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Effect of phenophasic development of wheat (*Triticum aestivum* L.) cultivars under different growing environment

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Abstract
The field experiment was conducted during *rabi* season 2015-16 to generate the ground truth data of wheat crop. The experiment was conducted in Split Plot Design and replicated four times. The treatment comprised of three dates of sowing *viz*. 25th November (D_1), 10th December (D_2) and 25th December (D_3) kept as a main plot with three varieties *viz*. PBW-343 (V_1), PWB-502 (V_2) and LOKE-1 (V_3) kept as a subplot. The crop weather condition overestimated the accumulation heat unit/ Thermal unit (GDD), Solar radiation interception (MJm^2), Temperature during growth stages, Relative humidity above and below crop canopy (%), Soil temperature (^0C) The phenological events were close to observed values in timely sown crop suggested that the yield was well within the accepted limits, therefore the predicting wheat phenological events in the regions of Uttar Pradesh, where experiment was conducted.

Keywords: Wheat, phenophasic, solar radiation interception

1. Introduction
Wheat is a major cereal crop, which plays an important role in food and nutritional security. About 40 per cent of the total food grain reserves of the country is contributed by wheat crop. In India, three species of wheat is cultivated, 87 per cent of cultivated wheat belongs to *Triticum aestivum (*bread wheat), 12 per cent of cultivated wheat belongs to *Triticum durum* (macaroni wheat) and 1 per cent of cultivated wheat belongs to *Triticum dicoccum* (emmer wheat). The global area of the wheat is 275.4 mha and production is 674.9 mt in 2015. In India, total area under wheat is 31.34 mha, with production of 95.91 mt and the productivity of wheat in India is 3.06 tonne ha^{-1} (Anonymous, 2014). In India, the highest area under wheat cultivation is in Uttar Pradesh. Uttar Pradesh also ranks first in terms of production and Haryana ranks first in productivity. In Haryana, area under wheat is 2.49 m ha and the production of wheat is 11.6 mt and the productivity is 4.72 tonne ha^{-1}. The wheat production in the country is highly variable due to its wide adaptability in different climatic regions. In the present scenario of climatic change of "global warming", there is a great challenge of sustainable wheat production in the country. It is projected by IPCC that 3-4 ^0C average temp. will be increased by 2080 A.D. and winter will be more warmer as compare of monsoon period etc, hence winter production will be adversely affected due to high temperature. It is a long day plant. Temperature ranging between 20° to 25°C is ideal for seed sowing and germination. Whereas the optimum temperature for vegetative growth ranges from 16 to 22°C. During the grain development wheat requires a mean maximum temperature of about 25°C for at least 4-5 weeks. Wheat is grown well in those areas where annual rainfall ranges between 1200 mm to 1600 mm. Winter wheat generally completes its life-cycle most rapidly when grown in low temperatures during the early stages of growth but high temperature is required during the later stages of growth (Bobade 2010) [2].

2. Materials and Methods
A field experiment was conducted during rabi season 2015-16 at the Agro Meteorological research farm, N.D. University of Agriculture & Technology, Kumarganj, Faizabad (U.P.) at a distance of about 42 km away from Faizabad district headquarter on Faizabad Raibarelly road and geographical situation of experimental site lies at latitudes 260 47' North and longitude 820 12′ East and altitude of 113 meters from main sea level in the Indo genetic alluvium of eastern (U.P). The Faizabad district falls in a semi-arid zone, receiving a mean annual rainfall

of amount 1100 mm. out of which about 90 Percent of the total rainfall received during south-west monsoon (from June to Sep.); with 7 percent in the winter season (Tripathi *et al*., 1998). Fertilizers were applied as per the recommended dose for the wheat crop by the university (i.e. 120 kg N, 60 kg P_2O_5 and 40 kg K_2O ha^{-1}). As per recommendation, we have applied nitrogen through Urea, phosphorus through diammonium phosphate and potassium through muriate of potash were applied to wheat. Half dose of N and a full dose of P_2O_5, and K_2O were applied as basal application as per treatment, 1/4th portion of N was applied during a tillering stage and rest 1/4th at ear head stage of the crop. The experiments consist of 9 treatment combinations which comprised 3 dates of sowing and three varieties. The experiment was conducted in split-plot design (SPD) and replicated four times. The crop was sown with three different dates on 25th November 2015, 10th December 2015, and 25th December 2015. Sowing was done in row 20 cm apart and plant spacing made 5 cm. a seed rate of 100 kg ha-1 was used. Planking was done to cover the seeds just after the sowing. The treatment comprised of three dates of sowing *viz*. 25th November (D_1), 10th December (D_2) and 25th December (D_3) kept as a main plot with three varieties *viz*. PBW-343 (V_1), PWB-502 (V_2) and LOKE-1 (V_3) kept as a subplot. The crop weather condition overestimated the accumulation heat unit/ Thermal unit (GDD), Solar radiation interception (MJm^2), Temperature during growth stages, Relative humidity above and below crop canopy (%), Soil temperature (^{0}C).

3. Result and Discussion

3.1 Accumulation heat unit/ Thermal unit (GDD)

Heat Unit requirement of Indian wheat cultivars at different Phenophases as affected by growing environments and cultivars have been presented in t able 3.1 The maximum heat Unit (GDD) requirement from sowing to maturity were recorded 1448.2^{0}days at growing environment (25th, Novemer) while minimum accumulated growing degree days from sowing to maturity1201.8 ^{0}days was observed under growing environment (14th, November) Wider growing environment recorded minimum GDD requirement at all the stages. Different cultivars had marked influence on the Thermal unit/ Accumulation heat unit/growing degree days of Indian mustard at all the phenophases. Accumulated GDD ranged from 1300.4^0 days to 1382.0^0 days irrespective of different cultivars. Maximum Thermal unit/G.D.D/Accumulated heat unit requirement from sowing to maturity 1382.0^{0}days were obtained in PBW-343 variety, while minimum thermal unit was obtained in LOK-1 Variety (1300.4^{0}days) from sowing to maturity of wheat cultivars. Masoni A. *et al.* (1990) [9], Singh, M. *et al.* (2003) [13], Prasad *et al.* (2008) [11], Kurek, I. *et al.* (2007) [8], Solanki, N.S. (2009) [15], Kumar, P.V. *et al.* (2015) [6].

Table 1: Accumulated heat unit/Thermal unit at different phenophases (˚days) of wheat crop as affected by growing environments and cultivars

Treatments	Heat unit/ Thermal unit		
	30 Das	60 Das	90 Das
Date of sowing			
25, Nov.	0.15	0.79	0.88
10, Dec.	0.17	0.85	100.08
25, Dec	0.20	0.83	95.88
Cultivars			
PBW-343	0.12	0.78	90.75
PBW-502	0.18	0.77	102.50
LOK-1	0.21	0.80	98.09

3.2 Solar radiation interception (MJm^2)

Solar radiations interception recorded during entire crop growth period of wheat as affected by Growing environment and cultivars are given in table 2 When crop was sown on 25 November recorded higher solar radiation (531.7 MJm^{-2}). While lowest value of solar radiation at all the stages were recorded under 25 December sowing date (469.0 MJm^{-2}) leading to poor seed yield. PBW-343 variety of wheat cultivars was relatively more efficient in light interception and hence yielded better grain yield because of higher solar radiation under the PBW-343 variety followed by PBW-502. Goswami B. *et al.* (2006) [5], Kumari, V. *et al.* (2009) [7], Mukherjee, J. *et al.* (2014) [14].

Table 2: Solar radiation interception (MJm^2) of wheat cultivars as affected by growing environments & cultivars

Treatments	Solar radiation interception		
	30 Das	60 Das	90 Das
Growing environment			
25, November	85.4	261.7	464.4
10, December	79.5	252.7	432.4
25, December	74.2	238.5	406.3
Cultivars			
PBW-343	73.3	226.5	428.2
PBW-502	83.5	236.0	465.1

3.3 Temperature during growth stages

Data regarding maximum, minimum and mean temperature during different phenological stages under different thermal environments are summarized in table 3. Data presented in reveals that for wheat variety PBW-343 during crop growth period experienced the difference in temperature at maturity stage from D_1 to D_3 for PBW-343 was 0.5 ^{0}C in maximum temperature, 0.2 ^{0}C in minimum temperature and 0.4 ^{0}C in mean temperature. Wheat variety PBW-502 sown on 10 December, 2015 showed that the difference in temperatures during maturity stage for variety PBW-343 was 1.2 ^{0}C in maximum temp., 0.8 ^{0}C in minimum temperature and 1 ^{0}C in mean temperature from D_1 to D_3. The difference in temperature from D_1 to D_3 for variety LOK-1 was 1 ^{0}C in maximum temp., 0.6 ^{0}C in minimum temperature and 0.8 ^{0}C in mean temperature. In general the maximum, minimum as well as mean temperature was higher when the crop was sown in timely sowing condition closely followed by early sown and late sown condition during sowing to emergence. During emergence to CRI stage the maximum temperature, minimum temperature and mean temperature was higher during early sown condition which gradually decreased when the sowing was delayed. The maximum, minimum as well as mean temperature increased gradually when the sowing was delayed from 25 November (D_1) during sowing emergence phase and later increasing putting the crop under thermal stress in D_3 (25 December) sowing. Rahman *et al.* (2009) [12], Solanki N. S. *et al.* (2014) [14], Chakrabarti, B. *et al.* (2011) [3].

3.4 Relative humidity above and below crop canopy (%)

Relative humidity recorded during entire crop growth period has been presented in Table 3. Different cultivars also produced marked variation on relative humidity at all the stages of crop growth period.

3.5 Soil temperature (^{0}C)

Soil temperature recorded at 5, 10 and 20 cm soil depth during entire crop growth period hasbeen presented in Table 3 Soil temperature decreased with successive increase in soil depth.

Table 3: Observed value of different types of weather elements such as min. T, max. T, RH, BSS, rainfall and soil temperature

Week No.	Temperature (^{O}C)		Relative - Humidity (%)		Brig-Ht Suns-Hine (hrs)	Rain fall (mm)	Soil temp.		
	Min.	Max.	Mor.	Eve.			5 cm	10 cm	20 cm
46.	12.04	30.7	79.5	43.2	5.6	00	26.6	26.8	26.9
47.	11.0	30.9	77.7	43.5	5.6	00	24.6	25.2	25.0
48.	12.7	30.6	82.1	51.2	4.6	00	24.9	25.2	25.0
49.	9.4	26.1	92.8	64.7	3.5	00	22.0	22.1	22.9
50.	7.7	23.2	92.7	59.2	3.2	00	20.0	20.9	20.0
51.	5.6	23.0	96.2	52.1	3.9	00	16.4	16.5	16.6
52.	6.2	27.2	96.2	52.8	6.1	00	19.8	19.8	18.6
01.	6.5	24.9	89.8	47.2	4.9	00	17.3	16.6	16.4
02.	7.5	25.1	86.2	48.2	5.1	00	18.5	18.5	18.6
03.	6.8	20.1	89.7	65.5	2.7	00	16.2	16.4	16.3
04.	5.2	22.7	88.5	52.5	3.1	00	16.7	19.2	17.7
05.	8.5	25.6	78.7	48.0	4.6	00	16.7	19.2	17.7
06.	7.5	25.4	86.8	46.8	5.5	00	19.3	19.4	19.3
07.	6.3	28.3	77.8	43.8	4.8	1.2	21.6	21.3	21.2
08.	11.6	28.9	78.7	41.8	6.1	00	23.5	23.4	23.4
09.	13.4	29.7	85.4	39.7	8.1	00	25.2	25.2	25.2
10.	15.1	32.0	79.4	44.5	7.9	00	27.1	31.0	26.9
11.	16.8	34.7	78.4	43.6	8.5	00	28.9	34.7	27.1
12.	22.1	35.8	75.8	40.2	9.1	00	27.8	35.8	26.2
13.	23.7	37.4	69.8	39.3	9.5	00	29.6	38.1	27.1

Fig 1: General view of experimental site

4. Conclusion

The all-weather parameter conditions pooled over cultivars, the most sensitive phonological stage for both maximum temperature and rainfall with absolute t-values -4.54 (P< 0.05) and 2.51 (P< 0.05), respectively, closely followed by the milking stage in maximum temperature. The influence of meteorological parameters will finally contribute to the grain yield. In this stage, maximum temperature, minimum temperature, and sunshine are found to be negatively correlated while the rainfall has been found to be positively affecting the grain yield. The weekly weather data *viz.*, maximum temperature and rainfall for the period 46-13 standard meteorological weeks were used to get weighted and unweighted indices for regression analysis. Although there may be a number of agronomic and meteorological reasons behind this slightly lower rate of accuracy during the particular Rabi season (2014-2015), yet it is significant at 95% and 99% confidence levels. That is, in this particular season, one of the two predictors was at their extreme i.e. maximum temperature and rainfall. The model could not incorporate the influence of these extremes effectively to evaluate the relevant yield up to the mark. This unusual situation may be the reason for the underestimation of yield by SPSS in this cropping season.

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