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Heat unit requirements of chickpea cultivars under different sowing environment of Kymore Plateau and Satpura Hills Zone of M.P.

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Abstract
A field experiment was carried out to study the thermal requirement of chickpea cultivars under different thermal environment during *rabi* seasons of 2020-21 and 2021-22 at Research Farm, AICRP on Agrometeorology, Department of Physics and Agrometeorology Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (Madhya Pradesh). The experiment was laid out in split plot design with three replications consisted of three sowing environments *viz*., 15th November, 30th November and 15th December, three chickpea types *viz*., JG14, JGK 1 and JG 36. Results revealed that duration to attain different phenophases and thermal unit during sowing to maturity decreased with successive delay in sowing form November. Chickpea sown on 30th November produced significantly higher total dry matter accumulation, higher seed yield and biological yield as compared to 15th November and 15th December. Among chickpea cultivars, JG 14 exhibited significantly higher total dry matter accumulation, higher seed yield and biological yield followed by JG 36 and JGK 1.

Keywords: Chickpea, cultivars, GDD, PTU, HTU, phenology

Introduction
Chickpea cultivation in India predominantly occurs during the rabi season, requiring cool and dry weather conditions for optimal growth. The crop is primarily cultivated under rainfed conditions and relies heavily on conserved soil moisture. Madhya Pradesh has allocated around 2.16 million hectares of land specifically for growing chickpeas. This has led to a production of 3.21 million tonnes of chickpeas, with a productivity rate of 1488 kg per hectare. The ideal sowing time for chickpea may differ among various varieties and also across different regions due to the variability in agro-ecological conditions. Various sowing times expose the vegetative and reproductive stages of the plant to different temperature ranges, solar radiation levels, and day lengths (Yadav *et al*., 1999) [17]. The changed environmental conditions arising from varying sowing dates affect the growth and development of the crop by exposing different phenological stages, such as germination, vegetative growth, and reproductive stages, to varying temperature, solar radiation, and day length. Optimizing the timing of sowing, together with the careful selection of cultivars with high-yield potential, is essential for maximizing crop development and production. Nevertheless, the timing of this event is influenced by various meteorological variables like temperature, humidity, and sunshine duration (Bazvand *et al*., 2015) [4]. The crop exhibits a high susceptibility to heat-stress specifically during its reproductive phase, resulting in a decrease in the number of flowers, an increase in flower abortion, and a reduction in seed production (Kaushal *et al*., 2013) [7]. Therefore, it is crucial to choose cultivars that are resistant to environmental fluctuations in order to sustain crop productivity. The correlation between the environment and the selected cultivar has a substantial impact on the ideal planting period for chickpea (Neenu *et al*., 2017) [9]. Determining the ideal sowing time is crucial to capitalize on favorable environmental conditions during chickpea growth for optimal production. Delayed sowing accelerates maturity, leading to a significant decline in yield, which can range from 30% to 60% depending on various factors such as genotypes, timing of sowing, geographical

location, and prevailing climatic conditions during the sowing season. Changes in seasonal temperature affect the grain yield mainly through changes in phenological development processes (Silawat *et al*., 2015) [14]. The productivity of chickpea fluctuates as it responds differently due to their variation in the thermal requirements of given cultivars in a particular climatic condition. Keeping above facts in view, the present investigation was under taken.

Materials and Methods

The field experiment was conducted at Research Farm, Department of Physics and Agrometeorology, J.N.K.V.V., Jabalpur (23° 09' N latitude, 79° 59' E longitude at an altitude of 411 m above mean sea level), Madhya Pradesh, India during two consecutive rabi seasons of 2020-21 and 2021-22. The soil of the experimental field was sandy-clay-loam having pH 6.72, electrical conductivity 0.06 dS/m^2, available N, P_20_5 and K_2O 284, 17.35 and 259 kg/ha, respectively. The experiment was conducted in split-plot design with three replications and comprised of three environments (15th November, 30th November and 15th December) as main plot treatment and three cultivars (JG-14, JG-36 and JGK-1) as sub plot treatment. The chickpea cultivars were sown according to different sowing environments with seed rate @ 80 kg/ha in rows 30 cm. The common dose of 20 kg N, 60 kg P_2O_5 and 20 kg K_20 /ha was applied in all the treatments. The crop was raised as per recommended package of practices. The crop was considered mature when 95% of pods had obtained their mature colour. The plants of the net plot area were harvested by cutting the plants to the ground level and then allowing for sun drying. After complete sun drying, the crop was threshed manually, seeds were cleaned and seed and straw yield were expressed in kilogram per hectare.

The date of occurrences of different phenological events were recorded when 50% of the plants in each replication reached the respective stages. Daily data on temperature (maximum and minimum), rainfall and bright sunshine hours during the crop season were obtained from the Department of Physics & Agrometeorology, JNKVV, Jabalpur. Various heat units were calculated as follows:

1. Growing degree days (Nuttonson, 1955) [10],

$$GDD = \Sigma (T_{max} + T_{min})/2 - Tb$$

Where, T_{max} and T_{min} are daily maximum and minimum temperature (°C) respectively, Tb is the base temperature, taken as 5 °C.

2. Photo thermal units (Wilsie, 1962) [16],

$$PTU = \Sigma (GDD \times \text{length of night or day})$$

3. HTU was computed by formula (Rajput, 1980) [13]:

$$HTU = \Sigma\ GDD \times \text{bright sunshine hours (BSH)}$$

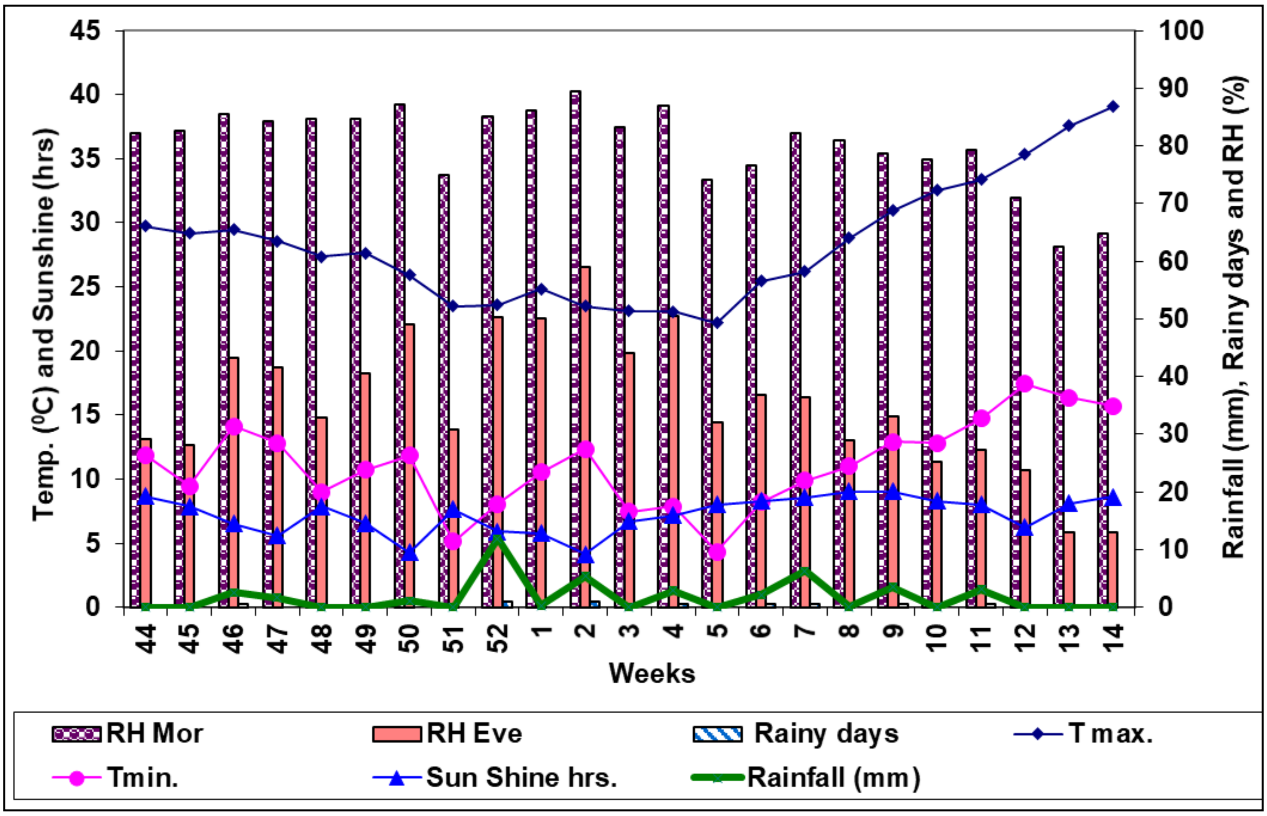

Fig 1: Weekly Meteorological Parameters during Rabi Crop Season 2020-21 and 2021-22 Pooled

Results and Discussion

Heat units during crop growth period

Effect on phenology

The different phenological stages as influenced by various sowing environments and chickpea cultivars are given in Table 1. The days taken to attain different phenological stages and total duration were differed significantly by changing the sowing environments and chickpea cultivars. The crop duration to attain physiological maturity ranges from 102 to 115 for different sowing environments. The crop sown on 15th November taken highest number of days (115) to attain different growth stages i.e. from emergence to physiological maturity followed by 30th

November (109) and 15th December (102) sown crop. This variation may be due to varied climatic conditions. Among the different cultivars JG 36 take maximum days (112) to attain the physiological maturity, whereas lowest number of days taken by JGK1 (106). This variation may be due to genetic makeup of the crop. These variations highlight the crop's sensitivity to changes in photothermal conditions. The late sown crop experienced warmer temperatures and longer daylight hours conditions known to accelerate chickpea growth. As a result, the total growing period shortened, leading to earlier maturity and ultimately lower seed yields. Agrawal *et al*., 2010.

Growing degree days (GDD)
GDD varied remarkably due to sowing dates and chickpea cultivars (Table 1). The chickpea crop sown on 15th November was accumulated maximum GDD (1499) at physiological maturity as compared to 30th November (1419) and 15th December (1392). Among the chickpea cultivars JG 36 recorded highest GDD (1505) as compared to JG 14(1425) and JGK1 (1379) at physiological maturity stage, this clearly described the effect of temperature on chickpea crop. Tyagi, 2014 was also reported lower consumption of heat units under delayed sowing.

Helio-thermal units (HTU)
The accumulated HTU required for attaining different phenological stages of chickpea types are presented in Table 1. Helio thermal unit from sowing to maturity ranged between 9911 to 10939 ^{0}days hr. Helio thermal unit was recorded highest in 15th November (10470 ^{0}days hr) followed by 30th November due to higher growing degree days (Hundal *et al*., 2005) [18] while lowest value was recorded at 15th December (10323 ^{0}days hr). Among cultivars, JG 36 recorded higher HTU (10939 ^{0}days hr) due to comparatively longer duration of maturity followed by JG 14 and JGK1. The varietal differences of chickpea for phasic duration and thermal units were also reported by Pandey (2013) and Sethi *et al*. (2018) [5].

Photo thermal units (PTU)
The variation in PTU in different treatments at various phenological phases of chickpea types are presented in Table 1. The chickpea sown on 15th November attained maximum PTU (16225 ^{0}days hr) at maturity during both the year as compare to other sowing environments. The PTU was found lowest (15417 ^{0}days hr) under late sown crop i.e. 15th December. In between the chickpea cultivars the JG 36 recorded highest PTU (16533 ^{0}days hr) as compared to JG 14(15573 ^{0}days hr) and JGK1(15038 ^{0}days hr). These findings are in confirmation with Singh *et al.* (2012) [15].

Grain yield and straw yield
Chickpea sown on 30th November recorded significantly maximum seed and straw yield (1866 kg/ha and 2144 kg/ha, respectively) over rest of the sowing dates. The significantly lowest seed and straw yield (1643 kg/ha and 1917 kg/ha) was recorded under 15th December sowing (Table 2). Maximum yield in November 30th sowing was a result of a favourable weather condition which provided the suitable vegetative and reproductive growth stages for chickpea plant. Among the chickpea varieties the highest seed and straw yield was recorded with JG 14 (1956 kg ha^{-1} and 2237 kg ha^{-1}, respectively) which was significantly superior over JG 36 (1769 kg ha^{-1} and 2045 kg ha^{-1}, respectively) and JGK 1 (1496 kg ha^{-1}). Sowing chickpea on 30th November fetched maximum mean net return of Rs. 62341/- per ha with B:C ratio of 2.46 followed by 15th November sowing which fetched mean net return of Rs. 53962/- per ha with B:C of 2.26. Among the cultivars the highest mean net return of Rs .67287/- per ha with B:C ratio of 2.57 was obtained from JG 14, followed by JG 36 (NMR of Rs. 57042/ha and B: C ratio 2.34) and then JGK 1 (Rs. 42115/ha) with B: C ratio (1.98). The yield reductions might be due to reduction in vegetative growth period in account of delayed sowing. (Patil *et al*., 2017; Ali *et al*., 2018, Mhaske *et al*., 2019 and Sandeep *et al*. 2023] [12, 1, 8, 6].

Table 1: Accumulated GDD, HTU and PTU of Chickpea cultivars at different phenological stages as influenced by environments (Mean of two year)

Treatments	50% Flowering				50% Pod Information				Physiological Maturity			
	Days	GDD	HTU	PTU	Days	GDD	HTU	PTU	Days	GDD	HTU	PTU
Environments												
E1: 15th Nov	56	741	4599	7828	72	928	5665	9801	115	1499	10470	16225
E2: 30th Nov	55	659	4007	6916	69	810	5109	8541	109	1419	10337	15501
E3: 15th Dec	52	593	3652	6255	65	738	4850	7855	102	1392	10323	15417
Cultivars												
V1: JG14	52	633	3859	6665	67	812	5090	8583	108	1425	10281	15573
V2: JGK1	49	597	3667	6265	64	771	4754	8135	106	1379	9911	15038
V3: JG36	63	763	4732	8047	74	893	5781	9479	112	1505	10939	16533

Table 2: Yield and economics of chickpea as influenced by different environments and cultivars (Mean of two years)

Treatments	Seed yield (kg/ha)	Straw yield (kg/ha)	GMR(Rs/ha)	NMR(Rs/ha)	B:C ratio
Environments					
15th November	1712	1999	94551	53962	2.26
30th November	1866	2144	102929	62341	2.46
15th December	1643	1917	90729	50141	2.17
S.Em ±	25.0	25.0	-	-	-
C.D. at 5%	75.0	75.0	-	-	-
Cultivars					
JG 14	1956	2237	107875	67287	2.57
JGK 1	1496	1778	82703	42115	1.98
JG 36	1769	2045	97630	57042	2.34
S.Em ±	29.0	29.0	-	-	-
C.D. at 5%	86.0	86.0	-	-	-

Conclusion

The present study concluded that sowing of chickpea cultivarJG14 on 30th November exhibited significantly higher growth and yield due to optimal thermal requirements for various plant processes at different growth stages. The heat unit requirements of chickpea types decreased with delay in sowing beyond 30th November.

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References

1. Ali Y, Biswas PK, Shahriar SA, Nasif SO, Raihan RR. Yield and quality response of chickpea to different sowing dates. Asian Journal of Research in Crop Science. 2018;1(4):1-8.
2. Agricultural Statistics at a glance. Directorate of Economics & Statistics, Government of India Report; c2022. p. 42-43.
3. Agrawal KK, Bhadauria UPS, Jha A, Jain S. Crop weather relationship studies on chickpea for improving crop adoption to climate change. International Journal of Tropical Agriculture. 2010;28(12):239-242.
4. Bazvand F, Pezeshkpour P, Mirzaie A. Chickpea (*Cicer arietinum* L.) yield and yield components as affected by sowing date and genotype under rainfed conditions. Bulletin of Environment and Pharmacological Life Sciences. 2015;4(11):59-65.
5. Sethi IB, Sewhag M, Kumar P, Hooda VS, Kumar A. Heat Unit Required in Relation to Phenology of Chickpea Cultivars as Influenced by Sowing Time and Seed Rate. International Journal of Current Microbiology and Applied Science. 2018;7(7):3556-3559.
6. Sandeep GS, Umesha C, Kiran UV. Effect of Dates of Sowing on Growth and Yield of Chickpea Varieties. International Journal of Environment and Climate Change. 2023;13(10):834-838.
7. Kaushal N, Awasthi R, Gupta K, Gaur PM, Siddique KHM, Nayyar H. Heat-stress-induced reproductive failures in chickpea (*Cicer arietinum*) are associated with impaired sucrose metabolism in leaves and anthers. Functional Plant Biology. 2013;40:1334-1349.
8. Mhaske S, Agrawal KK, Bhan M. Growth, Yield and economics of chickpea types as influenced by different thermal environment and irrigation. The Pharma Innovation Journal. 2019;8(9):401-403.
9. Neenu S, Ramesh K, Ramana S, Somasundaram J. Effect of cultivars and sowing dates on nutrient uptake and yield of chickpea under aberrant climatic conditions in black soils of central India. Advances in Research. 2017;12(4):1-11.
10. Nuttonson MY. Wheat climatic relationship and use of phenology in ascertaining the thermal and photo-thermal requirements of wheat. American Institute of Crop Ecology, Washington DC. 1955;388.
11. Pandey RK. Effect of sowing dates and varieties on growth, development and yield of Chickpea (*Cicer arietinum* L.) under irrigated conditions. M.Sc. Thesis. J.N.K.V.V., Jabalpur. 2013;101.
12. Patil DD, Nayak MK, Patel HR. Effect of date of sowing and irrigation levels on yield and yield attributing characters of chickpea. International Journal of Agriculture Science. 2017;9(20):4220-4221.
13. Rajput RP. Response of soybean crop to climatic and soil environments. Ph.D. Thesis, IARI, New Delhi, India; c1980.
14. Silawat S, Shrivastava AK, Agrawal KK. Charecterization of thermal environment for optimization of growth and yield in chickpea in Kymore plateau and Satpura Hills zone of M.P. Journal of Agricultural Physics. 2015;15(1):45-54.
15. Singh AK, Mishra AN, Tripathi P. Thermal regime requirement and plant responses of chickpea cultivars under variable weather conditions. Journal of Agrometeorology. 2012;14(1):67-69.
16. Wilsie CP. Crop Adaptation and Distribution. Freeman WH and Co., London; c1962. p. 52-59.
17. Yadav VS, Yadav SS, Singh JDS, Panwar D. Morpho-physiological basis of yield in chickpea under late planting conditions. Annals of Agricultural Research. 1999;20(2):227-230.
18. Hyde R, Hajduch E, Powell DJ, Taylor PM, Hundal HS. Ceramide down-regulates System A amino acid transport and protein synthesis in rat skeletal muscle cells. The FASEB journal. 2005 Mar;19(3):1-24.