International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2021; 9(1): 2049-2052

Received: 08-10-2020
Accepted: 19-11-2020

Deepak Lal
Department of Agrometeorology (COA), Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

GK Das
Department of Agrometeorology (COA), Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Pramod Kumar
Department of Agrometeorology (COA), Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Corresponding Author:
Deepak Lal
Department of Agrometeorology (COA), Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Thermal requirement of mustard (*Brassica juncea*) at different phonological stages under Chhattisgarh plain climatic conditions: A review

Deepak Lal, GK Das and Pramod Kumar

DOI: https://doi.org/10.22271/chemi.2021.v9.i1ac.11524

Abstract
Growth and yield of *Brassica species* largely depends upon change in environment during crop growth this change in environment can occur through many practices including sowing dates and water availability. For getting higher yield, sowing time of crop needs to be adjusted with suitable agro-climatic environment (Saha and Khan, 2008). Pradhan *et al.* (2014) reported that there was significant interaction between date of sowing and cultivars with respect to seed yield of mustard. It was concluded that normal or early sowing of Pusa Jai Kisan or Pusa Bold cultivar may be practiced for achieving higher seed yield, radiation and water use efficiency in semi-arid environment of north and north-western part of India. Indian-mustard is much sensitive to climatic variables; hence, climate change could have significant effect on its production. One month delay in sowing from mid of October resulted in 40.6% loss in seed yield (Lallu, *et al.*, 2010). Gill and Bains (2008) observed a linear and positive relation between leaf area development and photosynthetically active radiation (PAR) interception, which leads to higher dry matter production. LAI plays an important role for crop growth based on its interception and utilization of PAR for producing dry matter and with the delay in planting date, the higher mean temperature was experienced during flowering which led to accelerate the decrease in LAI and reduction in the flowering period.

Keywords: Growth intervals, mustard, sowing dates, yield and yield attributes

Introduction
Indian mustard (*Brassica juncea*) is the second most important oilseed crop in India after groundnut sharing 27.8% in the India's oilseed production. The crop occupies an area of approximately 6.90 million hectare with a production of 8.18 million tonnes (Shekhawate *et al.* 2016). In India, the Haryana state contributes 10.2% to the total rapeseed-mustard production in the country. Likewise, area under mustard in Haryana has increased from 1.98 lakh ha in 1966-67 to 5.70 lakh ha in 2015-16. A considerable improvement in mustard productivity has also happened during the period with its increase from 405 kg/ha in 1966-67 to 1350 kg/ha in 2013-14 (Indiastat, 2016).
Growing degree days (GDD), photo-thermal unit (PTU), helios thermal unit (HTU), photo-thermal index (PTI) and heat use efficiency (HUE) have frequently been used as a weather based parameters for assessing crop phenology. Therefore, all growth and development stages of crop may be estimated more accurately on the basis of GDD rather than calendar method. Mustard crop require different amount of GDD, PTU, HTU, PTI and HUE for growth and development stages. The GDD is used to quantify effect of temperature and described the timing of different biological process. The present investigation was carried out to quantify relationship of GDD, PTU, HTU, PTI and HUE with phenological development of crop.
A universal truth is that solar radiation is the unique source of energy especially for plant kingdom. Visible portion of radiation is most important for the crops. It is well known that radiant energy is directly converted into plant biomass. Solar radiation received by the plant during entire growing period is an important component of weather which directly affects the production and productivity of crop. Amount of solar radiation and its distribution over the crop canopy is another weather parameter which regulates the physiochemical and biological processes in plant community. Dry matter production is directly related to radiation use efficiency and conversion efficiency of radiation into photosynthates depends upon the

plant varieties and environmental conditions during the entire growing season of the crop. It is essential to determine the crop growth rates at different phenophase, heat use efficiency and radiation use efficiency of mustard cultivars under different thermal environment with manipulation of different sowing dates.

Review of literature

Effect of different thermal environments on growth, development and yield of mustard genotypes

Punia *et al.,* (2002) [18] suggested that October 10th is the best time of sowing for mustard in semi-arid tracts of Haryana and Punjab and varieties RL 135, RH 30 and PBR 157 performed better over other varieties tested. Delay in sowing up to 10th November resulted reduction in yield by 30.5% and 24.3% as compared to sowing of crop on 10th October and 25th October. They also concluded that varieties RL 1359 and PBR 157 responded well and produced optimum yield during all dates of sowing over other varieties tested in the trials. Shivani and Kumar, (2002) [21] reported that yield attributes *viz*. branches plant^{-1}, siliqua plant^{-1}, seeds siliqua^{-1} and higher seed yield of mustard crop were obtained from crop sown on 25th September and 5th October as compared to crop sown on 15th, 25th October and 4th November. Delayed in sowing up to 4th November resulted in lower seed yield. Row spacing also affect the seed yield significantly. It was also noted that 30 and 45 cm row spacing was suitable for 5th and 25th October sown crop. Yousaf *et al.,* (2002) observed that early sowing of Dunkled variety on 11th October produced higher grain yield of 2111.05 kg ha^{-1} as compared to rainbow and late sowings. Sowing of crop on 31st October resulted in very low yield *i.e.* 1806 kg ha^{-1}. All growth and yield parameters *viz.* primary branches plant^{-1}, number of secondary branches plant^{-1}, number of pods plant^{-1} and seed yield, significantly affected by various dates of sowing.

Haider *et al.,* (2003) [9] reported that number of days required for attained physiological maturity decreased in delayed sown crop. Higher value of GDD, HTU and PTI were recorded in crop sown on 25th November as compared to 15th December. Higher value of growing degree days recorded from cultivar C 306 as compared to Opata, Provita and Akber during all growth stages in both sowing dates. Value of HUE was also recorded higher in crop sown on 25th November as compared to 15th December. Singh *et al.,* (2003) [5, 8, 12, 19, 20, 22, 23] observed higher yield attributes and yield when crop was sown on 14th October as compared to delayed sowing on 24th October, 4th November and 14th November. Among the cultivars, Pusa Jai Kisan produced an additional yield of 0.10 t ha^{-1} over Pusa Bold (1.32 t ha^{-1}). Relatively higher number of siliquae plant^{-1} (260.9), number of grains siliqua^{-1} (11.6) and unit grain weight (0.088 g) obtained in Pusa Jai Kisan as compared to those in Pusa Bold (237.2, 11.1 and 0.086 g) might be responsible for relatively higher yield of Pusa Jai Kisan. Hossen, (2005) reported that significant variation was found in number of siliqua per plant in different mustard varieties. Delayed sowing resulted in lower number of branches, lower siliqua length and yield of mustard. Robertson *et al.,* (2005) reported that delay in sowing shortened the time of flowering and maturity of all the tested genotype. One day delay in sowing delayed in sowing delay the flowering by 0.42, 0.42 and 0.37 day in Indian mustard, Monty and Oscar respectively. Delayed sowing experienced higher temperature which lowers the biomass production, grain yield, seed weight harvest index and oil content of Indian mustard than both cultivars tested.

Goyal *et al.,* (2006) [8] reported that highest seed yield was recorded in early sown crop (6th November) as compared to delayed sowings. Among the varieties, Vardan was found best in all temperature regimes as compared to other varieties. Tested on the trial basis they concluded that Kranti and Vardan can be sown up to 17th November under Raipur conditions. Kaur *et al.,* (2006) [10, 13] reported that delayed sowing of the crop greatly suppressed various growth and yield components including plant height, numbers of flowers and siliquae and number of seeds per siliqua. The seed yield decreased by 46% in delayed sown crop. The dry matter accumulation and yield also declined due to delayed sowing. Neog *et al.,* (2006) found that crop growth rate (CGR), pod growth rate (PGR), total biomass and seed yield were higher in Pusa Jaikisan than in Varuna. Values of crop growth parameters and seed yield were maximum when crop cultivars were sown between 15th and 29th October in both the seasons. The value of LAI, total biomass production, CGR and PGR were higher in the first crop season than the second crop season in all sowing dates in both cultivars. Significant reduction of seed yield in both varieties *i.e.* Pusa Jaikisan and Varuna in second season was probably due to prevailing cold spell coupled with low bright sunshine hours during the month of January and February months. Khayat, (2015) [15] reported that grain yield, yield components and total dry matter were significantly affected by planting date. Maximum value of yield attributes, dry matter accumulation and yield were observed from crop sown on 6th November as compared to sowing of crop on 21st November 6th and 21st, December. The responses of different genotypes were also significant with respect to yield component and yield. The highest grain yield was recorded in Hyola 401 hybrid as compared to other cultivar tested *i.e.* PP 401, RGS 003 and Option 500 and the lowest grain yield was obtained from cultivar Option 500. Hyola 401 responded well to sowing dates and early sowing recorded maximum value of various yield contributing characters and grain yield.

Heat unit requirements, heat and radiation use efficiency

Agrawal *et al*., (1999) [1] observed that early planting not only required higher growing degree days but also resulted in higher heat use efficiency and grain yield. The pheno thermal indexes were nearly constant with a mean value of 14.3 for both the varieties and for different dates of plantings from sowing to flowering stage of wheat crop. Both the varieties did not differ significantly in their response to the different thermal regimes. Kar and Chakravarty, (1999) [11] reported that seed filling and maturity stage of the late sown crop (2nd week of November) experienced 2.5 to 3.0 °C higher temperatures than crops sown in the 2nd half of October. The heat utilization efficiency varied from 1.01 g m^{-2} degrees D^{-1} in Pusa Bold to 0.76 g m^{-2} degrees D-1 in Toria-T9. There were significant correlation between thermal growth rate (growing degree days) and the crop growth parameters dry biomass and green area index (leaf area index + pod area index) with the correlation coefficient ranging between 0.58 and 0.98 among different cultivars and sowing dates. In the first crop season, radiation use efficiency (RUE) varied from 3.01 g MJ^{-1} in the first sown crop of cv. Pusa Bold to 2.13 g MJ^{-1} from the second and third sowings of Toria-T9. In the second season, the RUE ranged between 3.22 g MJ^{-1} in the first sowing of Pusa Bold and 2.28 g MJ^{-1} with the 3rd sowing date of Toria-T9.

Rao *et al*., (1999) [19] reported that heat use efficiency (HUE) was highest in wheat in terms of seed yield (2.56 kg ha^{-1} day $^{-1}$

in 1993-94 and 2.18 kg ha^{-1} in 1994-95) as compared to mustard and chickpea crops in that order. HUE values varied between two seasons within dates of planting in three crops. The HUE in terms of dry matter accumulation (DMA) was highest in mustard followed by chickpea and wheat and lower down when planting was delayed from recommended time of sowing for these crops. Khichar *et al.*, (2000) [14] noted that Brassica crop sown on 20th October recorded higher value of growth parameters (LAI, plant height and dry matter) and yield in comparison to other time of sowing *i.e.* 10th November and 30th November. The radiation use efficiency (RUE) was highest from sowing to harvesting in 20th October sown crop which decreased with successive delayed sowings. *Brassica* cultivars also differed significantly with respect to growth parameters. However in case of yield the difference was not significant. Singh *et al.*, (2001) [5, 8, 12, 19, 20, 22, 23] observed that the crop sown on 25 November, took more number of days from sowing to maturity than later sowing but maturity period consistently reduced with subsequent delay in sowing. Late sowing reduced the duration of vegetative and reproductive growth by 17 days. Different genotypes did not differ markedly with respect to duration of vegetative and reproductive phases of wheat. The thermal units accumulated to reach physiological maturity from sowing ranged from 1542.9 to 1610.3 °C days with its maximum value (1539.9 to 1620.4 °C days) recorded from crop sown on 25th November. A decreasing trend in accumulated growing degree days with delay in sowing was also noticed.

Karambir *et al.*, (2003) [12] observed that mean value of HUE was maximum in wheat crop sown on 25th November as compared to delay in sowing (10th and 25th December). Maximum value of HUE was recorded from variety PBW-343 followed by UP-2338, WH-542, Raj-3765 and Sonak. HUE showed a negative linear response with weather parameters (maximum, minimum and mean temperature) and parabolic response with sunshine hours and relative humidity. Sharma *et al*, (2003) [20] reported that delay in sowing from 25th November to 10th December, significantly reduces the radiation use efficiency. Efficiencies varied from 1.24 to 2.85 gram dry matter MJ^{-1} of intercepted photosynthetically active radiation for wheat crop. Among variety and sowing dates, sunshine hours, vapour pressur deficit, maximum, minimum and mean temperature of whole season were negatively associated while positive correlation existed for relative humidity with radiation use efficiency. Singh *et al.*, (2003) [5, 8, 12, 19, 20, 22, 23] observed that wheat genotypes took more days under shade stress due to low radiation and thermal regimes in the crop canopies. The difference in cumulative heat units increased with the increase in shade level in advanced phenophase during crop season. The radiation use efficiency (RUE) increased from crown root initiation till anthesis and then decreased slightly up to dough stage.

Hundal *et al.*, (2004) [7, 10, 17] found the effect of cultivars and sowing date on RUE and CGR in mustard (cv. Bio-902 and Pusa Bold). The peak CGR was 33.7 and 30.4 g m^{-2} day^{-1} for Bio-902 and Pusa Bold, respectively sown in first week of November. The highest RUE of 2.44 MJ^{-1} of dry matter accumulation and 0.62 g MJ^{-1} for seed yield were recorded when the crop was sown in the third week of October. Significant linear regressions relationship (R^2 = 0.89) was observed between total dry matter accumulation and cumulative. Mallick *et al*., (2006) [17] reported that the number of days taken for maturity were maximum for crop sown on 12th November (151 and 155 day), followed by sowing of crop on 27th November (137 and 141 days) and lowest was associated with the crop sowing on 12th December (126 and 129 day). Numbers of days from sowing to anthesis (50%) decreased as sowing dates were delayed. Highest number of degree days taken by WH-542 as compared to PBW-343 for maturity under all the sowing dates. GDD were higher in sowing of crop on 12th November sowing in both the genotypes. Dhaliwal, (2007) [7] noted that early sown (5th October) crop accumulated more degree-days, helio thermal units and photo-thermal units over normal (30th October) and late sown (25th November) crop during both the years. The result showed a significant relationships between number of days and GDD (R = 0.87), HTU (R^2 = 0.87) and PTU (R^2 = 0.77).

Patra and Sahu, (2007) reported that under normal sowing condition the crop accumulated higher amount of heat units over late sown condition. The RUE and HUEs were also higher for early sowing crop as compared to late sown crop. Thus the study suggested that the appropriate time of sowing for wheat is 15th November to 25th November for getting higher and stable yield of wheat. Kumar *et al*., (2008a) [16, 21] observed that the solar radiation and intercepted photosynthetic active radiation (IPAR) had played a significant role in deciding the yield and sowing pattern of soybean. The RUE for seed was obtained highest 1.9 kg ha^{-1} MJ^{-1} on D_1 (16th June) treatment followed by D_2 (26th June) 1.8 kg ha^{-1} MJ^{-1} and D_3 (6th July) 1.24 kg ha^{-1} MJ^{-1} Stover RUE were 6.18, 5.40 and 5.22 kg ha^{-1} MJ^{-1} in D_1, D_2 and D_3 treatment, respectively. The weather variable had varied effect on crop growth, development and yield under various phenophase during its growing period. It was also noticed that the conversion efficiency of incident PAR (IPAR) to dry matter production varied much with date of sowing and four levels of spacing. The production of dry matter or productivity of soybean showed corresponding response to solar radiation. Higher seed yield was recorded with crop sown on 16th June closely followed by the seed yield of crop on 26th June sowing. Sowing of crop on 6th July recorded lowest yield.

Chopda *et al*., (2016) [2] reported that Dahod yellow variety gave higher value of GDD, HUE and RUE and higher seed yield in sowing of crop on 15th October. The degree of superiority of seed yield in early sowing date as compared to late was strongly affected by the environmental conditions and tolerance of varieties. The maximum value of GDD, HUE and RUE (1867 °C day^{-1}, 1.003 kg ha^{-1} day^{-1} °C and 0.090 g MJ^{-1}) and seed and fodder yield of chickpea crop (1874 kg ha^{-1} and 2116 kg ha^{-1}) were recorded from Dahod yellow variety sown on 30th October. Kushik *et al*., (2015) concluded that heat units *viz*. growing degree days (GDDs), photo-thermal units (PTU) and helio-thermal unit (HTU) values decreased with the delay in sowing from 10th June to 10th July in all the varieties. However, higher values of radiation use efficiency and heat use efficiency were recorded with variety JS -9752. Based on the results it was concluded that heat use efficiency of soybean cv. JS-9752 and JS-335 were suited better to utilize heat units under all the sowing dates as compared to JS-9305.

References

1. Agrawal KK, Sanker U, Upadhyay AP, Gupta VK. Accumulated heat unit requirements for different phenophase of wheat (*Triticum aestivum*) cultivars as influenced by sowing dates at Jabalpur. Journal of Agrometeorology 1999;1(2):173-176.

2. Chopda MC, Chhdavadia SK, Vora VD. Influence of Thermal Time Requirement And Heat Use Efficiency in Yield Related Parameters in Chickpea Crop in Gujarat. Indian Journal Agriculture Research 2016;5(3):308-310.
3. Gill KK, Bains GS. Growth-yield dynamics, radiation interception and RUE in Brassica carinata. J Agromet., (Special Issue-Part 1) 2008, P72-74.
4. Lallu RS, Baghel VS, Srivastava SBL. Assessment of mustard genotypes for thermo tolerance at seed development stage. Ind. J Plant Physiol 2010;15(1):36-43.
5. Pradhan S, Sehgal VK, Das DK, Jain AK, Bandyopadhyay KK, Singh R, Sharma PK. Effect of weather on seed yield and radiation and water use efficiency of mustard cultivars in a semiarid environment. Agric. Water manage 2014;139:43-52.
6. Saha G, Khan SA. Predicting yield and yield attributes of yellow sarson with agrometeorological parameters. J Agromet., (Special issue-Part 1) 2008, P115-119.
7. Dhaliwal LK, Hundal SS, Kular JS, Aneja A, Chahal SK. Accumulated heat units requirement for different phenophases of raya (*Brassica juncea* L.) as influenced by sowing dates. Indian Journal of Crop Science 2007;2(1):103-105.
8. Goyal KS, Das B, Singh R, Mohanty AK. Influence of the thermal environment on phenology, growth and development of mustard varieties. Journal of Soils and Crops 2006;16(2):283-290.
9. Haider SA, Alam MJ, Alam MF, Paul NK. Influence of different sowing dates on the phenology and accumulated heat units in wheat. Journal of Biological sciences 2003;3(10):932-939.
10. Hundal SS, Kaur P, Malikpuri SDS. Radiation use efficiency of mustard cultivars under different sowing dates. Journal of Agrometeorology 2004;6(1):70-75.
11. Kar G, Chakravarty NVK. Thermal growth rate, heat and radiation utilization efficiency of *Brassica* under semi-arid environment. Journal of Agrometeorology 1999;1(1):41-49.
12. Karambir S, Niwas R, Singh M. Heat use efficiency of wheat cultivars under different sowing dates. Haryayana Agriculture University Journal of Research 2003;33(2):117-124.
13. Kaur K, Setia N, Setia RC. Influence of delayed sowing and kinetin on growth and yield components of Indian mustard (*Brassica juncea*). Environment and Ecology 2006;24S(S3A):872-875.
14. Khichar ML, Yadav YC, Bishnoi OP, Niwas R. Radiation use efficiency of mustard as influenced by sowing dates, plant spacing and cultivars. Journal of Agrometeorology 2000;2(1):97-99.
15. Khayat M. Measuring yield and its components of canola genotypes in different planting date. Indian Journal of Fundamental and Applied Life Sciences 2015;5(2):48-55.
16. Kumar A, Pandey V, Shekh AM, Kumar M. Radiation Use efficiency and weather parameters influence during life cycle of Soybean (*Glycine max*. [L] Merill) production as well as accumulation of dry matter. American Eurasian Journal of Agronomy 2008;1(2):41-44.
17. Mallick K, Sarkar C, Bhattacharya BK, Nigam R, Hundal SS. Thermal indices for some wheat genotypes in Ludhiana region. Journal of Agrometeorology 2006;8(1):133-136.
18. Punia SS, Thakral SK. Screening of different cultivars of mustard (*Brassica juncea* L. *Czern* and *Coss*) at different temperature regimes. Haryana Journal of Agronomy 2000;16(1&2):137-138.
19. Rao VUM, Singh D, Singh R. Heat use efficiency of winter crops in Haryana. Journal of Agrometeorology 1999;1(2):143-148.
20. Sharma K, Ramniwas, Singh M. Effect of weather parameters on radiation use efficiency in wheat crop. Agricultural Science Digest 2003;23(4):259-262.
21. Shivani, Kumar S. Response of Indian mustard (*Brassica juncia*) to sowing date and row spacing in mid hill of Sikkim under rainfed conditions. Indian Journal of Agronomy 2002;47(3):405-410.
22. Singh AK, Tripathi P, Adhar S. Heat unit requirements for phenophase of wheat genotypes as influenced by sowing dates. Journal of Agrometeorology 2008;10(2):209-212.
23. Singh AK, Tripathi P, Mishra SR. Phenology, growing degree days and phasic development of wheat (*Triticum aestivum*) under rice (*Oryza sativa*) cropping system. Indian Journal of Agriculture Science 2001;71(8):363-366.
24. Yusaf M, Ahmed A, Jahangir M, Naseeb T. Effect of sowing dates on the growth, development, and yield of canola varieties. Asian Journal of Plant Science 2002;1:634-635.