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Ekta Kamboj
Department of Agronomy, CCS Haryana Agricultural University, Hisar, Haryana, India

Bhagat Singh
Department of Agronomy, CCS Haryana Agricultural University, Hisar, Haryana, India

Anil Kumar Dhaka
Department of Agronomy, CCS Haryana Agricultural University, Hisar, Haryana, India

Corresponding Author:
Ekta Kamboj
Department of Agronomy, CCS Haryana Agricultural University, Hisar, Haryana, India

Phenology and yield of wheat (*Triticum aestivum* L.) in relation to agrometeorological indices under different sowing times

Ekta Kamboj, Bhagat Singh and Anil Kumar Dhaka

Abstract
The present investigation was carried out during the *Rabi* season of 2016-17 at the research farm of Wheat & Barley Section, Chaudhary Charan Singh Haryana Agricultural University, Hisar. The experiment was laid out in a split plot design with four sowing times (5th November, 15th November, 25th November, 5th December) in main plots and four wheat varieties (WH 1105, HD 2967, HD 3086, DBW 88) in subplots with three replications. Crop sown on 5th November took the maximum number of days to attain days to 50% heading and days to maturity and thus, accumulated significantly higher growing degree days and helio-thermal units as compared to crop sown on 5th December. Sowing of wheat on 5th November resulted in a 27.4 per cent higher grain yield as compared to 5th December sowing. Wheat variety HD 2967 took the maximum number of days to 50% heading while DBW 88 took the maximum number of days for maturity, resulting in higher growing degree days and helio-thermal units in wheat variety DBW 88. However, the maximum grain yield (5822 kg/ha) and the maximum heat use efficiency was recorded in wheat variety HD 3086.

Keywords: Sowing time, varieties, phenology, growing degree days, yield

Introduction
Wheat (*Triticum aestivum* L.) is the most important cereal crop and a staple food of the vast majority of the human population. It is a winter season crop, widely cultivated under varied agro-ecological conditions and cropping systems throughout the world. It is the second most important food grain in India after rice. India is the second largest producer of wheat after China. India contributes 13.3% of wheat to world production. Globally, wheat production is 765.5 mt from an area of 218.2 mha. In India, wheat is cultivated on area of 31.4 mha with production of 107.9 mt (Anonymous, 2020) [1]. The stagnation in the productivity of this crop is now all-apparent. But there is still a wide gap in the potential productivity and actual yield of this crop in real farming situation. There are many factors responsible for lower yield, such as delayed planting, selection of unsuitable varieties, inappropriate seeding rates, improper planting geometry and soil type *etc*. Among various factors responsible for the lower yield of wheat crop in the country, sowing time and varietal selection are of primary importance. A sustainable increase in grain yield of wheat varieties can be achieved by sowing the wheat crop at the optimum time, which varies according to variety or genotype, climatic conditions and availability of resources. Suitability of varieties to a particular agro-climate is the most important factor in realizing their yield potential because production efficiency of the plants is determined by genotype and environment. Environmental conditions prevailing over a particular agro-climatic zone cannot be altered. However, the sowing time of a crop can be adjusted to take maximum advantage of the environmental factors to best suit various growth stages of the crop. Wheat has its own definite requirements for temperature and light for emergence, growth and flowering (Dabre *et al*., 1993) [4]. The optimum temperature required for wheat anthesis and grain filling ranges between 12 and 22°C and exposure to temperature above 30 °C at pre-anthesis or post-anthesis stages reduces the grain filling rate in wheat and thereby decreases the grain yield. Therefore, heat stress imposed on plant due to delayed sowing is considered as the most significant abiotic stress affecting wheat productivity (Prasad *et al*., 2017) [12]. The present day rice-wheat cropping system, keeping in view monsoonal irregularities, has compelled the wheat crops to be subjected to rapidly ascending temperatures coupled with hot dry winds during the post-anthesis stage, especially during grain development.

These unfavourable environments terminate grain growth prematurely and reduce yield considerably (Sharma and Kumar, 2009) [13]. Temperature plays an important role in determining sowing time. The crop environment varies with the date of sowing and determines the wheat yield. Therefore, to study the effect of climatic conditions on wheat cultivars, present experiment was conducted.

Material and Methods

The experiment was conducted during *Rabi* season 2016-17 at Research Farm of Wheat and Barley Section, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana (India), situated at 29°10' N latitude and 75°46' E longitude at an elevation of 215.2 m above mean sea level. The soil of the field was sandy loam in texture, slightly alkaline in reaction with a pH of 8.3, low in organic carbon (0.29-0.32%) and available nitrogen, medium in available phosphorus and high in available potassium. The experimental was laid out in a split plot design with three replications. In main plot, four sowing dates *i.e.* D_1 - 5th November, D_2 - 15th November, D_3 - 25th November and D_4 - 5th December were taken and wheat varieties *i.e.* V_1- WH 1105, V_2- HD 2967, V_3- HD 3086 and V_4- DBW 88 were taken in subplot. Sowing of different varieties of wheat was done manually with the help of hand plough by pora method at 5 cm depth according to treatments. Full dose of P_2O_5, K_2O and $ZnSO_4$ and half dose of N was applied to all the plots one day before sowing and remaining half dose of nitrogen was top dressed at 1st irrigation. Weeding was done with a hand hoe in all the plots after 30-35 days of sowing. Other management practices were adopted as per recommendations of the wheat crop. For crop phenological observations, five plants in each plot tagged after germination were used to record the number of days taken for initiation of different phenophases *i.e.* emergence, 50% heading and maturity. The weather data of different standard meteorological weeks (SMW) during the crop growth period was obtained from the meteorological observatory of CCS HAU, Hisar (Figure 1).

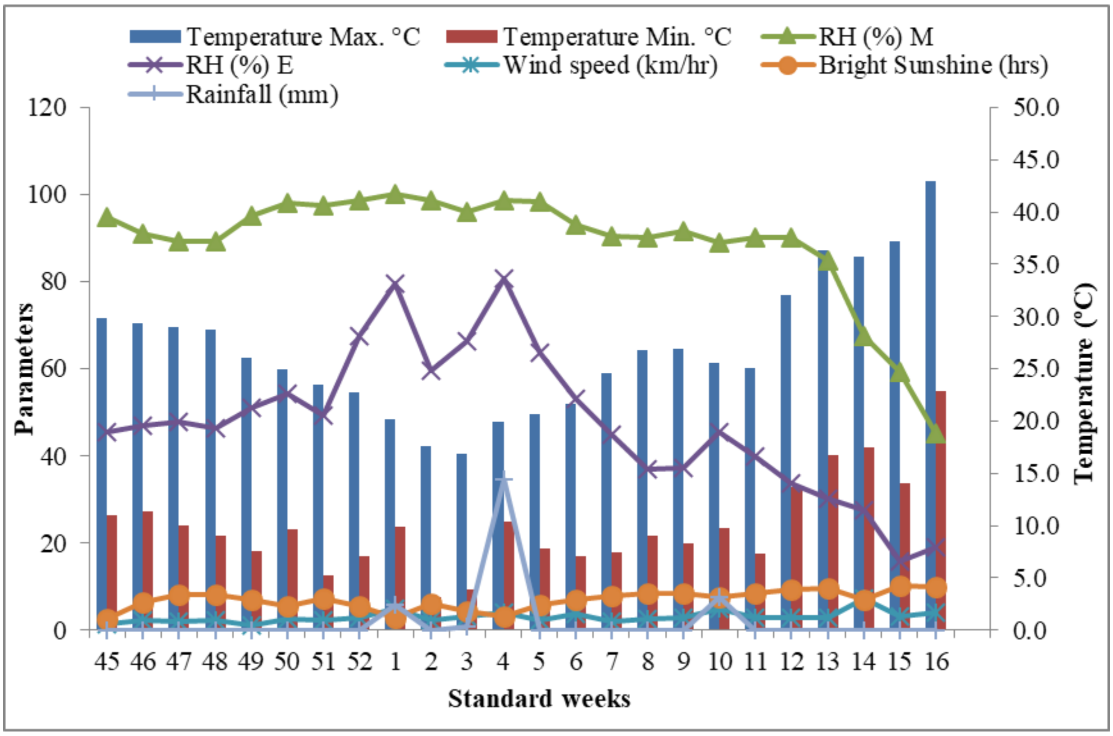

Fig 1: Mean weekly weather data recorded at agricultural meteorology observatory, CCS HAU, Hisar during *Rabi* (2016-2017)

The total rainfall received during the crop growing period was 48.7 mm. Weekly maximum and minimum temperatures remained under a suitable range for different crop growth stages. The average temperature on sowing dates for 5th November, 15th November, 25th November and 5th December was 20 °C, 18.5 °C, 18 °C, and 16.5 °C, respectively while the average temperature at harvesting was 22.5 °C, 26.2 °C, 28.4 °C and 31.2 °C for 5th November, 15th November, 25th November and 5th December sowing, respectively. The bright sunshine during the crop growth period ranged between 2.5 and 10.3 hours. The meteorological indices calculated were (Amravat *et al.*, 2013 and Prasad *et al.*, 2017) [12]:

Accumulated growing degree days

Accumulated growing degree days at maturity were calculated by using the formula:

$$\sum GDD\ (°C\ days) = \sum [(T_{max}+T_{min})/2 - T_{base}]$$

Where, GDD = Accumulated growing degree days at maturity
T_{max} = Daily maximum temperature
T_{min} = Daily minimum temperature
T_{base} = Base temperature for wheat (4.5°C)

Accumulated helio-thermal units

Accumulated helio-thermal units at maturity were calculated by using the formula:

$$\sum HTU\ (°C\ day\ hours) = \sum (GDD \times \text{Bright sunshine hours})$$

Where,
HTU = Accumulated helio-thermal units at maturity
GDD = Accumulated growing degree days

Heat use efficiency

Heat use efficiency on grain yield basis was calculated by using the formula:

$$\text{HUE (kg ha}^{-1}\text{/°C day)} = \frac{\text{Grain yield (kg/ha)}}{\sum \text{GDD (°C days)}}$$

Where, HUE = Heat use efficiency, GDD = Accumulated growing degree days at maturity

The data collected were subjected to statistical analysis by using 'Analysis of Variance Technique' as suggested by Gomez and Gomez (1983) [7]. Standard errors of mean and critical difference (CD) values at 5% level of probability were computed for making comparison between treatments.

Result and Discussion

Phenological studies

The maximum number of days for germination was taken by the crop sown on 5th December (10.1), which were significantly higher than early sowings (Table 1). With delay in sowing time, days required for crop emergence markedly increased. This might be due to the decrease in the mean daily temperature from 5th November (20 °C) to 5th December (16.5 °C). Similar results were also reported by Hussian *et al.* (2013) [8].

Table 1: Effect of sowing times and wheat varieties on days required to attain different phenological stages

Treatments	Phenological stages		
	Days to crop emergence	**Days to 50% heading**	**Days to maturity**
Sowing times			
5th November	7.0	98.3	150.9
15th November	8.5	97.8	141.6
25th November	9.1	93.4	133.4
5th December	10.1	87.1	122.8
S.Em±	0.1	0.3	0.2
CD (p=0.05)	0.4	0.9	0.6
Varieties			
WH 1105	8.7	94.1	136.9
HD 2967	8.7	97.0	137.1
HD 3086	8.8	90.3	136.7
DBW 88	8.6	95.2	138.0
S.Em±	0.2	0.2	0.1
CD (p=0.05)	NS	0.6	0.4

Days to 50% heading was significantly higher in 5th November sown crop (98.3) as compared to 25th November (93.4) and 5th December (87.1) sown crop and it was statistically at par with 15th November (97.8) sown crop. Similar findings were also reported by Ahmed *et al.* (2015) [2] which emphasized that growing crops at different sowing dates pass through each development stage under different environmental conditions. With delay in sowing, the number of days required for maturity statistically decreased in comparison to early sowing. Crop sown on 5th December (122.8) took minimum time for maturity. In late sown wheat, time to heading was reduced in a curvilinear fashion as temperature increased and grain development period was reduced that led to early maturity of crop (Suleiman *et al.*, 2014 and Mumtaj *et al.*, 2015) [15, 10]. Among different wheat varieties, no significant difference in days to emergence was reported. The highest number of days to 50% heading was recorded in HD 2967 (97.0), which was significantly higher than the other varieties. Varieties with ability to stay green under high temperature conditions took more number of days for anthesis (Wahid *et al.*, 2007) [17]. However, significantly higher number of days to maturity was recorded in wheat variety DBW 88 (138), which was significantly higher than other varieties. The differential behaviours to days required to reach the various phenological phases could be ascribed solely to their genetic makeup (Gill *et al*., 2016 and Singh *et al*., 2017) [6, 14].

Grain Yield: The wheat crop sown on 5th November recorded the highest grain yield (6178 kg/ha), which was significantly higher than subsequent later sowings and it was found that each delay in sowing by 10 days from 5th November to 5th December resulted in a 5.4, 12.7 and 21.5 per cent reduction in grain yield (Table 2).

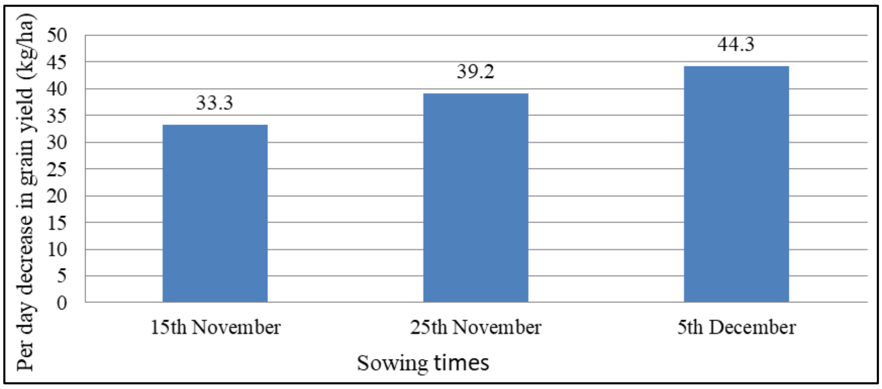

Fig 2: Per day decrease in grain yield due to delayed sowing from 5th November to 5thDecember

Among varieties, the highest grain yield was recorded in HD 3086 (5822 kg/ha), which was significantly higher than HD 2967 (5402 kg/ha) and DBW 88 (5336) but at par with WH 1105 (5707 kg/ha). This might be due to the prevailing favourable temperature required for the wheat crop for higher photosynthate accumulation, consequently resulting in higher yield parameters in 5th November sowing. These results are also in conformity to that of Dahiya *et al*. (2017) and Vashisht *et al*. (2017) [5, 16]. The per day decrease (mean of all varieties) in grain yield (Figure 2) with delayed sowing from 5th November to 15th November, 25th November and 5th December was found to be 33.3 kg/ha, 39.2 kg/ha and 44.3 kg/ha, respectively.

Meteorological Indices

Accumulated growing degree days, helio-thermal units and heat use efficiency on grain yield basis

The crop sown on 5th November accumulated maximum growing degree days and helio-thermal units to attain maturity which were significantly higher as compared to other treatments (Table 2). For the transition from the vegetative phase to the reproductive phase, each and every crop requires a definite amount of growing degree days. Crop sown early absorbed sufficient amount of growing degree days in more time as compared to late sown. Late sowing resulted in less consumption of heat units. Minimum and maximum temperatures remained higher during the reproductive phase, causing detrimental effect on grain yield. These results were in line with Nayak *et al*. (2017), Chhabra *et al*. (2017) and Prasad *et al*. (2017) [11, 3, 12].

Table 2: Effect of sowing times and varieties on the grain yield and meteorological indices at maturity of wheat

Treatments	Grain yield (kg/ha)	Meteorological indices at maturity		
		ΣGDD (°C days)	ΣHTU (°C day hour)	HUE (kg ha^{-1}/°C day)
Sowing times				
5th November	6178	1906.2	13284.0	3.25
15th November	5845	1756.6	12603.6	3.33
25th November	5395	1651.0	11713.2	3.27
5th December	4850	1502.5	10629.9	3.23
SEm±	93	4.0	19.2	0.1
CD (p=0.05)	302	12.9	62.3	NS
Varieties				
WH 1105	5707	1699.0	12035.3	3.37
HD 2967	5402	1701.7	12048.7	3.18
HD 3086	5822	1693.2	11995.1	3.44
DBW 88	5336	1722.3	12151.6	3.10
S.Em±	71	3.1	22.2	0.0
CD (p=0.05)	204	9.0	64.0	0.1

Heat use efficiency (kg ha^{-1}/°C day) was highest in 15th November sowing and lowest in 5th December sowing. Different sowing times do not show any significant effect on heat use efficiency. These results are in line with those reported by Kumar *et al.* (2017) [3]. Among the varieties, maximum number of growing degree days and helio-thermal units were reported from wheat variety DBW 88 to attain maturity, which was significantly more than other varieties. Minimum helio-thermal units (HTU) were accumulated by variety HD 3086. The differential behaviours to heat unit requirements could be ascribed solely to their genetic makeup (Chhabra *et al*., 2017 and Singh *et al*., 2017) [3, 14]. Among different wheat varieties, the highest heat use efficiency was obtained in HD 3086, which was significantly higher than HD 2967 and DBW 88 and it was statistically at par with WH 1105. The significant variation in grain yield heat use efficiency of different wheat varieties was also reported by Singh *et al.* (2017) [14].

Conclusion

The crop sown on 5th November took the maximum calendar days, growing degree days and helio-thermal units for maturity resulted in highest grain yield which got reduced with subsequent delay in sowing time. Among the wheat varieties, DBW 88 took highest calendar days, growing degree days and helio-thermal units for maturity, while, the highest grain yield and the highest heat use efficiency was recorded in variety HD 3086.

References

1. Anonymous. Ministry of agriculture and farmers welfare, Government of India, 2020. https://www.indiastat.com/table/agriculture/area-production-productivity-wheat-india-1949-1950/7400
2. Ahmed G, Ishaq M, Khan S, Ali R, Afridi K, Khalil IA *et al*. Performance of newly developed wheat advanced lines evaluated under different planting dates for important traits. European Academic Research. 2015;2(10):12598-12614.
3. Chhabra K, Singh R, Kumar A, Kumar Y, Sharma S, Singh S. Computation of agrometeorological indices in barley cultivars under different growing environments at Hisar. (Ab.) National Seminar on Agrometeorology for Sustainable Development from 12th-14th October, 2017 held at CCSHAU, Hisar, 2017, 39p.
4. Dabre WM, Lall SB, Lngole GL. Effects of sowing dates on yield, ear number, stomatal frequency and stomatal index in wheat. Journal of Maharashtra Agricultural Universities. 1993;18(1):64-66.
5. Dahiya S, Punia SS, Singh J. Effect of sowing dates on growth indices and crop phenology in wheat crop. (Ab.) National Seminar on Agrometeorology for Sustainable Development from October 12-14, 2017 held at CCS HAU, Hisar, 2017, 46p.
6. Gill KK, Kaur N, Gill RIS. Evaluation of growth and yield of wheat cultivars using agroclimatic indices under poplar-based agroforestry system in Punjab. Journal of Agrometeorology. 2016;18(1):124-127.

7. Gomez KA, Gomez AA. Statistical procedures for agricultural research, IRRI: A Wiley Publication, New York, 1983, 199-201p.
8. Hussian I, Ahmad R, Farooq M, Wahid A. Seed priming improves the performance of poor-quality wheat seed. International Journal of Agricultural Biology. 2013; 15:1343-1348.
9. Kumar M, Singh B, Dhaka AK. Impact of prevailing thermal based indices on phenology, yield attributes and yield of barley cultivars under different sowing windows at Hisar conditions. (Ab.) National Seminar on Agrometeorology for Sustainable Development from October 12-14, 2017 held at CCSHAU, Hisar, 2017, 55p.
10. Mumtaj MZ, Ahmad M, Aslam M, Zamil M, Zaman MF, Nasrullah HM *et al*. Evaluation of growth and yield attributes of different wheat genotypes sown under various planting times. Journal of Biology, Agriculture and Healthcare. 2015;5(19):85-90.
11. Nayak MK, Singh R, Kumar A, Ahatsham M, Dagar CS. Influence on the agrometeorological indices of wheat under different growing environment and irrigation regimes. (Ab.) National Seminar on Agrometeorology for Sustainable Development from October 12-14, 2017 held at CCSHAU, Hisar, 2017, 9p.
12. Prasad S, Agrawal KK, Kumar R, Prakash V. Heat unit requirement of wheat cultivars under varying thermal regimes at Jabalpur. Journal of Agrometeorology. 2017;19(3):283-285.
13. Sharma KD, Kumar A. Physiological and management approaches to mitigate terminal high temperature stress in wheat (*Triticum aestivum* L.). Journal of Agrometeorology. 2009;11:57-60.
14. Singh R, Singh S, Singh D, Kumar A. Radiation use efficiency and yield of wheat under different growing environments. (Ab.) National Seminar on Agrometeorology for Sustainable Development from October 12-14, 2017 held at CCSHAU, Hisar, 2017, 25p.
15. Suleiman AA, Nganya JF, Ashraf MA. Effect of cultivar and sowing date on growth and yield of wheat (*Triticum aestivum* L.) in Khartoum, Sudan. Journal of Forest Products and Industries. 2014;3(4):198-203.
16. Vashisht A, Karad G, Baloda RS, Joshi DK, Krishnan P. Effect of weather on radiation use efficiency and yield of wheat crop. (Ab.) National Seminar on Agrometeorology for Sustainable Development from October 12-14, 2017, held at CCSHAU, Hisar, 2017, 25p.
17. Wahid AS, Gelani MA, Foolad R. Heat tolerance in plants: An overview. Environmental and Experimental Botany. 2007;61:199-223.