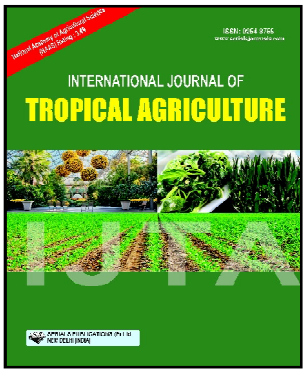

INTERNATIONAL JOURNAL OF TROPICAL AGRICULTURE

ISSN : 0254-8755

available at http: www.serialsjournals.com

Volume 36 • Number 1 • 2018

Heat and Radiation use Efficiency of Wheat Varieties under Different thermal Environment in Rice-wheat Cropping System

S. R. Patel and J. L. Chaudhary

Department of Agrometeorology, College of Agriculture, Indira Gandhi Kkrishi Vishwavidyalaya, Raipur-492012 (Chhattisgarh)
E-mail: spatelsr@ yahoo.com

Abstract: Field experiment was conducted during *Rabi* season of 2014-15 at Research and Instructional Farm of Indira Gandhi Krishi Vishwavidyalaya, Raipur to study the performance of seven wheat (*Triticum aestivam* L.) varieties *viz*. CG 1006, HI1544 (Zonal check), Ratan (State check), Kanchan, CG1013, GW 273 and HD 2967 (National check) under three different thermal environments *viz*. D_1-25 November, D_2-10 December and D_3-25 December in factorial Randomized Block Design. The soil of the experimental field was near neutral in reaction, low in available N and P_2O_5 and high in available K_2O. The results revealed that the duration decreased considerably due to thermal stress in all the varieties when sowing was delayed whereas, in general growing degree days and photothermal units increased under delayed sowing. The heliothermal units decreased in second set of thermal environments then again increased in third set of thermal environments. Higher heat use efficiency and radiation use efficiency were obtained with second set of thermal environments as compared to two other set of thermal environments. Higher grain yield was obtained with the sowing of wheat on 25 November (D_1) comparable with 10 December (D_2) sowing and both were significantly superior to that of 25 December (D_3) sowing.

Keywords: Growing degree days, heat use efficiency, radiation use efficiency, helio-thermal units and sowing dates.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the most important food-grain crop of India next to rice and is the staple food of millions of people, particularly in the northern and north-western parts of the country. The growing period is variable from one agro-climatic zone to other that effects the vegetative and reproductive period leading to differences in

potential yield. In Chhattisgarh state wheat crop is grown mostly in rice-based cropping system under irrigated condition in an area of 1.03 lakh ha with productivity of 1486 kg/ha Anonymous (2015) which is much below as compared to traditional wheat growing areas. The sowing is often delayed due to delay in harvesting of rice varieties and as far as wheat cultivation is concerned because of fluctuations of temperature during the cropping season as well as on temporal scale. As such the productivity of wheat fluctuates considerably in this area due to thermal stress faces high temperature during grain filling and ripening phases, which is one of the major causes of stunted growth and low productivity. It is therefore necessary to identify the suitable thermally insensitive varieties of wheat for this region as rice-wheat crop rotation is still prominent under Mahanadi and Hasdeo-Bango rivers command area. In view of this an attempt has been made to find out suitable variety of wheat for higher production under late sown condition. For this purpose, field experiment was conducted by sowing of wheat varieties in different dates to induce different thermal environment.

MATERIAL AND METHODS

The experiment was conducted at Research and Instructional farm of Indira Gandhi Krishi Vishwavidyalaya, Raipur situated in Eastern Central part of Chhattisgarh at latitude of 21^{0}16$^{'}$N, longitude 81^0 36$^{'}$E and altitude 289.5 m above mean sea level during rabi season of 2014-15. Seven wheat cultivars *viz.* CG 1006, HI1544 (Zonal check), Ratan (State check), Kanchan, CG1013, GW 273 and HD 2967 (National check) were grown and cultivated in a factorial Randomized Block Design. Different thermal environments were created by sowing the crop with three sowing dates *viz.* D_1-25 November, D_2-10 December and D_3-25 December. The soil of the experimental site was sandy loam in texture with pH of 6.2, organic carbon 0.6%, available N 180 kg/ha (low), available P_2O_5 14 kg/ha (low) and available K_20 362 kg/ha (high). All the recommended cultural practices were followed to raise the crop. Observations on phonology, yield attributes and yield were recorded following the standard procedures. Agro-meteorological indices i.e. GDD, PTU, HTU, HUE, RUE, etc. were derived using the following equations:

Growing Degree Days (GDD)

GDD = Σ [(Tx + Tn)/2 – Base temperature of 5^{o}C]

Where, Tx = Daily maximum temperature,
Tn = Daily minimum temperature

Photo Thermal Units (PTU) are calculated by multiplying GDD with maximum possible sunshine hours (N).

$$PTU = GDD \times N$$

Where, N = maximum possible sunshine hour.

Heliothermal Units (HTU)

HTU is calculated by multiplying GDD with actual sunshine hours (n)

$$HTU = GDD \times n$$

Where, n = actual sunshine hour.

Heat Use Efficiency (HUE)

Heat Use Efficiency (HUE) for total dry matter was obtained as under

$$HUE\,(g/m^2/^0\,day) = \frac{Biomass\,(g/m^2)}{GDD\,(^0\,days)}$$

Radiation Use Efficiency (RUE)

$$RUE\,(g/MJ/day) = \frac{Biomass\,(g/m^2)}{Radiation\ intercepted\,(M\,J/m^2/day)}$$

RESULTS AND DISCUSSION

Phenology: The days taken from sowing to 50 per cent flowering (50 % flwo.) and maturity (Matu.) of seven wheat varieties under different thermal

environments are given in Table 1. The data showed that the days taken for 50 per cent flowering decreased in 2nd data of sowing as compared to 1st date of sowing and again increased in 3rd date of sowing in most of the varieties except wheat variety Kanchan. Whereas, days to maturity decreased gradually with delay in sowing in al the varieties from 25 November to 05 December and 25 December. The range of decrease ranges from minimum of 7 days in variety GW 273 (115 to 108 days) to maximum of 14 days in DH 2967 (145 to 131 days). The decrease in duration at these stages varied differently for different varieties, the highest effect of thermal stress on phonological stages was observed in variety HD 2967 and Kanchan as the maturity duration came down significantly with delay in sowing whereas the least effect of thermal stress was observed in case of GW-273 and HI-1544. Similar results were also reported by Patel *et al.* (1999)

Growing degree day (GDD): The accumulated growing degree days (GDD) for different genotypes under different thermal environments varied considerably from sowing to maturity (Table 1). At 50 per cent flowering higher GDD values were observed under sowing of wheat on D_3-25 December followed by D_1- 25 November and D_2-10 December except for variety GW 273. Different wheat varieties responded differently in terms of accumulated GDD at the time of maturity. Overall higher GDD was observed under D_3-25 December sowing except in in variety HD 2967. In case of CG 1006, HI 1544, Ratan, CG 1013 and GW 273 highest GDD was noticed under D_3 and lowest was noticed under D_1. However, in case of variety Kanchan and Ratan, the highest GDD at maturity was noticed under D_2 sowing and the lowest GDD was noticed when crop was sown on 25 November. In case of wheat variety HD 2967 the accumulated GDD was recorded on higher side because of its late maturity under all the thermal environments. These results are in conformity with the results reported by Sandhu *et al.* (1999)

Photo Thermal Units (PTU): Photothermal units (PTU) for different genotypes under different thermal environment varied considerably at maturity (Table 1). The PTU values followed the same trend as in GDD as the PTU is a product of GDD multiplied by possible hours of sunshine. However, at maturity highest PTU was observed for variety HD 2967 (NC) as compared to other varieties in all the thermal environments, whereas the minimum PTU was observed with GW 273. In general, the PTU value at maturity increased with delay in sowing from D_1-25 November to D_3-25 December because of higher day length at the time of maturity under delayed sown condition.

Helio Thermal Units (HTU): The Heliotermal units (HTU) for different wheat varieties under different thermal environment at 50 per cent flowering and maturity period are given in Table 1. All the varieties varied considerably with each other at maturity period. Highest HTU was observed in varieties HD 2967 followed by HI 1544 almost in all the thermal environments. It was observed that the HTU values decreased in second date of sowing then again increased in third date of sowing at 50 per cent flowering and maturity in all the varieties except with variety HI 1544 at maturity.

Heat use efficiency (HUE): Heat use efficiency of different varieties are shown in Table 2. It was very well observed that on the mean basis variety Kanchan was having the highest HUE among all the wheat varieties tested and it was followed by GW-273 variety. The lowest HUE was noticed with variety HD 2967 (NC). Among the three sowing dates on the mean basis higher HUE was observed under D_2-10 December sowing followed by D_1-25 November and D_3-25 December. As for as the performance of varieties under different sowing dates is concern higher values of HUE was noticed in D_2-10 December sowing for variety CG 1006, HI 1544 (ZC), Ratan (SC) and Kanchan. In rest of the varieties i.e. CG 1013, GW 273 and HD 2967 (NC)

Table 1
Phenology and agrometeorological indices of wheat varieties under different thermal environments

	Phenology		*GDD*		*PTU*		*HTU*	
Sowing dates	*50% flow.*	*Matu.*	*50% flow.*	*Matu.*	*50% flow.*	*Matu.*	*50% flow.*	*Matu.*
V_1-CG1006								
D_1-25 Nov.	72	119	1031	1931	11282	21850	7507	14722
D_2-10 Dec.	66	116	946	1994	10422	22921	6414	14120
D_3-25 Dec.	82	110	1332	1998	15157	23352	10341	15495
V_2-HI 1544 (ZC)								
D_1-25 Nov.	74	122	1066	2004	11685	22724	7827	15387
D_2-10 Dec.	68	118	977	2045	10779	23566	6608	15450
D_3-25 Dec.	83	114	1354	2083	15423	24425	10493	15956
V_3-Ratan (SC)								
D_1-25 Nov.	74	119	1066	1931	11685	21850	7827	14722
D_2-10 Dec.	69	116	995	1994	10986	22921	6792	14120
D_3-25 Dec.	84	109	1377	1978	15696	23352	10587	15491
V_4-Kanchan								
D_1-25 Nov.	76	118	1099	1909	12065	21583	7963	14511
D_2-10 Dec.	71	110	1031	1947	11402	21084	7166	14014
D_3-25 Dec.	70	107	1091	1931	12256	22512	8376	15076
V_5-CG 1013								
D_1-25 Nov.	80	119	1166	1931	12826	21850	8420	13962
D_2-10 Dec.	71	116	1031	1994	11402	22921	7166	14354
D_3-25 Dec.	83	110	1354	1998	15423	23352	10493	15304
V_6-GW273								
D_1-25 Nov.	75	115	1082	1847	11871	20836	7915	13549
D_2-10 Dec.	74	112	1089	1893	12069	21650	7738	14354
D_3-25 Dec.	72	108	1124	1957	12654	22835	8661	15304
V_7-HD2967(NC)								
D_1-25 Nov.	95	145	1444	2556	16020	29626	10987	19360
D_2-10 Dec.	92	138	1438	2544	16179	29869	10584	19332
D_3-25 Dec.	93	131	1581	2547	18142	30372	12419	20166

higher values of HUE was noticed in D_1-25 November sowing and decreased gradually when the sowing was delayed to D_2-10 December and D_3-25 December. HUE is a ratio between the biomass and the GDD and it was inversely proportional i.e. the biomass yield decreased with delay in sowing due to thermal stress and the GDD increased at maturity with delay in sowing due to increase in temperature and because of this in general the HUE decreased under delayed sowing condition. Bobade *et al.* (2018) also reported similar observations.

Radiation use efficiency (RUE): Radiation use efficiency of seven wheat varieties was also worked out and shown in Table 3. Interestingly for the national check variety HD-2967, RUE value was lowest (0.77) on the mean basis as well as during each sowing dates except of variety CG1006 in D_1-25 November 0.80 and 0.76, respectively. Highest value of RUE was found for variety Kanchan followed by GW-273 and HI-1544. On the mean basis sowing of wheat on D_2-10 December showed higher RUE (0.99) as compared to other two sowing dates which were similar to each other. Chaudhary *et al.* (2016) also reported similar results.

Grain Yield: Grain yield of different wheat varieties under different growing environments are shown in Table 4. The results revealed that on an average maximum grain yield was harvested under thermal environment of crop sown on 25 November (D_1) closely followed by sowing of wheat on 10 December (D_2) but both sowing dates were significantly superior over 25 December (D_3). On the mean basis variety Kanchan out yielded among all the varieties tested but found statistically comparable with GW 273, the lowest grain yield was recorded with variety CG 1006. As for as the response of varieties is concern they responded differently to different thermal environments. The response of variety CG 1006, HI 1544 and Ratan was similar and these varieties produced higher grain yield when sown on 10 December (D_2) as compared to 25 November (D_1) and 25 December (D_3). Higher grain yield of Kanchan and CG 1013 was recorded with 25 November (D_1) sowing and decreased gradually with delayed sowing. Among the varieties, variety Kanchan is having maximum yield potential yielding maximum with yield of 4154 kg/ha and it is followed by GW-273 with grain yield of 3828 kg/ha. Puranik and Patel **(**2014) and Sandhu *et al.* (2016) also reported lower grain yield under delayed sowing.

Straw yield: The data pertaining to straw yield are given in Table 5 and it can be very well observed that on the mean basis Kanchan is having highest straw yield and this is statistically at par with all other varieties except CG-1006 which is having the least straw yield and these are statistically different. Straw yield was highest under second growing environment of 10 December (D_2) followed by first set of growing environments 25 November (D_1) and it was significant superior over third growing environment of 25 December (D_3). As for as the straw yield at different growing environment is concern it was observed that varieties responded differently. Highest straw yield of 4769 kg/ha was obtained with Kanchan in 10 December (D_2) sowing and the lowest straw yield of 3027 kg/ha was obtained with CG 1006 in 10 December (D_2) sowing.

Table 2
Heat use efficiency (g/m^2/^{o}day) of wheat varieties as influenced by different thermal environments

Varieties / date of sowing	*D_1-25 Nov.*	*D_2-10 Dec.*	*D_3-25 Dec.*	*Mean*
V_1-CG 1006	0.31	0.36	0.33	0.33
V_2-HI1544 (ZC)	0.39	0.41	0.35	0.38
V_3-Ratan (SC)	0.36	0.38	0.34	0.36
V_4-Kanchan	0.42	0.47	0.40	0.43
V_5-CG1013	0.40	0.38	0.36	0.38
V_6-GW273	0.45	0.40	0.38	0.41
V_7-HD2967 (NC)	0.30	0.27	0.27	0.28
Mean	0.37	0.38	0.35	0.37

Table 3
Radiation use efficiency (g/m²/Mj) of wheat varieties as influenced by different thermal environments

Varieties / date of sowing	*D_1-25 Nov.*	*D_2-10 Dec.*	*D_3-25 Dec.*	*Mean*
V_1-CG 1006	0.76	0.93	0.89	0.86
V_2-HI1544 (ZC)	0.97	1.07	0.95	1.00
V_3-Ratan (SC)	0.89	0.99	0.92	0.93
V_4-Kanchan	1.05	1.20	1.07	1.10
V_5-CG1013	0.98	0.99	0.98	0.98
V_6-GW273	1.12	1.03	1.02	1.06
V_7-HD2967 (NC)	0.80	0.73	0.77	0.77
Mean	0.94	0.99	0.94	0.96

Table 4
Grain yield (kg/ha) of wheat varieties under different thermal environments

Varieties / date of sowing	*D_1-25 Nov.*	*D_2-10 Dec.*	*D_3-25 Dec.*	*Mean*
V_1-CG 1006	2897	3237	2962	3032
V_2-HI1544 (ZC)	3522	3682	3622	3608
V_3-Ratan (SC)	3321	3691	2748	3254
V_4-Kanchan	4154	3825	3664	3881
V_5-CG1013	3772	3717	3232	3574
V_6-GW273	3828	3523	3719	3690
V_7-HD2967 (NC)	3434	2998	3279	3237
Mean	3561	3525	3318	3468
	Sem ±	CD (5%)	CV (%)	
Dates (D)	61	174	8.0	
Varieties (V)	93	266		
D X V	161	460		

Table 5
Straw yield (kg/ha) of wheat varieties under different thermal environments

Varieties / date of sowing	*D_1-25 Nov.*	*D_2-10 Dec.*	*D_3-25 Dec.*	*Mean*
V_1-CG 1006	3027	3939	3569	3512
V_2-HI1544 (ZC)	4279	4614	3733	4208
V_3-Ratan (SC)	3620	3908	3943	3824
V_4-Kanchan	3895	4769	4000	4221
V_5-CG1013	3883	3881	3973	3912
V_6-GW273	4471	4046	3647	4055
V_7-HD2967 (NC)	4125	3868	3694	3895
Mean	3900	4146	3794	3947
	Sem±	CD	CV	
Dates (D)	117	335	13.6	
Varieties (V)	179	512		
D X V	310	886		

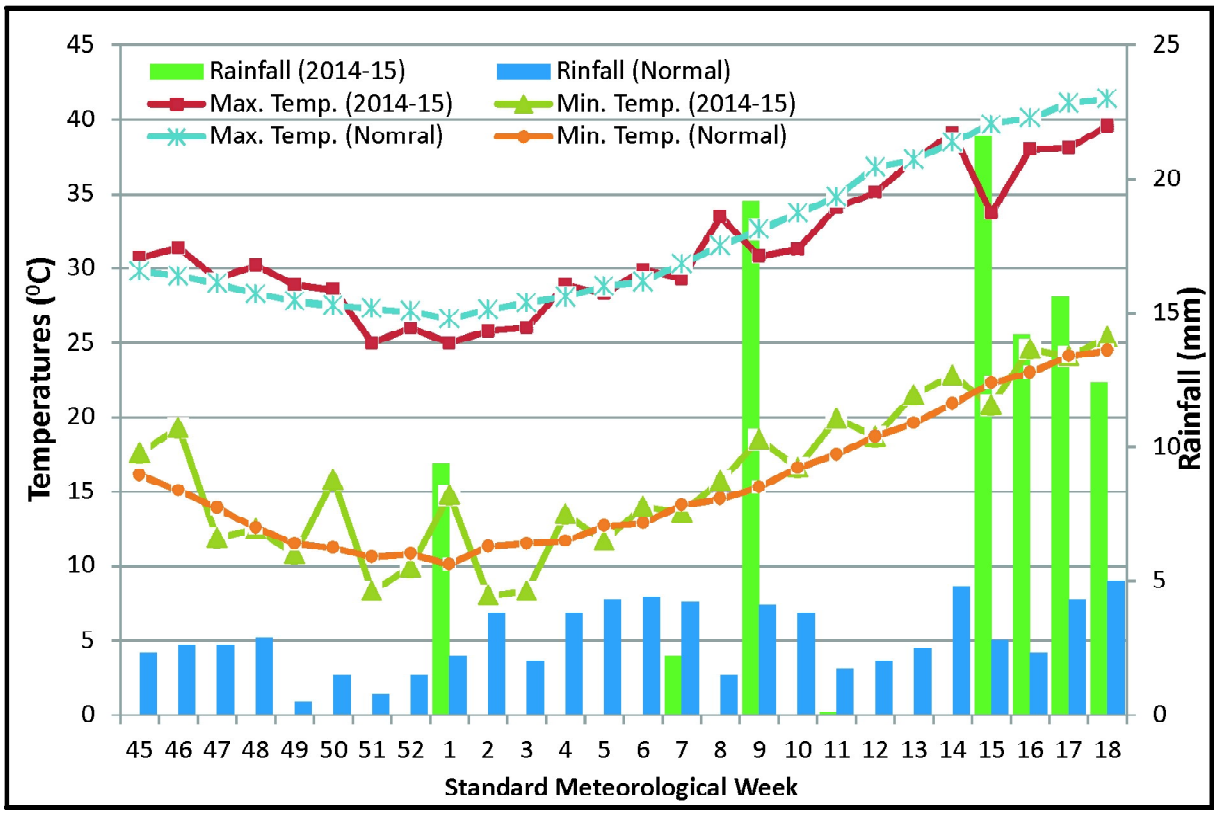

Figure 1: Weather during *rabi* 2014-15 at the experimental site as compared to normal

REFERENCES

Anonymous. (2015). Agricultural Statistics, Commissioner of Land Records, Chhattisgarh, Raipur (Chhattisgarh).

Bobade, Pandhurang, S. K. Chandrawanshi, S. R. Patel and Deepak Kausik. (2018). Thermal responses on different wheat cultivars under different thermal environments for Chhattisgarh plain. *MAUSAM*, 69(1):81-96.

Chaudhary, J.L., Patel, S.R., Verma, P.K., Manikandan, N. and Rajesh Khavse. (2016). Thermal and radiation effect studies of different wheat varieties in Chhattisgarh plain zone under rice-wheat cropping system. *MAUSAM*. 67(3):677-682.

Patel, S.R., Thakur, D.S. and Lal, N. (1999). Response of wheat varieties to sowing dates in eastern Madhya Pradesh in rice-based cropping system. *Journal of Maharashtra Agricultural Universities* 24(1): 53-55.

Puranik H. V. and Patel S.R. (2014). Effect of Sowing Dates on Yield and Yield Components of Wheat Cultivars. *Journal of Agricultural Research & Technology*. 39(2):347-350.

Sandhu, I.S., Sharma, A.R. and Sur, H.S. (1999). Yield performance and heat unit requirement of wheat (*Triticum aestivum*) varieties as affected by sowing dates under rainfed condition. *Indian Journal of Agricultural Science* 69 (3): 175-179.

Sandhu, S. S., Prabhjyot Kaur, Padmakar Tripathi, S. R. Patel, Rajinder Prasad, N. S. Solanki, Ramesh Kumar, C. B. Singh, A. P. Dubey and V. U. M Rao. (2016). Effect of intra-seasonal temperature on wheat at different locations of India: A study using CERES-Wheat model. *Journal of Agrometeorology*. 18(2):222-233.