and *Triticum dicoccum* were evaluated. The experimental site consisted of medium deep black soil and crop was raised in a plot size of 3.0 × 1.5 m with a spacing of 30 cm between rows, fertilized with 100:70:50 N:P_2O_5:K_2O (kg ha^{-1}).

Five plants were selected at random in each plot and tagged for recording plant height (cm). Plant height was measured from the soil surface to the base of the ear head of main shoot at 50 per cent anthesis and every 15 days intervals after anthesis up to maturity and at harvest. Plants from five hills were uprooted and separated into leaf, stem and spike at 50 per cent anthesis and every 15 days interval after anthesis up to maturity and at harvest. The different plant parts were first air dried and then oven dried at 80°C to a constant weight to determine the total dry matter production and its distribution into different parts and expressed on per hill basis. Five plants tagged earlier for recording various morphological observations were collected at physiological maturity to record the data on yield and yield attributes.

Results and Discussion

There was a clear cut difference in environmental condition with respect to temperature between two dates of sowing. It was observed that maximum temperature varied from 26.8°C to 35.3°C and 27.9°C to 38.9°C during normal sown and late sown condition respectively, whereas the minimum temperature ranged from 11.1°C to 22.0°C in normal sown and 11.1°C to 24.0°C during late sown crop. It is further used in the text as D_1 temperature regime and D_2 temperature regime instead of 'normal sown' and 'late sown crop', respectively.

The data on plant height recorded at 50 per cent flowering, 15 DAA (days after anthesis), 30 DAA and at harvest are furnished in table 1. The data revealed that the plant height increased progressively from 50 per cent anthesis to 30 DAA and decreased slightly at harvest in

Table 1 : Effect of temperature regimes on plant height (cm) at different growth stages in wheat genotypes.

Genotypes	At 50 % anthesis			15 DAA			30 DAA			Harvest		
	Temperature regimes											
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
UAS-304	56.37^{e}	52.24^{f}	54.30^{e}	70.41^{g-i}	62.84^{j}	66.62^{e}	72.71^{d-f}	62.21^{h}	67.46^{e}	70.69^{ef}	61.58^{h}	66.14^{d}
NIAW-34	60.97^{cd}	56.52^{e}	58.74^{cd}	67.73^{i}	59.25^{k}	63.49^{e}	68.10^{g}	58.66^{i}	63.38^{f}	66.66^{g}	58.07^{h}	62.37^{e}
HD-3090	63.80^{c}	59.13^{de}	61.46^{c}	77.57^{de}	69.27^{hi}	73.42^{d}	81.07^{bc}	69.52^{e-g}	75.29^{b-d}	78.97^{bc}	68.82^{e-g}	73.89^{bc}
UAS-415	58.90^{de}	53.34^{f}	56.12^{de}	82.09^{bc}	72.86^{f-h}	77.47^{bc}	83.60^{ab}	72.13^{d-f}	77.86^{b-c}	82.07^{a-c}	71.41^{de}	76.74^{a-c}
UAS-458	60.87^{cd}	56.43^{e}	58.65^{cd}	79.23^{c-e}	69.80^{hi}	74.52^{cd}	79.37^{c}	69.10^{fg}	74.24^{cd}	78.17^{c}	68.41^{e-g}	73.29^{c}
UAS-459	62.37^{c}	57.84^{de}	60.10^{c}	81.03^{b-d}	71.36^{g-i}	76.20^{b-d}	81.53^{a-c}	70.65^{e-g}	76.09^{b-d}	80.73^{a-c}	69.94^{e-g}	75.34^{a-c}
HW-1098	69.91^{b}	63.84^{c}	66.88^{b}	77.70^{de}	68.41^{i}	73.05^{d}	80.00^{bc}	67.73^{g}	73.86^{d}	79.07^{a-c}	67.05^{fd}	73.06^{c}
DDK-1045	74.70^{a}	68.94^{b}	71.82^{a}	86.33^{a}	76.06^{ef}	81.20^{a}	85.10^{a}	75.30^{d}	80.20^{a}	82.87^{ab}	74.55^{d}	78.71^{a}
DDK-1046	75.23^{a}	69.77^{b}	72.50^{a}	83.83^{ab}	73.82^{fg}	78.83^{ab}	83.60^{ab}	73.08^{de}	78.34^{ab}	83.00^{a}	72.35^{de}	77.68^{ab}
Mean	**64.79**	**59.78**		**78.44**	**69.30**		**79.45**	**68.71**		**78.02**	**68.02**	
	S.Em.±	**LSD@0.05**		**S.Em.±**	**LSD@0.05**		**S.Em.±**	**LSD@0.05**		**S.Em.±**	**LSD@0.05**	
Temperature regimes	0.70	2.00		0.83	2.39		0.86	2.47		0.87	2.51	
Genotypes	0.33	0.94		0.39	1.13		0.40	1.16		0.41	1.18	
Interaction	0.98	2.83		1.18	3.38		1.21	3.49		1.24	3.55	

Note:- DAA- Days after anthesis, D_1- Early sown (Low temperature regime), D_2- Late sown (High temperature regime), DMRT- Values in the column followed by the same letters do not differ significantly.

both the temperature regimes. Significant reduction in plant height was observed under D_2 temperature regime as compared to D_1 temperature regime at all the growth stages. Among the genotypes, DDK-1046 recorded significantly maximum plant height in both D_1 and D_2 temperature regimes (75.23 and 69.77, respectively) and was on par with DDK-1045 (74.70 and 68.94, respectively). Significantly minimum plant height was recorded by UAS-304 (56.37 and 52.24) under D_1 and D_2 temperature regimes, respectively. At 15 DAA, maximum plant height was observed in DDK-1045 (86.33 and 76.57) followed by DDK-1046 (83.83 and 73.82) under both D_1 and D_2 temperature regimes, respectively and significantly minimum plant height was observed in NIAW-34 (67.73 and 59.25) under both D_1 and D_2 temperature regimes, respectively. Similar trend in plant height was observed at 30 DAA and at harvest. Plant height is a morphological character controlled genetically but environmental factors also influence this character. Variation in plant height was observed because of the effect of temperature regimes. Gupta *et al*. (2002) reported significantly maximum plant height under normal sowing (15th November), which was shown to be decreased to maximum under late sown condition (15th December) irrespective of genotypes in wheat. Moinoddin and Goswami (2004) reported that the highest plant height was recorded in wheat under normal irrigated crop. These results are in conformity with present study. Lad *et al*. (2002) reported that analysis of variance showed highly significant differences among genotypes for plant height indicating appreciable amount of variability among the genotypes. The genotypes DDK-1045 and NIAW-34 recorded significantly maximum and minimum plant height respectively, because of genotypic characters.

The data on total dry weight at 50 per cent anthesis, 15 DAA, 30 DAA and at harvest are furnished in table 2. Mean total dry weight increased from 50 per cent anthesis to maturity. The data on total dry weight showed significantly higher total dry weight under D_1 temperature regime as compared to D_2 temperature regime at all the growth stages. Among the genotypes, at 50 per cent anthesis, DDK-1045 recorded significantly maximum total dry weight in (7.92) and was on par with HW-1098 (7.87) under D_1 temperature regime. Under D_2 temperature regime DDK-1045 recorded significantly maximum total dry weight (7.12) followed by HW-1098 (6.99). At 15 DAA, HW-1098 recorded significantly maximum total dry weight (16.49) and was on par with DDK-1045 (16.40) under D_1 temperature regime. Under D_2 temperature regime HW-1098 recorded significantly maximum total dry weight (14.89) followed by DDK-1045 (13.94) and significantly minimum total dry weight was recorded UAS-304 under both D_1 and D_2 temperature regimes (10.71 and 9.00 respectively). At 30 DAA, HW-1098 recorded significantly maximum total dry weight (16.89) followed by DDK-1045 (15.69) under D_1 temperature regime. Under D_2 temperature regime HW-1098 recorded significantly maximum total dry weight (14.95) followed by DDK-1046 (13.66). At harvest, HW-1098 recorded significantly maximum total dry weight (18.96) followed by DDK-1045 (17.60) under D_1 temperature regime and D_2 temperature regime HW-1098 recorded significantly maximum total dry weight (16.41) followed by UAS-459 (15.49). Significantly minimum total dry weight was recorded by NAIW-34 at all the growth stages except at 15 DAA under both D_1 and D_2 temperature regimes. Dry matter production and its distribution is one of the most important physiological parameters controlling the crop productivity and represent net photosynthesis of crop. High temperature adversely affects all the vigor parameters and results in significant decline in dry weight. Md. Parwaiz *et al*. (2013) observed significantly higher maximum dry matter at maturity in the treatment where wheat was sown at 25th November as compared to 20th December. Tripati *et al*. (2009) reported that rate of respiration was enhanced by high temperature during reproductive stages resulting in loss of stored food material, which reduces fresh weight in turn and there was decline in dry weight of leaf, stem and roots.

Significantly maximum yield was recorded under D_1 temperature regime as compared to D_2 temperature regime. Genotypes differed significantly with respect to yield. Significantly maximum yield was recorded by HW-1098 (8102 and 6093) under both the under D_1 and D_2 temperature regimes, respectively. Significantly minimum yield (5517 and 3612) was recorded by NIAW-34 in both the temperature regimes. 1000 grain weight (test weight) was significantly higher under D_1 temperature regime as compared to D_2 temperature regime. Among genotypes, UAS-415 and DDK-1046 recorded significantly maximum (45.95) and minimum (39.77) test weight respectively, under D_1 temperature regime. HW-1098 and NIAW-34 recorded significantly maximum (40.84) and minimum (33.53) test weight respectively, under D_2 temperature regime. There was significant reduction in harvest index under D_2 temperature as compared to D_1 temperature regime. Among the genotypes HD-3090 and DDK-1045 recorded significantly maximum (0.47) and minimum (0.35) HI under D_1 temperature regime. Under D_2 temperature regime HW-1098 and NIAW-34 recorded significantly maximum (0.42) and minimum

Table 2 : Effect of temperature regimes on total dry weight (g hill^{-1}) at different growth stages in wheat genotypes.

Genotypes	At 50% anthesis			15 DAA			30 DAA			Harvest		
	Temperature regimes											
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
UAS-304	6.27^{e}	5.60^{f}	5.94^{b}	10.71^{hi}	9.00^{j}	9.85^{d}	13.08^{e-g}	10.87^{h}	11.97^{d}	13.99^{e-g}	12.57^{gh}	13.28^{d}
NIAW-34	3.64^{i}	3.27^{i}	3.45^{d}	11.42^{g-i}	9.98^{ij}	10.70^{d}	11.91^{gh}	9.56^{i}	10.74^{d}	12.22^{h}	10.47^{i}	11.35^{e}
HD-3090	5.25^{fg}	4.66^{gh}	4.96^{c}	15.15^{a-c}	10.72^{hi}	12.94^{c}	14.70^{bc}	12.84^{e-g}	13.77^{bc}	16.69^{b-d}	14.11^{e-g}	15.40^{bc}
UAS-415	5.21^{fg}	4.59^{h}	4.90^{c}	14.67^{c-e}	11.54^{gh}	13.10^{c}	14.48^{b-d}	12.31^{fg}	13.39^{bc}	16.47^{b-d}	14.47^{ef}	15.47^{bc}
UAS-458	7.41^{a-c}	6.81^{c-e}	7.11^{a}	15.06^{a-c}	12.22^{fg}	13.64^{bc}	14.02^{c-e}	12.42^{fg}	13.22^{c}	15.46^{c-e}	13.20^{f-h}	14.33^{cd}
UAS-459	6.36^{de}	5.45^{f}	5.90^{b}	15.30^{a-c}	13.29^{ef}	14.30^{a-c}	15.68^{ab}	13.02^{e-g}	14.35^{bc}	17.59^{ab}	15.49^{c-e}	16.54^{ab}
HW-1098	7.87^{a}	6.99^{cd}	7.43^{a}	16.49^{a}	14.89^{b-d}	15.69^{a}	16.89^{a}	14.95^{bc}	15.92^{a}	18.96^{a}	16.41^{b-d}	17.69^{a}
DDK-1045	7.92^{a}	7.12^{bc}	7.52^{a}	16.40^{a}	13.94^{c-e}	15.17^{a}	15.69^{ab}	13.31^{d-g}	14.50^{bc}	17.60^{ab}	15.41^{c-e}	16.50^{ab}
DDK-1046	7.71^{ab}	6.79^{c-e}	7.25^{a}	16.28^{ab}	13.45^{d-f}	14.86^{ab}	15.66^{ab}	13.66^{c-f}	14.66^{b}	17.23^{a-c}	15.17^{de}	16.20^{ab}
Mean	**6.40**	**5.70**		**14.61**	**12.12**		**14.68**	**12.55**		**16.24**	**14.15**	
	S.Em.±	**LSD@0.05**		**S.Em.±**	**LSD@0.05**		**S.Em.±**	**LSD@0.05**		**S.Em.±**	**LSD@0.05**	
Temperature regimes	0.14	0.41		0.33	0.94		0.30	0.87		0.40	1.14	
Genotypes	0.07	0.19		0.15	0.44		0.14	0.41		0.19	0.54	
Interaction	0.20	0.58		0.46	1.33		0.43	1.24		0.56	1.62	

Note:- DAA- Days after anthesis, D_1- Early sown (Low temperature regime), D_2- Late sown (High temperature regime), DMRT- Values in the column followed by the same letters do not differ significantly.

Table 3 : Effect of temperature regimes on yield and yield attributes in wheat genotypes.

Genotypes	Yield (kg ha^{-1})			1000 grain weight (g)			HI			No of tillers (m^{-2})		
	Temperature regimes											
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
UAS-304	6552^{b-d}	3929^{gh}	5240^{bc}	39.89^{b-e}	33.53^{f}	36.71	0.45^{ab}	0.39^{c-e}	0.42^{ab}	246.67^{a-g}	218.89^{e-g}	232.78^{bc}
NIAW-34	5517^{d-f}	3612^{h}	4564^{c}	44.56^{ab}	36.98^{-c-e}	40.77	0.42^{a-d}	0.32^{f}	0.37^{bc}	268.89^{ab}	233.33^{b-g}	251.11^{ab}
HD-3090	7156^{ab}	4622^{f-h}	5889^{b}	39.77^{b-e}	35.55^{ef}	37.66	0.47^{a}	0.39^{c-e}	0.43^{a}	272.22^{ab}	225.56^{d-g}	248.89^{ab}
UAS-415	6403^{b-d}	4767^{fg}	5585^{bc}	45.95^{a}	36.64^{c-e}	41.29	0.43^{a-c}	0.41^{b-d}	0.42^{ab}	267.78^{a-d}	258.89^{a-e}	263.33^{ab}
UAS-458	6019^{c-e}	4469^{f-h}	5244^{bc}	44.47^{ab}	36.59^{c-f}	40.53	0.39^{c-e}	0.35^{ef}	0.37^{bc}	206.67^{g}	214.44^{fg}	210.56^{c}
UAS-459	6824^{bc}	5065^{ef}	5944^{b}	44.44^{ab}	35.78^{ef}	40.11	0.42^{a-d}	0.41^{b-d}	0.41^{ab}	227.78^{c-g}	237.78^{a-g}	232.78^{bc}
HW-1098	8102^{a}	6093^{b-e}	7098^{a}	41.50^{a-c}	40.84^{b-d}	41.17	0.46^{ab}	0.42^{a-d}	0.44^{a}	277.78^{a}	273.33^{ab}	275.56^{a}
DDK-1045	6304^{b-d}	4499^{f-h}	5402^{bc}	41.60^{a-c}	37.71^{c-f}	39.65	0.35^{ef}	0.33^{f}	0.34^{c}	272.22^{ab}	261.11^{a-d}	266.67^{ab}
DDK-1046	6254^{b-d}	4619^{f-h}	5437^{bc}	39.77^{-b-e}	35.93^{d-f}	37.85	0.45^{ab}	0.37^{d-f}	0.41^{ab}	261.11^{a-d}	253.33^{a-f}	257.22^{ab}
Mean	**6570**	**4631**		**42.44**	**36.62**		**0.43**	**0.38**		**255.68**	**2.41.85**	
	S.Em.±	**LSD@0.05**		**S.Em.±**	**LSD@0.05**		**S.Em.±**	**LSD@0.05**		**S.Em.±**	**LSD@0.05**	
Temperature regimes	235	676		1.06	3.04		0.01	0.03		4.58	24.65	
Genotypes	111	319		0.50	NS		0.01	0.02		4.04	11.62	
Interaction	333	956		1.49	4.29		0.02	0.05		12.13	34.85	

Note:-NS- Non-significant, HI- Harvest index, D_1- Early sown (Low temperature regime), D_2-Late sown (High temperature regime), DMRT- Values in the column followed by the same letters do not differ significantly.

(0.32) HI, respectively. Significant reduction was seen under D_2 temperature regime as compared to D_1 temperature regime with respect to number of tillers. Significant genotypic differences were also observed. HW-1098 recorded significantly maximum (277.8) number of tillers per m^{-2} and minimum (206.7) number of tillers was observed in UAS-458 under D_1 temperature regime. Similar trend in number of tillers was observed under D_2 temperature regime. The results of present investigation indicated that grain yield and all the yield attributing characters decreased significantly under D_2 temperature regime as compared to D_1 temperature regime. Among the genotypes HW-1098 maintained highest yield in both the temperature regimes and the per

cent yield reduction was less in HW-1098 (24.79) as compared to all other genotypes. The reason might be the prevailing of favorable temperature required for wheat crop for higher photosynthate accumulation consequently resulting in higher yield parameters in timely sown crop (Md. Parwaiz *et al*., 2013). Similar results were obtained by Sharma *et al*. (2008), Yin *et al*. (2009), Talukder *et al*. (2014), Upadhyay *et al*. (2015). The yield decrease was due to reduction in the number of seeds per spike and also due to reduction in seed size as well as 1000-grain weight.

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