



International Journal of Research in Agronomy

E-ISSN: 2618-0618
P-ISSN: 2618-060X
© Agronomy
NAAS Rating (2025): 5.20
www.agronomyjournals.com
2025; 8(11): 406-410
Received: 26-08-2025
Accepted: 29-09-2025

Vinita Parte
College of Agriculture, Ganjbasoda,
Vidisha, JNKVV, Jabalpur,
Madhya Pradesh, India

PK Mishra
Dean, College of Agriculture
Powarkheda, JNKVV, Jabalpur,
Madhya Pradesh, India

Abhishek Sharma
Jawaharlal Nehru Krishi Vishwa
Vidyalaya, Jabalpur, Madhya
Pradesh, India

Effect of thermal environments and weed control treatments on agrometeorological indices of wheat (*Triticum aestivum* L.)

Vinita Parte, PK Mishra and Abhishek Sharma

DOI: <https://www.doi.org/10.33545/2618060X.2025.v8.i11f.4200>

Abstract

A field experiment was conducted during *rabi* season of 2023-24 and 2024-25 to study the agrometeorological indices viz. accumulated growing degree days (GDD), helio-thermal unit (HTU), photo-thermal unit (PTU) at different phenological stages of wheat variety HI-1544 under different herbicidal mixtures and thermal environments. To address this, a two-year field experiment (2023-24 and 2024-25) was conducted at the Farm B, College of Agriculture, GanjBasoda, District Vidisha (M.P.). The experiment was conducted in split plot design with three thermal environments (15th November, 30th November and 15th December) and 6 weed control treatments (W₁: Fenoxaprop-p-ethyl + Metribuzin, W₂: Clodinafop-propargyl + Metsulfuron Methyl, W₃: Sulfosulfuron + Metsulfuron Methyl, W₄: Metribuzin + 2,4-D, W₅: single hand weeding at 30 DAS and W₆: Weedy check) with three replications. Results of present study revealed that the crop sown on thermal environment of 15th November took maximum calendar days, total growing degree days, photo thermal unit, helio-thermal unit and heat use efficiency to attained different phenological stages till maturity. Among the weed control treatments, maximum calendar days, agrometeorological indices (GDD, HTU, PTU) was higher under W₃ (Sulfosulfuron + Metsulfuron Methyl).

Keywords: Thermal environments, herbicidal mixtures, calendar days, growing degree days, photo thermal unit, helio-thermal unit and heat use efficiency.

Introduction

The most essential and commonly cultivated staple food crop across all the cereals is wheat. Wheat is essential crop for the food security and eliminates poverty in rural areas which also improves the livelihoods of Indian farmers. There are several factors which affecting the growth and yield of wheat. Among various factors responsible for low yield of wheat crop in the country are sowing at proper time, favorable environment and cultural management practices (Tahir *et al.*, 2009) ^[22]. Thermal environment is also the most significant factor that administrates the phenological growth of the crop as well as the biomass conversion in to economic yield. All the stages of growth like tillering, flowering and grain filling are negatively impacted by the shortening of growing period in the condition of late sowing wheat. Increase in temperature causes the optimum growth period reduction leads to leaf senescence resulting in a photosynthetic rate that is too low to meet plant economy (Sharma-Natu *et al.*, 2006) ^[20]. Approximately 50 per cent decrease in yield of wheat is noticed due to some dominating weed flora which appears at early stage and also restricts the growth of crop. Mostly wheat farmers depending on the herbicides due to its effectiveness and easy application as compare to the manual weeding. Presently, weeds are being controlled mainly by herbicides. Therefore, the present investigation aimed to study the effect of thermal environments and weed control treatments on agrometeorological indices of wheat.

Materials and Methods

The field experiment was carried out during the *rabi* season of 2023-24 and 2024-25 at the Farm B, College of Agriculture, GanjBasoda, District Vidisha (M.P.). The weekly maximum temperature during crop season of 2023-24 varied from 22.3 °C (1st metrological week) to 38.2

Corresponding Author:
Vinita Parte
College of Agriculture, Ganjbasoda,
Vidisha, JNKVV, Jabalpur,
Madhya Pradesh, India

°C (13th metrological week) while during the crop season 2024-25, it was varied from 22.9 °C (2nd week) to 38.2 °C (14th week) and minimum temperature varied from 7.7 °C (4th week) to 22.6 °C (13th week) during 2023-24 and from 5.8 °C (50th week) to 21.5 °C (14th week) in the crop season 2024-25. The experiment was conducted in split plot design with three thermal environments (15th November, 30th November and 15th December) and 6 weed control treatments (W₁: Fenoxaprop-p-ethyl + Metribuzin, W₂: Clodinafop-propargyl + Metsulfuron Methyl, W₃: Sulfosulfuron + Metsulfuron Methyl, W₄: Metribuzin + 2,4-D, W₅: single hand weeding at 30 DAS and W₆: weedy check) with three replications. The agrometeorological indices growing degree days (GDD), helio-thermal unit (HTU), photo-thermal unit (PTU) and heat use efficiency were calculated using following formula.

Growing degree days (GDD)

Growing degree days (GDD)

The growing degree days (GDD) were determined as per Nuttonson (1955)^[14].

$$GDD = \frac{T_{max} + T_{min}}{2} - T_t$$

Where, T_{max} and T_{min} are the daily maximum and minimum (°C) and T_t is the base temperature. Base temperature was taken 4.5 °C for the analysis.

Helio-thermal unit (HTU)

The HTU is the product of heat unit (HU) and daily hours of bright sunshine. The HTU worked using the formula (Rajput, 1980)^[17]:

$$HTU = \sum_{i=1}^n GDD \times BSH$$

Where, BSH = Bright sunshine hours

Photo thermal unit (PTU)

Photo thermal units (PTU) was calculated by using the equation given by Wilsie (1962)^[23]. Photo thermal units (PTU) was calculated by using the equation

$$PTU = GDD \times L$$

Where, GDD=Growing degree days L=Maximum possible day length

Heat use efficiency (HUE)

The HUE was calculated using the formula (Rao *et al.*, 1999)^[18].

Seed yield

$$HUE = \frac{\text{Seed yield}}{\text{Growing degree day}}$$

Results and Discussion

Duration of phenological stages of wheat as influenced by thermal environments and weed control treatments during emergence, earhead emergence and physiological maturity are presented in Table 1. The crop sown on 15th November took longest duration (117 days) and 15th December took lowest

duration (105 days) for physiological maturity. Delayed sowing reduced the time needed for phenological stages, as supported by Bhuiyan *et al.* (2008)^[5], Mondal *et al.* (2011)^[13] and Begna and Angadi (2016)^[4]. Late sowing exposed crops to cooler temperatures during the vegetative phase and warmer temperatures during the reproductive phase, required to attain various phenological stages, as noted by Agrawal *et al.* (2001)^[1], Jhanji and Gill (2011)^[7], Amrawat *et al.* (2013)^[2], Pathania *et al.* (2019)^[15], Gupta *et al.* (2021)^[6] and Kamboj *et al.* 2022^[8]. Khavse *et al.* (2015)^[9] also reported that the time-span of different phenological events decreased from tillering and continued in all stages as the sowing was delayed in wheat. In case of weed control treatments, W₂ (Clodinafop-propargyl + Metsulfuron Methyl) and W₃ (Sulfosulfuron + Metsulfuron Methyl) took more number of days for physiological maturity (112 days) due to effective weed suppression, which reduced intra as well as inter-plant competition and promoted vigorous crop growth, as supported by Mir *et al.* (2024)^[12].

Table 1: Duration of phenological stages of wheat as influenced by thermal environments and weed control treatments (pooled of two years)

Treatments	Emergence	Earhead emergence	Physiological maturity
Main plot- Thermal environments			
E ₁	6	73	117
E ₂	6	70	112
E ₃	5	65	105
Sub plot- Weed control treatments			
W ₁	5	69	111
W ₂	6	70	112
W ₃	6	70	112
W ₄	5	69	111
W ₅	5	68	111
W ₆	5	68	111

Note: E: Thermal environments, E₁: 15th November, E₂: 30th November, E₃: 15th December, W: Weed control treatments, W₁: Fenoxaprop-p-ethyl + Metribuzin, W₂: Clodinafop-propargyl + Metsulfuron Methyl, W₃: Sulfosulfuron + Metsulfuron Methyl, W₄: Metribuzin + 2,4-D, W₅: Hand weeding at 30 DAS, W₆: Weedy check.

Agrometeorological indices at emergence, earhead emergence and physiological maturity

Growing degree days at emergence

Data on GDD of wheat under different thermal environments and weed control treatments during emergence, earhead emergence and physiological maturity were presented in Table 2. The crop grown on 15th November had accumulated maximum GDD at emergence, earhead emergence and physiological maturity (103.32, 992.94 and 1711.53 °C days respectively) as compared to 30th November and 15th December. Early sowing required more heat units, while delayed sowing shortened phenophase durations, reducing GDD accumulation and hastening maturity Agrawal *et al.* (2001)^[1] reported similar findings while comparing normal and late sowing in wheat. A steady delay in planting reduced the length of phenophases due to which accumulation of GDD get reduced during different phenophases and forced the crop to complete its life cycle early. The post emergence application of W₃ (Sulfosulfuron + Metsulfuron Methyl) accumulated maximum GDD at all the stages of wheat (95.31, 959.49 and 1711.45°C days) in every phenophases compared to other weed control treatments, likely due to better crop growth under reduced weed pressure, as noted by Punia *et al.* (2018)^[16] and Rohit *et al.* (2019)^[19].

Table 2: Effect of thermal environments and weed control treatments on growing degree days of wheat (pooled of two years)

Treatments	GDD (°Cdays)		
	Emergence	Earhead emergence	Physiological maturity
Main plot- Thermal environments			
E ₁	103.32	992.94	1711.53
E ₂	92.59	942.36	1688.66
E ₃	59.12	882.58	1668.06
Sub plot- Weed control treatments			
W ₁	82.79	935.62	1682.15
W ₂	92.80	952.48	1702.55
W ₃	95.31	959.49	1711.45
W ₄	87.95	940.34	1689.36
W ₅	77.28	925.81	1676.16
W ₆	73.93	922.02	1674.83

Note: E: Thermal environments, E₁: 15th November, E₂: 30th November, E₃: 15th December, W: Weed control treatments, W₁: Fenoxaprop-p-ethyl + Metribuzin, W₂: Clodinafop-propargyl + Metsulfuron Methyl, W₃: Sulfosulfuron + Metsulfuron Methyl, W₄: Metribuzin + 2,4-D, W₅: Hand weeding at 30 DAS, W₆: Weedy check.

Helio-thermal unit

Data on HTU of wheat under different thermal environments and weed control treatments during emergence, earhead emergence and physiological maturity were presented in Table 3. Among the thermal environments, the highest HTU were required at emergence, earhead emergence and physiological maturity by 15th November date of sowing (764.77, 5776.86 and 12257.54 °Cdays hr.). HTU decreased with delayed sowing, determined by variations in temperature and sunshine hours, combined with the shorter duration of late-sown crops. These findings are also obtained by Pathania *et al.* (2019) [15], Mehta *et al.* (2020) [11], and Sultana *et al.* (2020) [21], who noted that timely sown crops required longer periods for maturity. In case of weed control treatments, W₃ (Sulfosulfuron + Metsulfuron Methyl) required maximum HTU at emergence, earhead emergence and physiological maturity (585.23, 5864.52 and 12386.23 °Cdays hr. respectively) and the lowest total HTU accumulated by W₆ (weedy check). This might be due to higher crop and weed competition for various resources pushes the plants to complete life cycle more rapidly, as supported by Punia *et al.* (2018) [16] and Rohit *et al.* (2019) [19].

Table 3: Effect of thermal environments and weed control treatments on heliothermal unit of wheat (pooled of two years)

Treatments	HTU (°Cdayshr.)		
	Emergence	Earhead emergence	Physiological maturity
Main plot- Thermal environments			
E ₁	764.77	5776.86	12257.54
E ₂	428.90	5716.36	12237.91
E ₃	366.77	5595.11	12195.62
Sub plot- Weed control treatments			
W ₁	507.23	5665.29	12177.34
W ₂	568.47	5803.41	12325.49
W ₃	585.23	5864.52	12386.23
W ₄	541.06	5706.81	12229.48
W ₅	470.54	5584.65	12138.58
W ₆	448.35	5552.00	12126.03

Note: E: Thermal environments, E₁: 15th November, E₂: 30th November, E₃: 15th December, W: Weed control treatments, W₁: Fenoxaprop-p-ethyl + Metribuzin, W₂: Clodinafop-propargyl + Metsulfuron Methyl, W₃: Sulfosulfuron + Metsulfuron Methyl, W₄: Metribuzin + 2,4-D, W₅: Hand weeding at 30 DAS, W₆: Weedy check

Photo thermal unit

Data on PTU of wheat under different thermal environments and

weed control treatments during emergence, earhead emergence and physiological maturity were presented in Table 4. The crop grown on 15th November had accumulated maximum PTU at emergence, earhead emergence and physiological maturity (1109.86, 10450.24 and 18593.19 °C days hr. respectively). This might be happened due to longer duration taken by crop to reach different phenological stages. This study is supported with the findings of Langangmeilu (2023) [10]. Among weed control treatments, the treatment W₃ (Sulfosulfuron + Metsulfuron Methyl) accumulated maximum PTU at all the phenological stages (1006.60, 10197.10 and 18843.90 °C days hr) and the lowest PTU accumulated by W₆ (Weedy check). This might happen due to weed competition hastening crop development, as noted by Rohit *et al.* (2019) [19] and Mir *et al.* (2024) [12].

Table 4: Effect of thermal environments and weed control treatments on photothermal unit of wheat (pooled of two years)

Treatments	PTU (°Cdayshr.)		
	Emergence	Earhead emergence	Physiological maturity
Main plot- Thermal environments			
E ₁	1109.86	10450.24	18593.19
E ₂	969.72	9991.71	18584.04
E ₃	616.11	9474.08	18574.64
Sub plot- Weed control treatments			
W ₁	875.29	9930.71	18494.27
W ₂	980.27	10118.70	18737.38
W ₃	1006.60	10197.10	18843.90
W ₄	929.38	9983.63	18580.20
W ₅	817.48	9821.80	18452.63
W ₆	782.35	9780.11	18406.91

Note: E: Thermal environments, E₁: 15th November, E₂: 30th November, E₃: 15th December, W: Weed control treatments, W₁: Fenoxaprop-p-ethyl + Metribuzin, W₂: Clodinafop-propargyl + Metsulfuron Methyl, W₃: Sulfosulfuron + Metsulfuron Methyl, W₄: Metribuzin + 2,4-D, W₅: Hand weeding at 30 DAS, W₆: Weedy check

Heat use efficiency

Heat use efficiency was calculated to determine the number of growing degree days required to produce unit amount of grain yield. Data on heat use efficiency of wheat under different thermal environments and weed control treatments were presented in Table 5 and in Fig. 1. The highest heat use efficiency for grain yield was recorded under 15th November thermal environment (2.51 Kg ha⁻¹ °C day⁻¹) while the lowest recorded on 15th December. The highest heat use efficiency (HUE) for grain yield was observed in early sowing in November due to proportional increment in dry matter accumulation per heat unit used. Delayed sowing, particularly on mid December, resulted in lower HUE due to elevated temperatures during the reproductive phase, which negatively impacted grain yield and dry matter accumulation. Early sowing optimized heat unit accumulation, enabling wheat to complete phenological stages under favorable conditions, enhancing growth and yield. After that, 30th November sowing, while effective, had slightly reduced heat units and yield due to a shorter growing period, while 15th December sowing accelerated phenology and exposed crops to heat stress during grain filling, lowering HUE. These findings are consistent with Pathania *et al.* (2019) [15] and Anonymous (2025) [3]. Among the weed control treatments, W₃ (Sulfosulfuron + Metsulfuron Methyl) and W₂ (Clodinafop-propargyl + Metsulfuron Methyl) recorded the highest HUE (2.46 Kg ha⁻¹ °C day⁻¹) and the lowest HUE was noticed in W₆ (Weedy check). These variations in grain yield and GDD were due to weed management efficacy which was highest in Sulfosulfuron + Metsulfuron Methyl and Clodinafop-

propargyl + Metsulfuron Methyl among all the weed control treatments, as supported by Mir *et al.* (2024)^[12] and Punia *et al.* (2018)^[16].

Table 5: Effect of thermal environments and weed control treatments on heat use efficiency of wheat at harvest (pooled of two years)

Treatments	Grain yield (kg ha ⁻¹)	GDD at harvest	HUE
Main plot-Thermal environments			
E ₁	4623.03	1844.89	2.51
E ₂	4562.97	1833.52	2.49
E ₃	3490.14	1792.82	1.95
Sub plot- Weed control treatments			
W ₁	4204.44	1816.1	2.32
W ₂	4511.17	1832.55	2.46
W ₃	4549.44	1846.85	2.46
W ₄	4375.28	1823.65	2.40
W ₅	4001.00	1814.78	2.20
W ₆	3710.94	1808.52	2.05

Note: E: Thermal environments, E₁: 15th November, E₂: 30th November, E₃: 15th December, W: Weed control treatments, W₁: Fenoxaprop-p-ethyl + Metribuzin, W₂: Clodinafop-propargyl + Metsulfuron Methyl, W₃: Sulfosulfuron + Metsulfuron Methyl, W₄: Metribuzin + 2,4-D, W₅: Hand weeding at 30 DAS, W₆: Weedy check.

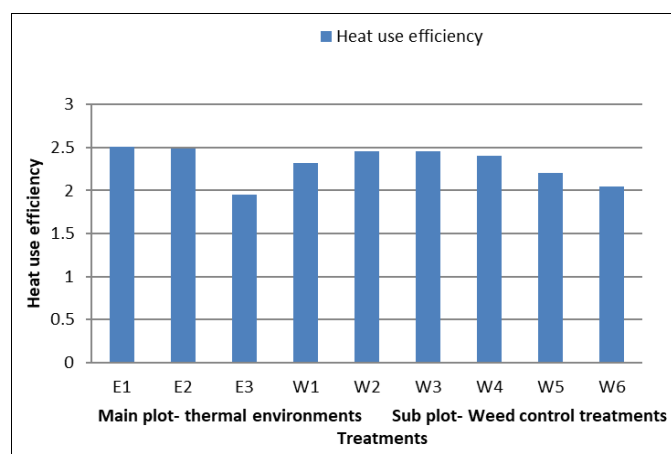


Fig 1: Effect of thermal environments and weed control treatments on heat use efficiency of wheat at harvest (pooled of two years)

Conclusion

On the basis of findings of this study, it is possible to conclude that agrometeorological indices provided a scientific foundation for assessing the effect of temperature at various phenological stages of the wheat crop. The crop sown on 15th November took maximum calendar days, GDD, HTU, PTU and HUE for phenological stages, which got reduced significantly with subsequent delay in sowing time and recorded lowest value on 15th December. Thus the crop sown on 15th November recorded the highest grain yield as compare to 30th November and 15th December. Sulfosulfuron + Metsulfuron Methyl accumulated maximum agrometeorological indices among all the weed control treatments and produced maximum yield. It has the potential to convert heat units into economic yield in an efficient manner.

References

1. Agrawal KK, Shanker U, Upadhyay AP, Gupta VK. Phenological behaviour and thermal requirements of wheat genotypes under different dates of sowing. *Annals of Plant and Soil Research*. 2001;3(1):12-16.
2. Amrawat T, Solanki NS, Sharma SK, Jajoria DK, Dotaniya ML. Phenology, growth and yield of wheat in relation to

- agrometeorological indices under different sowing dates. *African Journal of Agricultural Research*. 2013;8(49):6366-6374.
3. Anonymous. Helio-thermal units (HTU) influence on crop-weed dynamics in wheat: role of canopy closure and light interception across sowing dates. 2025;1-3.
4. Begna SH, Angadi SV. Effects of planting date on winter canola growth and yield in the southwestern US. *American Journal of Plant Sciences*. 2016;7(1):201-217.
5. Bhuiyan MS, Mondol MRI, Rahaman MA, Alam MS, Faisal AHMA. Yield and yield attributes of rapeseed as influenced by date of planting. *International Journal of Sustainable Plant Production*. 2008;3(3):25-29.
6. Gupta V, Gupta M, Kour S, Sandhu SS. Agromet indices and response of varieties of wheat (*Triticum aestivum* L.) to sowing environments and nitrogen levels under irrigated lower hills of North-West plains of Shiwaliks. *Indian Journal of Agronomy*. 2021;66(1):25-32.
7. Jhanji S, Gill DS. Phenological development and heat unit requirement of wheat under different dates of sowing. *Indian Journal of Animal Research*. 2011;45:161-166.
8. Kamboj E, Singh B, Dhaka AK. Phenology and yield of wheat (*Triticum aestivum* L.) in relation to agrometeorological indices under different sowing times. *The Pharma Innovation Journal*. 2022;11(3):1737-1741.
9. Khavse R, Deshmukh R, Verma N, Kaushik D. Phenology, growth and yield of wheat in relation to agrometeorological indices under different sowing dates. *Plant Archives*. 2015;15(1):81-87.
10. Langangmeilu G. Effect of sowing technique and date of sowing on growth, growing degree days, yield, oil yield and economics of rapeseed (*Brassica napus* L.) cultivars in Alfisols of Chhattisgarh plains [PhD thesis]. Raipur (Chhattisgarh): Indira Gandhi Krishi Vishwavidyalaya; 2023.
11. Mehta P, Dhaliwal LK. Effect of different sowing dates on helio-thermal, photo-thermal, heat use efficiencies and productivity of wheat (*Triticum aestivum* L.). *Journal of Agricultural Physics*. 2020;20(1):106-119.
12. Mir MS, Singh P, Kantha RH, Bhata TA, Shah ZA, Darde EA, *et al.* Impact of different sowing dates and weed management strategies on phenological development, productivity, and thermal efficiencies of direct seeded rice. *Advances in Weed Science*. 2024;42:e020240069.
13. Mondal MRI, Begum F, Saiyed IM. Effect of planting dates on seed and oil yield of rapeseed (*Brassica campestris* L.) genotype BCYS-03. *SAARC Journal of Agriculture*. 2011;9(1):85-93.
14. Nuttonson MY. Wheat-Climate Relationships and the Use of Phenology in Ascertaining the Thermal and Photothermal Requirement of Wheat. Washington (DC): American Institute of Crop Ecology; 1955. 388 p.
15. Pathania R, Prasad R, Rana RS, Mishra SK. Heat unit requirement and yield of wheat (*Triticum aestivum* L.) varieties under different growing environments in mid-hill conditions of Himachal Pradesh. *Journal of Agrometeorology*. 2019;21(3):282-287.
16. Punia R, Punia SS, Devi S, Hooda VS, Kamboj NK, Thakral SK. Phenological behaviour, weed dynamics and productivity of green gram influenced by weed control treatments. *International Journal of Current Microbiology and Applied Sciences*. 2018;7(2):1795-1804.
17. Rajput RP. Response of soybean crop to climate and soil environments. New Delhi: Indian Agricultural Research

- Institute; 1980.
18. Rao UVM, Singh D, Singh R. Heat use efficiency of winter crops in Haryana. *Journal of Agrometeorology*. 1999;1(2):143-148.
 19. Rohit P, Priyanka M, Maurya BM, Kurmvanshi SM. Thermal response of scented rice under different weed management practices in organic production system. *International Journal of Current Microbiology and Applied Sciences*. 2019;8(3):1833-1841.
 20. Sharma-Natu P, Sumesh KV, Lohot VD, Ghildiyal MC. High temperature effect on grain yield in wheat cultivars: an evaluation of responses. *Indian Journal of Plant Physiology*. 2006;11(3):239-245.
 21. Sultana A, Shaikh N, Zahan M, Akter R, Islam S, Issak M. Agroclimatic indices of rice (*Oryza sativa* L.) influenced by different planting times. *Bangladesh Rice Journal*. 2020;23(2):87-94.
 22. Tahir M, Ali A, Nadeem MA, Hussain A, Khalid F. Effect of different sowing dates on growth and yield of wheat (*Triticum aestivum* L.) varieties in district Jhang, Pakistan. *Pakistan Journal of Life and Social Sciences*. 2009;7(1):66-69.
 23. Wilsie CP. *Crop Adaptation and Distribution*. London: W.H. Freeman & Co.; 1962. p. 52-59.