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Short Communication

Response of wheat crop to different thermal regimes under the agroclimatic conditions of Jharkhand

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Temperature is an important environmental factor that affects plant development, growth and yield. Changes in seasonal temperature affect the grain yield mainly through bringing changes in phenological development processes. Winter Crops are especially vulnerable to high temperature during reproductive stages and differential response of temperature change (rise) to various crops has been noticed under different production environments (Kalra *et al* 2008). Hundal (2004) observed that a 2 ^{o}C increase in temperature in wheat or rice resulted in 15-17 percent decrease in grain yield of both crops but beyond that the decrease was very high in wheat. Next to paddy and maize, wheat is the most important staple cereal for Jharkhand state which occupies an area of 4% of total cropped area. Jharkhand comes under the agro-climatic region of Eastern plateau and Hills. Since rainfall in this region is relatively high with an average annual rainfall of 1398.8 mm, wheat cultivation in Jharkhand has gained popularity in recent years and area under this crop is gradually expanding with the adoption of rainwater harvesting and re-uses technique for assured irrigation. Cool weather during vegetative period and warm weather during maturity are ideal requirements for wheat (Mavi, 1986).

Heat unit concept has been applied to correlate phenological development in crops to predict sowing and maturity dates (Mills. 1964; Nuttonson, 1955). The quantification of heat use efficiency (HUE) is useful for the assessment of yield potential of a crop in different environment. However, information on heat unit requirement and temperature response on wheat are lacking for Jharkhand region. Keeping this in view the present investigation was carried out.

A field experiment with wheat (Triticum aestivum L), cultivar K 9107, was conducted at Research farm of BAU Kanke, Ranchi, located at 23^{0} 17' N latitude 83^{0} 19' E longitude and altitude of 625m above msl during *rabi* season of 2006-07. The soil was clay loam in texture and acidic in reaction. The experiment comprised of four sowing dates viz., 20th Nov (normal-D1), 5th Dec (moderately late-D2), 20th Dec (late-D3) and 5th Jan (very late-D4). The dates of initiation of various phenological stages of the crop viz., emergence, CRI, tillering, jointing, booting, flowering, milking and physiological maturity were identified visually by keenly watching randomly selected plants. The crop was raised following the recommended package of practices of the Birsa Agricultural University, Kanke. Weather parameters were recorded at the agro meteorological observatory located 300 meters away from experimental field. Daily soil temperatures of cropped fields (at 6.00am and 2.00pm) were recorded at 0-15 cm depth using a soil thermometers inserted into the field at the time of sowing. Three temperature reading were taken per replication on each occasion.

Growing degree days (GDD) or heat units were determined as per Nuttonson (1955) using base temperature of 5^{0}C. All thermal units were accumulated from the date of sowing to each date of sampling and a particular date of phenophase to give accumulated indices. Phenothermal index (PTI), the ratio of degree-days to the number of days between two phenological stages was calculated as;

$$PTI = \frac{\text{Degree days consumed between two phenological stages}}{\text{Number of days between two phenological stages}}$$

Heat use efficiency (HUE) for Grain yield was obtained as;

$$\text{Heat use efficiency} = \frac{\text{Grain yield (kg ha}^{-1}\text{)}}{\text{Accumulated heat units }^{0}\text{C day}}$$

The number of days and accumulated heat units (GDD) required to attain different stages, under different sowing dates are presented in Table 1. Every delay in crop sowing reduced the crop duration of the wheat crop. Every delay in sowing, by 15 days, caused a reduction of 5, 7, and 9 days in the lengths of crop periods of respective treatments.

Heat unit accumulation of the crop, irrespective of dates of sowing, has remained almost similar at all the stages particularly from late jointing to maturity. At flowering stage

Table 1: Heat unit and number of days needed to attain different phenophases in wheat crop

Sowing dates/ Pheno-phases	20th Nov.		5th Dec.		20th Dec.		5th Dec.	
	DAS	GDD	DAS	GDD	DAS	GDD	DAS	GDD
Sowing	0		0		0		0	
Germination	8	123	10	131	8	94	10	103
CRI	23	303	24	275	22	218	27	277
Max Tillering	43	498	43	447	43	434	45	523
Late jointing	64	689	65	682	63	679	60	700
Boot	77	791	78	689	76	856	72	742
Flowering	88	983	89	989	87	1193	83	1214
Milking	112	1335	113	1364	106	1370	98	1382
Maturity	134	1687	129	1709	122	1717	113	1724

Table 2: Heat use efficiencies (HUE) of wheat crop

Treatments (Sowings)	GDD (deg days)	Grain yield (kg ha^{-1})	HUE (kg ha^{-1} degday^{-1})	Re yi
Normal (D1)	1687	3768	2.23	
Mod. Late (D2)	1709	3139	1.83	
Late (D3)	1717	3078	1.79	
Very Late (D4)	1724	2909	1.68	

the wheat crop under treatments D_1, D_2, D_3 and D_4 accumulated 983, 989, 1193 and 1214 degree days respectively. The maximum reduction in crop period due to delayed sowing has been observed between flowering and maturity. In wheat this is the period when maximum production and accumulation of metabolite occurs. Hence, any reduction in the length of this period is supposed to be reflected into poorer grain yield.

Heat use efficiency (HUE) of wheat

Amongst the date of sowing the timely (normal) sown wheat crop exhibited maximum HUE of 2.23 kg grain ha^{-1} deg days^{-1} (T able 2). Timely sowing (normal) of wheat crop, in this region, seems to be essential for harnessing the good impact of the prevailing weather conditions.

Phenothermal index (PTI)

The average daily heat units between two phenological stages, expressed as PTI, were computed (Table 3). PTI value decreased till booting stage and thereafter gradually increased towards maturity. Phenothermal index can be used to express development characters as it integrates phenological behaviour with the thermal regime.

Leaf area index (LAI)

Maximum LAI was maintained at flowering stage (Fig.1). However, at flowering stage the normal sown crop exhibited highest LAI of 2.78 followed by Mod.sown (2.54). Every delay in sowing caused lesser LAI.

Air and soil temperature

The average air temperatures and soil temperatures (0-15cm depth) of cropped fields, between different crop stages, have been illustrated in Fig.2 and 3. It has been reported that an average temperature of 15°C during grain formation is nearly optimum for maximum grain weight. (Chowdhury and Wardlaw, 1978 and Fischer, 1985). The deviation in maximum and minimum temperatures above or below optimum value is found to influence the plant activities in many ways, the cumulative effects of which are observed in yield. Temperatures above 25°C during this period tend to depress grain weight. When temperatures are high, too much energy is lost through the process of transpirations by the plants and the reduced residual energy results in poorer grain formation and lower yields.

Until maximum tillering stage wheat crop sown on all the dates grew in a moderate soil and air temperature regime but after this stage all the later stages of later sown crops,

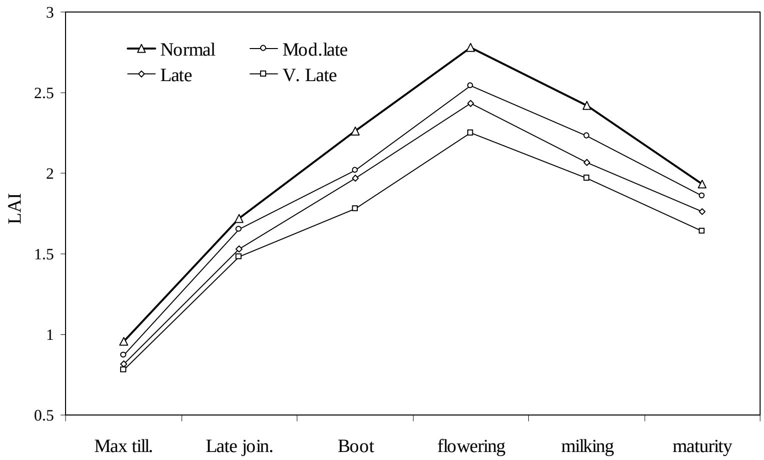

Fig. 1: Leaf area index (LAI) of wheat crop at different stages

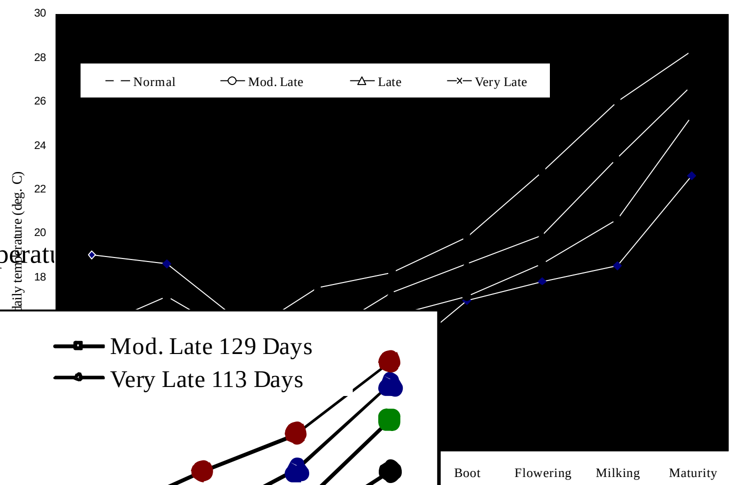

Fig. 2: Average mean daily air temperatu

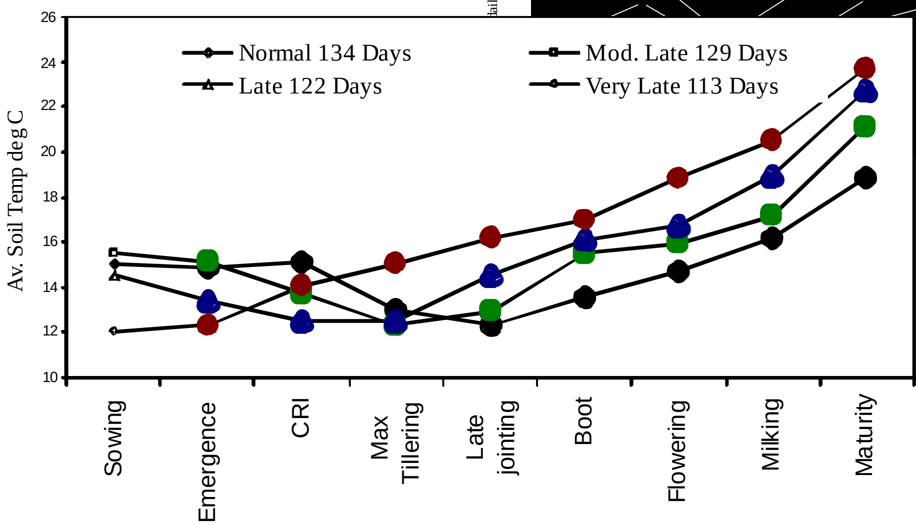

Fig. 3: Average soil surface temperature between two stages of wheat crop sown under different dates

Table 3: Phenothermal index (PTI) at different phenological stages under different sowing dates.

Sowing dates/ Pheno-phases	20th Nov.	5th Dec.	20th Dec	5th Dec
Germination	15.4	13.3	11.7	10.3
CRI	13.2	11.4	9.9	10.3
Max Tillering	11.6	10.4	10.1	11.6
Late jointing	10.8	10.5	10.8	11.7
Boot	10.3	8.8	11.3	10.3
Flowering	11.2	11.1	13.7	14.6
Milking	11.9	12.1	12.9	14.1
Maturity	12.6	13.2	14.1	15.3

from late jointing onwards, were exposed to comparatively higher temperature regimes (18.2 °C to 28.3 °C and 16.2 °C to 20.5 °C air temperature and soil temperature respectively) and causing earlier maturity of corresponding crops. At flowering, the most thermally sensitive stage, later sown crops were exposed to higher air temperatures (22.8 °C) compared to earlier sown crops (17.8 °C), and this was maintained till the maturity (28.3 °C for very late sown as against 22.6 °C for normal sown).The maximum differences of 7.5 °C in temperature was observed at the milking stage between very late and normal sown conditions. With every delay in wheat sowing beyond normal date the risk of sterility increases. The risk would be more in case of the abnormal rise in temperature. Hence, timely sowing (20th Nov.) of wheat crop may escape the risk of temperature rise and sterility at flowering stage.

Yield response of wheat

Timely sown wheat crop on arround 20th Nov. with an average seasonal air temperature of 17.5 °C produced highest grain yield of 37.68 q ha^{-1}, where as with every fortnightly delay in sowings an increase in average seasonal air temperature (18 to 20°C) caused reduction in yield by 16 to 22 percent (Table.2).

The above findings on the response of wheat crop to different thermal regimes, suggest that under the agro-climatic conditions of Jharkhand state normal sowing (around 20th Nov) of wheat crop has to be advocated so that the farmers get improved yield.

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