



## Review paper

# Influence of sowing date on growth and productivity of rapeseed-mustard: a review

Rakshit Bhagat\*, Mahender Singh<sup>1</sup>, BC Sharma<sup>1</sup> and Gurinder Singh

Department of Agronomy, Punjab Agricultural University, Ludhiana 141004, Punjab, India

<sup>1</sup>Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu, 180009, J&K, India

\*Corresponding author: rakshit.bhagat232@gmail.com

(Received: 17 August 2022; Revised: 29 December 2022; Accepted: 03 January 2023)

## Abstract

Sowing date is an important factor that determines the length of growing season affecting yield attributes and yield of any crop. Rapeseed-mustard being a photosensitive crop is significantly influenced by sowing date with respect to growth and productivity has been studied by different research workers. The optimum time for sowing of rapeseed-mustard is important as the phenological (phasic) development in terms of organ appearance and its rate of development is directly associated with prevailing weather conditions and the sowing date depends on the prevailing climatic conditions in the location. Shift in sowing dates directly influences both thermoperiod and photoperiod as temperature regimes affects phenological and physiological parameters of mustard and consequently causes variation in yield. Therefore, results from different studies revealed that the maximum yield potential of rapeseed-mustard crop is usually achieved when the crop is exposed to the most appropriate temperature range, which can be controlled by sowing at the proper time. In this paper an attempt has been made to critically review the research works carried out by the researchers which may contribute in realizing the optimum date of sowing for higher growth and productivity in rapeseed-mustard.

**Keywords:** Growth, rapeseed-mustard, sowing dates, weather, yield

## Introduction

Oilseed crops play an important role in Indian agriculture wherein, rapeseed-mustard is one of the major oilseed crops, traditionally grown everywhere in the country due to their high adaptability in conventional farming systems. Among nine oilseeds, soybean (39 %), groundnut (26 %), and rapeseed-mustard (24 %) account for more than 88 % of the total oilseeds production in the country. However, rapeseed-mustard (31 %) contributes the most in edible oil production in the country, followed by soybean (26 %) and groundnut (25 %) (Bhagat *et al.*, 2022a). Rapeseed-mustard is grown in tropical and sub-tropical regions as a cold season crop during 2019-20 (Shekhawat *et al.*, 2012), it was grown on 6.86 million ha in India, with a production of 9.12 million tonnes and a productivity of about 1329 kg/ha (Anonymous, 2021) and. India is the largest importer of edible oils (\$10.5 billion) in the world followed by China and USA (Choudhary *et al.*, 2021). Several species within the *Brassica* genus including Indian mustard (*Brassica juncea*), oilseed rape (*B. napus*), Ethiopian mustard (*B. carinata*), Indian rape (*B. rapa* var. Toria), Brown Sarson, (*B. rapa* var. Brown sarson), Yellow Sarson (*B. rapa* var. Yellow Sarson), black mustard (*B. nigra*) and taramira (*Eruca sativa*) are grown as oilseed crops. Among which, *B. napus*, *B. rapa* and *E.*

*sativa* species are classified as “rapeseed”, while *B. juncea*, *B. carinata*, and *B. nigra* are classified as “mustard” (Hayward, 2011). The change in crop environmental conditions due to sowing dates is bound to affect the production potential of the crop. Different sowing dates provide variable environmental condition within the same location for growth and development of crop and its yield of *Brassica* species largely depends upon change in environment during crop growth (Panda *et al.*, 2004; Prasad *et al.*, 2018). The physical factors mainly climatic factors cannot be manipulated under field conditions but sowing time can be adjusted to meet the optimum thermal requirements of crop at various phenological stages to avoid any adverse effect on the yield of mustard (Gupta *et al.*, 2017). The growth phase of the crop should synchronize with optimum environmental conditions for better expression of output as yield through the change in environment with many practices including sowing dates. Therefore, sowing at optimum time gives higher yields due to suitable environment that prevails at all the growth stages (Shekhawat *et al.*, 2012). Moreover, optimum sowing time is an important agronomic factor and non-monetary input which plays a key role in achieving the potential yield of a crop in any region by creating suitable environment for

optimum growth and development that converts into better yield attributes (Bhagat *et al.*, 2022b). Many authors have reported from experiments carried out to determine the effect of sowing time on rapeseed-mustard, but the results are often contradictory as it is probably subject to variation due to differences in weather at sowing time between seasons and within the range of climates. Due to climate change, it becomes difficult to predict optimum sowing dates for mustard crop. In practice, recommended dates are normally drawn up from the results of long-running series of agronomic experiments, which can give mean sowing dates for higher yield together with realistic estimates of expected yield penalties for each week of delay in planting. However, in accepting such guidelines, several reservations must be appreciated in addition to the fact that use of the recommended date is not a guarantee of highest yield under growing season. First, there can be very large differences in the pattern of response to sowing date among cultivars. Secondly, the interactions between plant diseases and sowing dates are not fully understood. The literature available on effect of sowing date on mustard was reviewed and described as under by using various headings namely phenology, growth parameters (plant height, leaf area index, dry matter accumulation, crop growth rate and relative growth rate), agrometeorological indices, yield attributes (number of branches per plant, number of siliquae per plant, number of seeds per silique and test weight) and yield (seed yield, stover yield and biological yield). Hence, the work of previous researchers and scientists relevant to sowing date has been gleaned from the different sources of literature over the years are collected and presented in a systematic way in this paper.

### **Effect of sowing date on phenology of rapeseed-mustard**

To evaluate the development of any crop with respect to prevailing weather conditions, the most important aspect is to study the occurrence of different phenological stages, which determines the phasic development of crop with respect to the prevailing environments. Kumar *et al.* (2004) observed that flower initiation delayed significantly under 7<sup>th</sup> October planting as compared to crop sown on 14<sup>th</sup> October and 21<sup>st</sup> October in mustard crop at Haryana. Kaur *et al.* (2006) stated that the rate of development from emergence to anthesis in most of mustard crop species depends upon photoperiod and the temperature. Khushu *et al.* (2008) found that duration of each phenophase and the number of days to reach physiological maturity was shortened under the delayed sowing of mustard crop at sub-tropical zone of Jammu region. Gomez and Miralles (2011) suggested that length of the reproductive phase

can be increased at the expense of a reduction in the duration of the vegetative phase, but without changing the whole duration of the crop cycle in gobhi sarson (*B. napus*). The results showed that oilseed rape evidenced photoperiod responses during vegetative and early reproductive phases that yield could be increased by lengthening the duration of that phase. Akhter *et al.* (2015) studied the effect of date of sowing and varieties on yield of Brown Sarson (*B. rapa*) and reported that the number of days were increased to reach flower bud initiation stage due to delay in sowing. Moreover, early planting on 1<sup>st</sup> October had taken lesser number of days for seedling emergence and rosette stage as compared to the later dates of sowing. Devi and Sharma (2017) conducted field experiments for two consecutive years (2015 and 2016) to determine the effect of sowing date on flowering in mustard (*B. juncea*) and found that the crop sown on 6<sup>th</sup> October had the longest flowering duration (45 days) followed by the crop sown on 23<sup>rd</sup> October (41 days) and 12<sup>th</sup> November (35 days) during 2015. Likewise, in 2016 the crop sown on 1<sup>st</sup> October had the longest flowering duration of 42 days and minimum in 3<sup>rd</sup> November (35 days). Gupta *et al.* (2017) conducted field experiments for two consecutive years *i.e.*, 2010-11 and 2012-13 on two cultivars of mustard (RL-1359 and RSPR-01) with three dates of sowing (9<sup>th</sup> October, 24<sup>th</sup> October and 8<sup>th</sup> November) at Jammu and reported that late sown crop took more number of days to complete early stages *viz.*, fifth true leaf exposure and pod development. Whereas, it took lesser number of days from flower bud initiation stage. Singh *et al.* (2017) found that mustard sown on 25<sup>th</sup> October took more number of days to attain physiological maturity followed by 5<sup>th</sup> November and 15<sup>th</sup> November sown crop. Prasad *et al.* (2018) revealed that the early sown gobhi sarson crop took more number of days to attain different phenological stages due to the maximum mean temperatures during the reproductive phase. Kaur *et al.* (2018) at Ludhiana observed that each successive delay of 15 days in sowing of oilseed rape (*B. napus*) from 15<sup>th</sup> October to 15<sup>th</sup> November significantly delayed the initiation and completion of emergence and required significantly more number of days for completion of flowering stage but required lesser number of days to attain physiological maturity.

### **Effect of sowing date on growth of rapeseed-mustard**

#### **Plant height**

Plant height is an important index for studying the growth and development of the crop plant. Due to the indeterminate growth habit shown by the *Brassica sp.* leads to the continuous increase in the plant height with the advancement in age of crop. Sharma and Thakur (1993)

conducted a field experiment to evaluate the performance of Gobhi Sarson (*B. napus*) under different dates of sowing viz., October 15<sup>th</sup>, October 30<sup>th</sup>, November 15<sup>th</sup> and November 30<sup>th</sup> and found that the plant height reduced significantly under late sown crop as compared to early sown crop. Dinda *et al.* (2015) studied the effect of sowing dates on growth of rapeseed-mustard varieties at West Bengal and found that 20<sup>th</sup> October (156.68 cm) sown crop recorded significantly higher plant height as compared to the crop sown on 5<sup>th</sup> November (151.91 cm) and 20<sup>th</sup> November (147.04 cm). Gogoi *et al.* (2017) conducted an experiment for two years to study the influence of different sowing dates on toria (*B. rapa*) at Assam and revealed that crop sown on 1<sup>st</sup> December recorded significantly taller plant height as compared to the crop sown on 8<sup>th</sup> December, 15<sup>th</sup> December and 22<sup>nd</sup> December. Similarly, Patel *et al.* (2017) conducted a field experiment at Faizabad, Uttar Pradesh and assessed the effect of different dates of sowing on the growth, yield and quality of various Indian mustard (*B. juncea*) varieties and reported significantly highest plant height in crop sown on 14<sup>th</sup> November in comparison to 15<sup>th</sup> October and 29<sup>th</sup> November sown crop at 60 DAS, 90 DAS as well as at harvest stage but was at par with 30<sup>th</sup> October sown crop. Keerthi *et al.* (2017) reported that the Indian mustard (*B. juncea*) sown on 15<sup>th</sup> October (226.7 cm) recorded significantly highest plant height as compared to 25<sup>th</sup> October (222.3 cm), 5<sup>th</sup> November (218.2 cm) and 15<sup>th</sup> November (208.6 cm) sown crop. Kumar *et al.* (2017) conducted an experiment on Indian mustard genotypes with three different dates of sowing i.e., 26<sup>th</sup> October, 5<sup>th</sup> November, and 15<sup>th</sup> November at Hisar, Haryana and they reported that significantly maximum plant height of 190.5 cm was recorded under crop sown on 26<sup>th</sup> October followed by the crop sown on other two dates i.e. 5<sup>th</sup> November (188.2 cm) and 15<sup>th</sup> November (178.1 cm). Singh *et al.* (2017) revealed that the mustard (*B. juncea* L.) crop sown on 25<sup>th</sup> October produced significantly taller plant (146.3 cm) over 25<sup>th</sup> September sown crop (111.0) among the four dates of sowing viz., 25<sup>th</sup> September, 5<sup>th</sup> October, 15<sup>th</sup> October and 25<sup>th</sup> October. Lakra *et al.* (2018) studied the response of Indian mustard (*B. juncea*) with the four dates of sowing (28<sup>th</sup> October, 07<sup>th</sup> November 17<sup>th</sup> November and 27<sup>th</sup> November) and showed that the crop sown on 28<sup>th</sup> October and 07<sup>th</sup> November produced significantly taller plant height of about 135 cm and 108 cm, respectively as compared with other two dates of sowing but was at par with each other. They concluded decrease in plant height with progressive delay in sowing from 28<sup>th</sup> October to 27<sup>th</sup> November.

### Leaf area index

Leaf area index is another most important growth characteristics which determines the amount of solar radiation intercepted by crop canopy which is utilized for various metabolic activities of the plants. Hundal *et al.* (2003) found significantly higher leaf area under early sown *B. juncea* coupled with large sink strength and capacities to accommodate more photosynthesis which resulted in significantly higher yield and yield contributing characteristics as compared to late sown crop. Panda *et al.* (2004) highlighted that leaf area index reduced significantly under delay sowing of *B. juncea* from October 16<sup>th</sup> to November 15<sup>th</sup> due to decrease in mean temperature at later dates of sowing which resulted in reduction in expansion and growth of the crop. Kumar *et al.* (2017) stated that leaf area index of Indian mustard reduced significantly with the delay in sowing at all growth intervals and maximum leaf area index was found under 26<sup>th</sup> October (1.73) sown crop followed by 5<sup>th</sup> November (1.40) and 15<sup>th</sup> November (1.17) at harvesting. Patel *et al.* (2017) conducted a field experiment to study the effect of different dates of sowing on the growth of various Indian mustard varieties and revealed that the crop sown on 14<sup>th</sup> November recorded significantly higher LAI over 15<sup>th</sup> October and 29<sup>th</sup> November, but was found at par with 30<sup>th</sup> October at 60 DAS. Bhagat *et al.* (2022b) studied the growth of *B. napus* cultivars under diverse sowing environment at Jammu and revealed that crop sown under first sowing environment (20<sup>th</sup> October in 2018-19 and 15<sup>th</sup> October in 2019-20) recorded significantly higher leaf area index of about 5.14 as compared to the second environment (4.59) and third environment (3.50) sown crop. Kaur *et al.* (2022) studied the performance of oilseed rape (*B. napus*) as influenced by different date of sowing under irrigated condition of central Punjab and revealed that crop sown on 25<sup>th</sup> October (4.3) being at par with crop sown on 10<sup>th</sup> October (3.9) recorded significantly higher leaf area index over 15<sup>th</sup> November (2.2) sown crop at 90 DAS.

### Dry matter accumulation

Dry matter accumulation is also an important growth parameter affecting the photosynthetic efficiency (sink) of the crop which ultimately influences the crop yield. Dudhade *et al.* (1996) stated that delay in sowing of Indian mustard from October 15<sup>th</sup> adversely affected the dry matter accumulation/plant. Singh *et al.* (2002) reported that the dry matter accumulation of *Brassica* was significantly reduced with delay in sowing due to the increased temperatures during latter reproductive phase (36.0 to 41.5 °C). Hundal *et al.* (2003) conducted a field experiment at PAU, Ludhiana on *B. juncea* under different dates of sowing during *rabi* seasons of 1999-2000 and

2000-2001 and observed that dry matter accumulation was reduced with delay in sowing from second week of October to first week of December. Keerthi *et al.* (2017) revealed that the total dry matter accumulation decreased significantly with delay in sowing dates at all the growth stages *viz.*, 30, 90, 120 DAS and at harvest during both the years. However, the difference in dry matter accumulation at 60 DAS was statistically at par with October 25<sup>th</sup> and November 5<sup>th</sup> sown crop. Kumar *et al.* (2017) revealed that higher biomass accumulation was found under the first date of sowing *i.e.* 25<sup>th</sup> October (124.1 g/m<sup>2</sup>) in comparison to other dates of sowing *i.e.* 5<sup>th</sup> November, and 15<sup>th</sup> November. Patel *et al.* (2017) reported that higher dry matter accumulation was recorded under 14<sup>th</sup> November over 29<sup>th</sup> November sown crop and was found at par with 15<sup>th</sup> October and 30<sup>th</sup> October at 60 and 90 DAS. Tyagi (2017) observed significantly higher dry matter at all the growth stages under 20<sup>th</sup> October sown crop followed by November 4<sup>th</sup> and November 19<sup>th</sup>, respectively. Therefore, fifteen-day successive delay in sowing from 20<sup>th</sup> October to 4<sup>th</sup> November and 19<sup>th</sup> November decreased the total dry matter accumulation at maturity by 9.37 per cent and 17.6 per cent, respectively. Singh *et al.* (2017) revealed that the crop sown on 25<sup>th</sup> October accumulated significantly higher dry matter/plant than 15<sup>th</sup> October sown crop. Samant *et al.* (2018) conducted an experiment to assess the effect of sowing dates and nutrient management practices on important parameters in toria (*B. rapa*) and reported that dry matter accumulation/plant were significantly higher under the crop sown on 15<sup>th</sup> October (28.6 g/plant) as compared to 30<sup>th</sup> October (28.0 g/plant) and 14<sup>th</sup> November (25.2 g/plant) sown crop at Angul (Odisha). Kaur *et al.* (2018) reported that oilseed rape (*B. napus*) sown on 15<sup>th</sup> October (15835 kg/ha) recorded significantly higher dry matter accumulation over crop sown on 30<sup>th</sup> October (14000 kg/ha) and 15<sup>th</sup> November (11807 kg/ha) on 120 DAS.

### **Crop growth rate (CGR) and relative growth rate (RGR)**

CGR and RGR are the growth indices which are calculated from the change in dry matter accumulation to study the growth of the plant within a particular time interval. Rameshwar *et al.* (2000) found that RGR increased with delay in sowing of *B. napus*. Panda *et al.* (2004) evaluated the growth and development of Indian mustard under different dates of sowing and stated that CGR decreased significantly with delay in sowing and the highest values of CGR were calculated in crop sown on 16<sup>th</sup> October whereas the least values were calculated on 15<sup>th</sup> November sowing at all the growth stages. Kumari and Rao (2005) emphasized that CGR in *B. juncea* was lowest in crops

sown earlier than 1<sup>st</sup> October whereas it increased under 15<sup>th</sup> and 30<sup>th</sup> October sown crop due to higher temperature prevailed during initial stages of the crop growth. They also reported that RGR was lowest in crop sown earlier than 1<sup>st</sup> October in *B. juncea* due to higher temperature prevailed during initial stages of the crop growth. Alam *et al.* (2014) observed the decreased crop growth rate under 25<sup>th</sup> December sowing as compared to 25<sup>th</sup> November and 5<sup>th</sup> December sown crop due to high temperature at grain filling stage. Kumar *et al.* (2018) found the minimum crop growth rate (2.57 g/m<sup>2</sup>/day) in crop sown on 21<sup>st</sup> November whereas maximum crop growth rate (3.59 g/m<sup>2</sup>/day) under 23<sup>rd</sup> September sown crop at Hisar.

### **Effect of sowing dates on agrometeorological indices of rapeseed-mustard**

Agrometeorological indices *viz.*, growing degree days, photothermal units, heliothermal units, heat use efficiency and radiation use efficiency are useful for assessing the agroclimatic resources for effective crop planning and reflecting the impact of weather variables at different crop developmental stages (Bauer *et al.*, 1985). Tripathi *et al.* (2007) found that the radiation use efficiency was highest in early sown crop *i.e.* [5<sup>th</sup> October (2.18 g/MJ)] followed by later sown crops *viz.*, [20<sup>th</sup> October (1.71 g/MJ) and 5<sup>th</sup> November (1.23 g/MJ)]. Khushu *et al.* (2011) reported that the utilized solar energy was higher in early sown crop as compared to normal and late sowing at all the phenophases except during reproductive stage, where the utilized energy was same in early and normal sowing on 10<sup>th</sup> October and 25<sup>th</sup> October. Keerthi *et al.* (2016) stated that the total accumulated thermal unit of the crop decreased from 2288 °C day to 2262 °C day, 2225 °C day and 2125 °C day as sowing was delayed from October 15<sup>th</sup> to October 25<sup>th</sup>, November 5<sup>th</sup> and November 15<sup>th</sup>, respectively. However, maximum heat use efficiency was recorded for the crop sown on 15<sup>th</sup> October (1.294 g/m<sup>2</sup> °C day) followed by October 25<sup>th</sup> (1.177 g/m<sup>2</sup>/ °C day), November 5<sup>th</sup> (1.108 g/m<sup>2</sup> °C day) and November 15<sup>th</sup> (1.012 g/m<sup>2</sup> °C days) sown crop at maturity. Rana *et al.* (2017) reported that the early sown (10<sup>th</sup> October) crop took maximum growing degree days for flower initiation (492±1), 50 per cent flowering (682±1), pod initiation (742±1), 90 per cent pod formation (811±4) and maturity (1394±8) which decreased with delay in sowing time and recorded lowest under late sown (9<sup>th</sup> November) crop. Ahatsham *et al.* (2018) revealed that the growing degree days were higher in 1<sup>st</sup> fortnight of October sown mustard at every phenophase [Early vegetative phase (379 °C day), 50 per cent flowering (785 °C day), pod initiation (890 °C day), seed development (1231 °C day), physiological



maturity (1969 °C day)] as compared to the crop sown on 2<sup>nd</sup> fortnight of October and 1<sup>st</sup> fortnight of November. Choudhary *et al.* (2018) observed that the accumulation of heat units to attain crop maturity was higher under the crop sown on 10<sup>th</sup> October (1582.2 °C day) as compared to the other sowing dates *i.e.*, 25<sup>th</sup> October (1354.1 °C day) and 10<sup>th</sup> November (1290.5 °C day). Likewise, 10<sup>th</sup> October sown crop also accrued higher heliothermal units and photothermal units over the crop sown on 25<sup>th</sup> October and 10<sup>th</sup> November. Jiotode *et al.* (2017) recorded higher thermal use efficiency (0.45 kg/ha/ D °C) under sowing of mustard on 43<sup>rd</sup> SMW (22 to 28 October) over other dates of sowing. Singh *et al.* (2018) revealed that the maximum per cent of PAR interception was observed in crop sown on 7<sup>th</sup> October [Vegetative (62.0 %), flowering (91.3 %) and pod filling (80.9 %)] as compared to 17<sup>th</sup> October [vegetative (49.6 %), flowering (84.6 %) and pod filling (78.7 %)] and 27<sup>th</sup> October [Vegetative (25.6 %), flowering (79.5 %) and pod filling (67.5 %)] sown crop. Similarly, the maximum radiation use efficiency was also observed in crop sown on 7<sup>th</sup> October *viz.*, [Vegetative (2.72 g/MJ), flowering (3.26 g/MJ) and pod filling (3.42 g/MJ)] as compared to 17<sup>th</sup> [Vegetative (2.27 g/MJ), flowering (2.72 g/MJ) and pod filling (2.86 g/MJ)] and 27<sup>th</sup> October [vegetative (1.60 g/MJ), flowering (1.92 g/MJ) and pod filling (2.02 g/MJ)] sown crop. Singh *et al.* (2019) at Arunachal Pradesh observed maximum pheno thermal index under 10<sup>th</sup> October sown crop at 50 per cent flowering (7.6), siliquae filling (8.0), physiological maturity (8.4) sown crop and followed by 20<sup>th</sup> October and 30<sup>th</sup> December. Likewise, the highest heat use efficiency for grain yield (1.14 kg/ha °C days) as well as for biological yield (3.73 kg/ha °C days) recorded under 10<sup>th</sup> October sown crop and the minimum values were observed for late sown crop *i.e.* 30<sup>th</sup> October crop.

## Effect of sowing dates on yield attributes of rapeseed-mustard

### Number of branches per plant

Bhuiyan *et al.* (2008) conducted a field experiment to study the yield attributes and yield of rapeseed as influenced by date of planting (October 20<sup>th</sup>, October 30<sup>th</sup>, November 10<sup>th</sup>, November 20<sup>th</sup> and November 30<sup>th</sup>) at Bangladesh and revealed that significantly highest number of primary branches/plant (6.85) was recorded under the first the planting date (October 20<sup>th</sup>) over other planting dates but found at par with 2<sup>nd</sup> date of planting (October 30<sup>th</sup>: 6.72). Kumari *et al.* (2012) reported that crop sown on 10<sup>th</sup> October recorded significantly higher primary (7.8) as well as secondary branches (19.9) /plant over 20<sup>th</sup> October (7.0 & 17.6) and 30<sup>th</sup> October sown crop (6.4 & 14.1), respectively. Dinda *et al.* (2015) revealed that 20<sup>th</sup> October

(6.07) sown rapeseed-mustard varieties recorded significantly more number of branches followed by 5<sup>th</sup> November (5.78) and 20<sup>th</sup> November (5.32) at West Bengal. Meena *et al.* (2017) at Banswara revealed that the maximum primary branches/plant were recorded under 25<sup>th</sup> September sown mustard (4.58) and 05<sup>th</sup> October (4.59) as compared to early sown mustard on 15<sup>th</sup> September (4.05) and late sown 15<sup>th</sup> October (4.14). Bhagat *et al.* (2022a) reported significantly higher primary and secondary branches under *B. napus* sown on 20<sup>th</sup> October (5.2, and 12.9, respectively) over 30<sup>th</sup> October (4.5 and 11.6, respectively) and 9<sup>th</sup> November (4.0 and 10.1, respectively) sown crop.

### Number of siliquae per plant

Dinda *et al.* (2015) reported that early sown (20<sup>th</sup> October: 125.7) crop recorded significantly higher number of siliquae per plant as compared to late sown crop (5<sup>th</sup> October: 118.6 and 5<sup>th</sup> November: 109.5). Gawariya *et al.* (2015) evaluated the effect of sowing dates on yield attributes of mustard and found that number of siliquae/plant were significantly affected at Karnal. They further reported that the crop sown on 1<sup>st</sup> October (1391.47 g/plant) recorded significantly higher number of siliquae/plant as compared to 16<sup>th</sup> October (1227.96 g/per plant) and 31<sup>st</sup> October (847.41 g/plant) and 15<sup>th</sup> November (656.75 g/plant) sowing. Keerthi *et al.* (2016) reported that there was decreased number of siliquae/plant by 5.8, 10.2, and 32.6 per cent, when sowing of the crop was delayed from 15<sup>th</sup> October to 25<sup>th</sup> October, 5<sup>th</sup> November and 15<sup>th</sup> November. Bhagat *et al.* (2022a) reported significantly higher siliquae per plant under *B. napus* sown on 20<sup>th</sup> October (160.2) followed by 30<sup>th</sup> October (149.8) and 9<sup>th</sup> November (130.8) sown crop. Kaur *et al.* (2022) recorded significantly higher siliquae/plant under oilseed rape (*B. napus*) on 25<sup>th</sup> October (325) as compared to 15<sup>th</sup> November (321) sown crop but at par with 10<sup>th</sup> October (294) sown crop sown.

### Number of seeds per siliqua

Bhuiyan *et al.* (2008) assessed the yield attributes and yield of rapeseed influenced by date of planting at Bangladesh and recodeded significantly less number of seeds/siliqua (18.8) in the plants sown on 30<sup>th</sup> November in comparison to all other sowing dates *i.e.* [20<sup>th</sup> November (21.8), 10<sup>th</sup> November (22.8), 30<sup>th</sup> October (24.0) and 20<sup>th</sup> October (21.3)]. Akhter *et al.* (2015) studied the delayed planting effects on yield of rapeseed (brown sarson) and reported significant decline in no. of seeds/siliqua sown under 1<sup>st</sup> October (21.4) followed by 15<sup>th</sup> October (20.6) and 30<sup>th</sup> October (16.8) sown crop, respectively. Kumar *et al.* (2017) reported that the crop sown on 25<sup>th</sup> October

recorded significantly highest seeds/siliqua (13.4) followed by 15<sup>th</sup> October (12.5), 5<sup>th</sup> October (11.21) and 25<sup>th</sup> September (10.9) sown crop. Bhagat *et al.* (2022) reported significantly higher seeds/siliqua in 20<sup>th</sup> October (19.2) sown gobhi sarson followed by crop sown on 30<sup>th</sup> October (18.2) and 9<sup>th</sup> November (17.1) at Jammu.

### Test weight

Bhuyian *et al.* (2008) revealed the lowest test weight with each successive delay in sowing after 30<sup>th</sup> October (3.80 g) in rapeseed (*B. rapa*) to 30<sup>th</sup> November (3.24 g). Akhter *et al.* (2015) reported a significant decline in test weight in brown sarson under delayed planting of rapeseed sown on 1<sup>st</sup> October (2.27 g) followed by 15<sup>th</sup> October (2.1 g) and 30<sup>th</sup> October (2.1 g), respectively. Kumar *et al.* (2017) stated that test weight was successively decreased with early sowing of the Indian mustard as crop sown on 25<sup>th</sup> October recorded highest test weight (4.7 g) followed by 15<sup>th</sup> October (4.7 g), 5<sup>th</sup> October (4.4 g) and 25<sup>th</sup> September (4.4 g) sown crop. Kaur *et al.* (2022) revealed significantly higher test weight under oilseed rape (var. GSC-7) sown on 25<sup>th</sup> October (4.6 g) over 15<sup>th</sup> November (4.0 g) but at par with 10<sup>th</sup> October (4.3 g).

### Effect of sowing dates on yield of rapeseed-mustard

#### Seed yield

Khandey *et al.* (1991) revealed that *B. napus* gave higher seed yield when sown on 15<sup>th</sup> October, but non-significant differences were found under October 5<sup>th</sup> and 15<sup>th</sup> sown crop at Shalimar (Kashmir). Bali *et al.* (1992) found that when *B. juncea* crop sown on 25<sup>th</sup> September, gave significantly higher seed yield (14.4 q/ha) as compared to the crop sown on 15<sup>th</sup> October and 4<sup>th</sup> November as they yielded 12.7 and 5.1 q/ha, respectively. Moreover, *B. juncea* L. crop sown on 25<sup>th</sup> September gave 13.4 and 18.4 % higher seed yield than 15<sup>th</sup> October and 4<sup>th</sup> November sowing under Kashmir conditions. Bhagat *et al.* (1996) reported that dates of sowing had significant effect on seed yield as 5<sup>th</sup> October sown crop being at par with 15<sup>th</sup> October sowing recorded significantly highest seed yield than later dates of sowing. Singh *et al.* (2019) also reported transplanting of mustard on 13<sup>th</sup> October was found highly superior with respect to growth, physiological parameters, yield and yield attributes compared to transplanting done on 22<sup>nd</sup> October and 01<sup>st</sup> November. Yadav *et al.* (1996) evaluated the effect of sowing time on performance of Indian mustard at Morena (M.P.) and portrayed that the crop sown on 17<sup>th</sup> October (22.5 q/ha) being at par with 27<sup>th</sup> October (21.6 q/ha) sown crop yielded significantly higher seed yield than late sown crop *viz.*, 6<sup>th</sup> November and 16<sup>th</sup> November yielding 18.8 q/ha and 16.4 q/ha,

respectively. Thakur and Singh (1998) reported that crop sown on October 5<sup>th</sup> gave significantly higher seed yield than later dates of sowing *viz.*, October 20<sup>th</sup>, November 4<sup>th</sup> and November 19<sup>th</sup>, respectively. Shivani and Kumar (2002) concluded that the maximum seed yield of 18.8 q/ha was obtained when crop was sown on 25<sup>th</sup> September which was at par with crop sown on 5<sup>th</sup> October but was significantly higher yielding than crop sown on 4<sup>th</sup> November. Srivastava *et al.* (2011) evaluated the growth and yield of mustard at IARI, New Delhi and concluded that crop sown on 1<sup>st</sup> October produced less seed yield than that of crop sown during October 8<sup>th</sup> to 22<sup>nd</sup>. Dinda *et al.* (2015) revealed significantly higher seed yield of rapeseed-varieties sown on 20<sup>th</sup> October (1.35 t/ha) followed by the crop sown 5<sup>th</sup> November (1.30 t/ha) and 20<sup>th</sup> November (1.22 t/ha). Gupta *et al.* (2017) recorded significantly higher seed yield of mustard crop sown on 9<sup>th</sup> October (1136 kg/ha) followed by the crop sown on 24<sup>th</sup> October (828 kg/ha) and 9<sup>th</sup> November (610 kg/ha), respectively. Khajuria *et al.* (2017) reported that 25<sup>th</sup> October sown crop produced highest seed yield of about 1710 kg/ha and remained significant superior to 5<sup>th</sup> November and 15<sup>th</sup> November sown crop in Jammu region. Kumar *et al.* (2017) reported that the maximum seed yield was recorded under 26<sup>th</sup> October (1870 kg/ha) as compared to 5<sup>th</sup> (1525 kg/ha) and 15<sup>th</sup> November (1100 kg/ha). Singh *et al.* (2017) concluded that crop sown on 14<sup>th</sup> November recorded significantly higher seed yield over 15<sup>th</sup> October and 29<sup>th</sup> November sowing but at par with 30<sup>th</sup> October sowing. Kaur *et al.* (2018) at Ludhiana revealed that *B. napus* sown on 15<sup>th</sup> October produced 4.1% more (significantly) seed yield (2476 kg/ha) than 30<sup>th</sup> October sown crop, while, produced 36.1% more seed yield than 15<sup>th</sup> November sown crop. Prasad *et al.* (2018) found that every 10 days delay in sowing from 20<sup>th</sup> October to 10<sup>th</sup> November resulted in a reduction of 10.1-28.9 and 10.1-45.1%, respectively, in rapeseed (*B. napus*) with an overall reduction of 30.2% from 20<sup>th</sup> October to 10<sup>th</sup> November in 20 days delay in sowing at Palampur, Himachal Pradesh. Bhagat *et al.* (2022a) reported that the seed yield of *B. napus* was recorded significantly higher under 20<sup>th</sup> October sown crop to the extent of 29.91 and 61.45% than delayed sowing on 30<sup>th</sup> October and 9<sup>th</sup> November, respectively at Jammu.

#### Stover yield

Bhuyian *et al.* (2008) from Bangladesh reported that the highest stover yield (6.06 t/ha) was found under first sowing (October 20<sup>th</sup>) while the lowest stover yield (4.80 t/ha) recorded on November 30<sup>th</sup> sown crop. Akhter *et al.* (2015) highlighted that significantly maximum stover yield of rapeseed (brown sarson) was obtained with 1<sup>st</sup> October

(56.73 q/ha) sowing followed by 15<sup>th</sup> October crop sown (39.93 q/ha) and 30<sup>th</sup> October (20.85 q/ha), respectively at Kashmir valley. Kumar *et al.* (2017) observed that stover yield of mustard crop was significantly affected as crop sown on 25<sup>th</sup> October (57.81 q/ha) recorded significantly higher stover yield as compared to 5<sup>th</sup> October (48.21 q/ha) and 25<sup>th</sup> September (43.84 q/ha) sown on different dates, respectively. Kaur *et al.* (2018) reported significantly higher stover in the crop (oilseed rape) sown on 15<sup>th</sup> October (9458 kg/ha) recorded significantly higher stover yield as compared to 30<sup>th</sup> October (7427 kg/ha) and 15<sup>th</sup> November (5445 kg/ha) sown crop at Ludhiana. Bhagat *et al.* (2022a) recorded significantly higher stover yield in *B. napus* sown 20<sup>th</sup> October (6074 kg/ha) sown crop in comparison to the crop sown on 30<sup>th</sup> October (4694 kg/ha) and 9<sup>th</sup> November (3801 kg/ha) at sub-tropical conditions of Jammu region.

### Biological yield

Panda *et al.* (2004) reported that the biomass yield of crop was significantly influenced by the date of sowing as October 16<sup>th</sup> sown crop produced the highest biomass (73.5 q/ha), which was higher than about 18 per cent under crop sown on October 31<sup>st</sup> but there was drastic reduction in total harvested biomass when crop was sown on November 15<sup>th</sup>. Jiotode *et al.* (2017) found that the mustard crop sown on 43<sup>rd</sup> SMW (22 to 28 October) recorded significantly higher biomass (2946.6 kg/ha) as compared to the Mustard sown on 44<sup>th</sup> SMW (29 October to 4 November), 45<sup>th</sup> SMW (5 to 11 November) and 46<sup>th</sup> SMW (12 to 18 November) but was found par with 42<sup>nd</sup> SMW (15 to 21 October) sown crop. Keerthi *et al.* (2017) stated that biological yield decreased significantly with delay in sowing date from 15<sup>th</sup> October (11828 kg/ha) to 15<sup>th</sup> November (9311 kg/ha) while Kumar *et al.* (2017) showed that the variety RH 0749 of Indian mustard sown on 26<sup>th</sup> October (12239 kg/ha) produced significantly higher biological yield as compared 5<sup>th</sup> November (10881 kg/ha) and 15<sup>th</sup> November (6242 kg/ha), respectively. Bhagat *et al.* (2022a) recorded significantly higher biological yield in the oilseed rape (*B. napus*) sown on 20<sup>th</sup> October (7849 kg/ha) in comparison to the crop sown on 30<sup>th</sup> October (6060 kg/ha) and 9<sup>th</sup> November (4906 kg/ha) at Jammu region.

### Effect of sowing dates on quality of mustard

Angrej *et al.* (2002) observed that oil content and oil yield recorded higher with 10<sup>th</sup> and 30<sup>th</sup> October sowing as compared to 20<sup>th</sup> November and 10<sup>th</sup> December sowing at PAU, Ludhiana. Shivani and Kumar (2002) reported that oil yield of 25<sup>th</sup> September (619 kg/ha) and 5<sup>th</sup> October (583 kg/ha) sown crops were significantly higher than

15<sup>th</sup> October (425 kg/ha), 25<sup>th</sup> October (284 kg/ha) and 04<sup>th</sup> November (197 kg/ha) sown crops, respectively. Srivastava *et al.* (2011) evaluated the quality of *B. juncea* with ten different dates of sowing on weekly intervals starting from 1<sup>st</sup> October to 3<sup>rd</sup> December in two seasons at IARI New Delhi. Further, they recorded that the oil content drastically reduced after the optimum sowing window (15<sup>th</sup> October to 22<sup>nd</sup> October) in both the cultivars of *B. juncea* i.e., Pusa Jaikisan and Varuna. Akhter *et al.* (2015) emphasized that oil content of brown sarson varieties had non-significant effect among dates of sowing, but crop sown on 1<sup>st</sup> October recorded significantly higher oil yield (634 kg/ha). Patel *et al.* (2017) reported that the significantly higher oil yield of 838 kg/ha in crop sown on 14<sup>th</sup> November as compared to 15<sup>th</sup> October (723 kg/ha) and 29<sup>th</sup> November (660 kg/ha) sowing, but was found at par with 30<sup>th</sup> October (782 kg/ha) sowing whereas, protein content of mustard was not influenced significantly due to different dates of sowing.

### Conclusion

The perusal of literature reveals that the sowing dates are the most significant non-monetary input that describe yield of rapeseed-mustard. Early or delayed sowing is associated to a considerable decline in yield-attributing characters due to unfavourable weather conditions leading to declining trend in seed yield. It is agreed upon in the literature that altering the sowing date of the rapeseed-mustard is responsible to achieve the synchronisation of the important phenophases (phasic development) with the favourable weather regime, which ensures a promising productivity. Therefore, in order to increase mustard yield and ensure food security under climate change scenario, it is crucial to choose the ideal sowing date depending upon the prevailing weather conditions of that location.

### References

- Ahatsham M, Singh S and Dagar CS. 2018. Heat Use Efficiency of Indian mustard (*B. juncea*) at different phenophases in western Haryana, India. *Int J Curr Microbiol Appl Sci* **7**: 1977-1981.
- Akhter L, Singh L, Rasool R and Ramzan S. 2015. Effect of dates of sowing and varieties on yield of Brown Sarson (*B. rapa*) under temperate Kashmir. *Int J Eng Sci Inv* **4**: 65-69.
- Alam MJ, Ahmed KS, Mollah MRA, Tareq MZ and Alam J. 2014. Effect of planting dates on the yield of mustard seed. *Int J Appl Sci Biotechnol* **3**: 651-654.
- Angrej S, Dhingra, KK, Singh J and Singh MP. 2002. Effect of sowing time and plant density on growth, yield and quality of Ethiopian mustard (*B. carinata*). *J Res*

- PAU **39**: 471-475.
- Anonymous, 2021. Ministry of Agriculture and Farmers' Welfare, Government of India.
- Bali AS, Singh T, Shah MH, Singh KN and Nehvi FA. 1992. Response of Indian mustard (*B. juncea*) to sowing date and fertilizer application. *Indian J Agric Sci* **62**: 690-691.
- Bauer A, Frank AB and Black AL. 1985. Estimation of spring wheat grain dry matter assimilation from air temperature. *Agron J* **77**: 743-752.
- Bhagat KL, Gupta JP and Khanna YP. 1996. Performance of Gobhi Sarson (*B. napus* var. GSL-1) in relation to sowing dates and row spacings. *J Oilseeds Res* **13**: 116-117.
- Bhagat R, Singh M, Sharma BC and Shankar U. 2022a. Effect of sowing environments on yield attributes and yield of Gobhi Sarson (*B. napus*) cultivars under subtropics of Jammu region. *J Oilseed Brassica* **13**: 7-10
- Bhagat R, Singh M and Sharma BC. 2022b. Growth and productivity of Gobhi Sarson (*B. napus*) cultivars under diverse sowing environments. *Indian J Agric Sci* **92**: 1202-1207
- Bhuiyan MS, Mondol MRI, Rahaman MA, Alam MS and Faisal AHMA. 2008. Yield and yield attributes of rapeseed as influenced by date of planting. *Int J Sustain Crop Prod* **3**: 25-29.
- Choudhary D, Singh R, Dagar CS, Kumar A, Rajeev and Pattam K. 2018. Response of Indian mustard to different sowing environments and varieties in semi-arid of Haryana. *Int J Chem Stud* **6**: 1452-1457.
- Choudhary RL, Langadi AK, Jat RS, Anupama, Singh HV, Meena MD, Dotaniya ML, Meena MK, Premi OP and Rai PK. 2021. Mitigating the moisture stress in Indian mustard (*B. juncea*) through polymer. *J Oilseed Brassica* **12**: 21-27.
- Devi M and Sharma HK. 2017. Effect of sowing date on flowering and seed set of mustard (*B. juncea*). *J Entomol Zool Stud* **5**: 1534-1537.
- Dinda NK, Ray M and Sarkar P. 2015. Effect of sowing date vis-a-vis variety of rapeseed and mustard on growth, yield and aphid infestation in gangetic plains of West Bengal. *The Ecoscan* **9**: 21-24
- Dudhade DD, Gare BN, Khade KK and Ramshe, DG. 1996. Effect of sowing date on growth and yield attributes and yield of Indian mustard (*B. juncea*). *Indian J Agron* **41**: 445-447.
- Gawariya SC, Chopra NK, Chopra N and Harika AS. 2015. Effect of date of sowing and crop geometry on growth and yield parameters of forage mustard (Var. Chinese Cabbage). *African J Agric Res* **10**: 3292-3295.
- Gogoi B, Kurmi K, Thakuria K, Ojha NJ and Dutta S. 2017. Influence of crop management practices on late sown Toria (*B. rapa*) under rainfed rice-fallow situation of Assam. *J Oilseed Brassica* **8**: 168-174
- Gomez NV and Miralles DJ. 2011. Factors that modify early and late reproductive phases in oilseed rape (*B. napus*): Its impact on seed yield and oil content. *Ind Crops Prod* **34**: 1277-1285.
- Gupta M, Sharma C, Sharma R, Gupta, V and Khushu MK. 2017. Effect of sowing time on productivity and thermal utilization of mustard (*B. juncea*) under sub-tropical irrigated conditions of Jammu. *J Agrometeorol* **19**: 137-141.
- Hayward A. 2011. Introduction – oilseed Brassica. In: Kole C, editor. Genome mapping and molecular breeding in plants vol. 2: oilseeds. Berlin: Springer; Pp: 1-13.
- Hundal SS, Kaur P and Malikpuri SDS. 2003. Agroclimatic models for predicting growth and yield of Indian mustard (*B. juncea*). *Indian J Agric Sci* **73**: 142-44.
- Jiotode DJ, Parlawar ND, Patil SR, Kuchanwar OD, Khawle VS and Dhanwate AG. 2017. Effect of weather parameter on rabi Mustard varieties under different sowing dates. *Int J Res Bio Sci Agric Tech* **2**: 72-78.
- Kaur K, Kumar S and Bhagat V. 2022. Performance of gobhi sarson (*B. napus*) as influenced by different date of sowing and nitrogen levels under irrigated condition of central Punjab. *J Oilseed Brassica* **13**: 153-157
- Kaur L, Sardana V and Sharma P. 2018. Effect of sowing dates and nitrogen application on growth and productivity of canola oilseed rape (*B. napus*). *J Oilseed Brassica* **9**: 114-121
- Kaur P, Khehra MK and Hundal SS. 2006. Development of thermo based phenophasic model for predicting phenological stages of Indian mustard (*B. juncea* L) in central plains of Punjab. *Indian J Agric Sci* **76**: 377-379.
- Keerthi P, Pannu RK and Dhaka AK. 2017. Effect of sowing dates and nitrogen levels on total dry matter and its partitioning at different growth stages and yield of Indian mustard (*B. juncea*). *Agric Sci Digest* **37**: 27-31.
- Keerthi P, Pannu RK, Singh R and Dhaka AK. 2016. Thermal requirements, heat use efficiency and plant responses of Indian mustard (*B. juncea*) for different levels of nitrogen under different environments. *J Agrometeorol* **18**: 201-205
- Khajuria S, Dwivedi MC, Kumar S, Kachroo D and Puniya



- R. 2017. Yield performance and nutrient uptake of Indian Mustard (*B. juncea*) varieties under different dates of sowing and planting geometry. *Int J Plant Soil Sci* **15**: 1-6.
- Khanday BA, Shah MH, Majid MA, Khushu M K and Kachroo D. 1991. Effect of planting time and seed rates on growth and yield of KOS-1 rapeseed (*B. napus*). *Indian J Agron* **36**: 409-411.
- Khushu MK, Rahman N, Singh M, Prakash A, Tiku AK and Bali AS. 2008. Thermal time indices for some Mustard genotypes in the Jammu region. *J Agrometeorol* **10**: 224- 227.
- Khushu MK, Tiku AK and Singh M. 2011. Photosynthetically active radiation (PAR) distribution in Mustard canopy. *Crucif Newsl* **30**: 9-10.
- Kumar A, Lal M, Kumar P, Kumar R and Kumar J. 2018. Effect of different sowing dates on yield and yield attributes of Indian mustard (*B. juncea*) genotypes. *Int J Curr Microbiol Appl Sci* **7**: 1435-1440.
- Kumar A, Singh B, Yashaial and Yadav JS. 2004. Effect of sowing time and crop geometry on tetralocular Indian Mustard under southwest Haryana. *Indian J Agric Sci* **74**: 594-596.
- Kumar Y, Singh R, Kumar A and Dhaka AK. 2017. Effect of growth and yield parameters on Indian mustard genotypes under varying environmental conditions in western Haryana. *Journal Appl Nat Sci* **9**: 2093 -2100.
- Kumari A, Singh RP and Yeshpal. 2012. Productivity and nutrient uptake and economics of mustard hybrid (*B. juncea*) under different planting time and row spacing. *Indian J Agron* **57**: 61-67.
- Kumari CR and Rao DSK. 2005. Effect of land treatment and dates of sowing on growth parameters of Mustard (*B. juncea*). *J Oilseed Res* **22**: 188-189.
- Lakra RK, Alam P and Nayar A. 2018. Effect of sowing time and crop geometry on productivity of mustard (*B. juncea*) under irrigated condition of Jharkhand. *Int J Curr Microbiol Appl Sci* **7**: 777-781.
- Meena M, Meena PKP and Kumhar BL. 2017. Studies on response of mustard varieties to different sowing dates under humid southern plain zone of Rajasthan. *Int J Pure Appl Biosci* **5**: 385-391.
- Panda BB, Shivay YS and Bandyopadhyay SK. 2004. Growth and development of Indian Mustard (*B. juncea*) under different levels of irrigation and date of sowing. *Indian J Plant Physiol* **9**: 419-425.
- Patel A, Singh AK, Singh S, Sharma A, Raghuvanshi N and Singh AK. 2017. Effect of different sowing dates on growth, yield and quality of various Indian mustard (*B. juncea*) varieties. *Int J Curr Microbiol Appl Sci* **4**: 71-77.
- Prasad R, Kumari V, Sharma A and Sood R. 2018. Effect of temperature on phenology and yield of rapeseed in mid hill region of Himachal Pradesh. *J Agrometeorol* **20**: 69-71.
- Rameshwar, Negi PS and Sharma S. 2000. Effect of planting date and row spacing on growth parameters, yield and economics of gobhi sarson (*B. napus*) under mid hill conditions of Himachal Pradesh. *Crop Resour* **20**: 39-45.
- Rana RS, Vaijinath BA, Kumar S and Pathania R. 2017. Forecasting phenology of mustard crop in north-western Himalayas. *J Appl Nat Sci* **9**: 230- 236.
- Samant T K and Panigrahi D. 2018. Effect of sowing dates and nutrient management practices on important parameters in Toria (*B. rapa*). *J Oilseed Brassica* **9**: 22-26
- Sharma J and Thakur DR. 1993. Performance of rainfed argentine rape (*B. napus*) under dates of sowing and row spacing in the mid hills of north western Himalayas. *Indian J Agron* **38**: 254-256.
- Shekhawat K, Rathore SS, Premi OP, Kandpal BK and Chauhan JS. 2012. Advances in agronomic management of Indian mustard (*B. juncea*): An overview. *Int J Agron* 40824.
- Shivani and Kumar S. 2002. Response of Indian mustard (*B. juncea*) to sowing date and row spacing in mid-hills of Sikkim under rainfed conditions. *Indian J Agron* **47**: 405-410.
- Singh AK, Singh H, Rai H, Singh G, Singh V P, Singh NP and Singh R. 2017. Effect of sowing dates and varieties for higher productivity of Indian mustard (*B. juncea*). *J Appl Nat Sci* **9**: 883-887.
- Singh HV, Choudhary RL, Meena MD, Dotaniya ML, Meena MK, Jat RS, Premi OP and Rai PK. 2019. Productivity enhancement of Indian mustard (*B. juncea*) through innovative crop establishment technique. *Indian J Agric Sci* **89**: 1669–73.
- Singh J, Singh SP and Kingra PK. 2018. Influence of sowing time and planting geometry on yield and radiation use efficiency of various rapeseed-mustard cultivars. *J Agrometeorol* **20**: 246-248.
- Singh R, Rao VUM and Singh D. 2002. Biomass partitioning in *Brassica* as affected by sowing dates. *J Agrometeorol* **4**: 59-63.
- Singh SP, Sharma P, Jena AK, Bhuyan T, Deuri R and Nyori T. 2019. Heat unit requirement of mustard (*B. juncea*) under different thermal regimes and irrigated conditions of namsai region of Arunachal Pradesh. *Int J Chem Stud* **7**: 1038-1041.

- Srivastava AK, Adak T and Chakravarty NVK. 2011. Quantification of growth and yield of oilseed Brassica using thermal indices under semi-arid environment. *J Agrometeorol* **13**: 135-140.
- Thakur KS and Singh CM. 1998. Performance of *Brassica* species under different dates of sowing in mid-hills of Himachal Pradesh. *Indian J Agron* **43**: 464-468.
- Tripathi M, Rao VUM and Singh D. 2007. Effect of sowing time and in-season growth manipulations on phenology of Indian mustard (*B. juncea*). *Indian J Agric Sci* **77**: 153-57.
- Tyagi PK. 2017. Thermal requirements and heat use efficiency of Indian mustard varieties under different environment. *J Agrometeorol* **19**: 164-166.
- Yadav RN, Bhan S and Uttam SK. 1996. Effect of sowing date, variety and plant population on growth and yield of rainfed Indian mustard (*B. juncea*). *Indian J Agron* **39**: 682-684.