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Growth and Development of Rapeseed Mustard and Other Field Crops under Different Sowing Dates

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ABSTRACT

Indian mustard (Brassica juncea L. Czern) belongs to family Cruciferae, genus Brassica and species juncea popularly known as rai. Mustard is cultivated mostly under temperate climate. It is also cultivated in certain tropical and subtropical region as a cold weather crop. Appropriate sowing time is the most important non monetary input which contributes towards the greater yield as sowing time influences phenological development of crop plants through temperature and heat unit. Thus sowing at optimum time gives higher yields due to suitable environment that prevails at all the growth stages. During rabi season early sown crops exposed to low temperature at their vegetative stages while late sown crops experienced high temperature at their terminal stages of development. Transitory or constantly high or low temperatures causes an array of morphological, physiological and biochemical changes in plants. Temperature stress affects plant growth throughout its ontogeny, though heat-threshold level varies considerably at different developmental stages, for instance, during seed germination, may slow down or totally inhibit germination and at later stages, high or low temperature may adversely affect photosynthesis, respiration, water relations and membrane stability, enhanced expression of a variety of heat shock proteins, production of reactive oxygen species (ROS) and accumulation of osmolytes constitute major plant responses. This review describes the effect of sowing dates and temperature on growth and development of mustard plant and other important crops throughout its life cycle.

Key words: *Sowing dates, Mustard, Growth, Temperature and Yield*

INTRODUCTION

Rapeseed-mustard (*Brassica spp.*) is one of the most important oilseed crops of the world where India is ranking third in area and production in the world[14]. Among the seven edible oilseeds cultivated in India, rapeseed-mustard contributes 28.6% in the total oilseeds production and ranks second after groundnut sharing 27.8% in the India's oilseed economy[53]. however due to more oil content (ranging from 35-45%) rapeseed-mustard ranks first in terms of oil yield among all oilseeds crops. Its seed contains 37 to 49 percent edible oil[55].

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Demand of edible oil has increased with increasing population and improvement in the living standard of the people, resulting thereby in short supply of edible oils which is being met with imports of edible oil worth 44,000 crores per annum. Thus, there is need to boost the oilseed production through area expansion and productivity enhancement.

In India, rapeseed-mustard occupy 5.99 million ha area with production and productivity of 6.31 million tones and 1053 kg/ha respectively[21]. Indian mustard (*Brassica juncea* L.) is an important *rabi* crop of Haryana. In Haryana, rapeseed and mustard is one of the major growing crop occupying 0.56 million ha of area, with production and productivity of 0.699 million tones and 1248 kg/ha respectively[21]. Rapeseed–mustard is the third most important source of edible oil next to soybean and groundnut in India, and is grown in certain tropical and subtropical regions as a cold-season crop[53]. Mustard seed in general, contains 30-33 % oil, 17-25 % proteins, 8-10 % fibers, 6-10 % moisture, and 10-12 % extractable substances[40]. The seed and oil of mustard are used as a condiment in the preparation of pickles, flavouring curries and vegetables as well as for cooking and frying purposes. Its oil is used in many industrial products, cake as cattle feed and manure and green leaves for vegetable and green fodder[34].

Indian mustard is sown late due to delay in harvesting of rainy season crops like cluster bean, cotton and rice[32]. Under late sown condition, productivity declines primarily due to the shortening of vegetative and reproductive phase. Late sown Indian mustard is exposed to high temperature coupled with high evaporative demand of the atmosphere, during the reproductive phase which consequently results in forced maturity, increased senescence and low productivity[41]. The rise in temperature, even by a single degree beyond the threshold level is considered as heat stress in the plants[19,64].The global mean surface air temperature increased by 0.5°C in the twentieth century and is expected to increase a further 1.5–4.5°C by the late twenty-first century[22]. Climate change has increased the intensity of heat stress and heat stress due to increased temperature is an agricultural problem in many areas in the world as well as in India[9]. There is a specific time for the sowing of particular variety of a crop on specific area[48,63]. Time of sowing is very important for crop production as different sowing dates provide variable environmental conditions within the same location for growth &development of crop[39]. The late sowing of mustard decreased seed yield through synchronization of silique filling period with high temperatures, the decrease in assimilates production, drought stress occurrence, shortened silique filling period and acceleration of plant maturity[35]. because it is a thermo sensitive as well as photosensitive crop[15].

The literature on research work carried out in India and abroad on effect of sowing dates are described in this review for oilseed brassicas and other crops under following heading and subheadings.

2. Efeect of sowing dates on various stages of Rapeseed Mustard and other crops:

2.1 Effect on Phenology
2.2 Effect on Growth
2.3 Effect on physiology
2.4 Effect on biochemical traits
2.5 Effect on yield and yield attributes

2.1 Effect on Phenology:

Whole life cycle of mustard plant has been divided into three development stages, sowing to seedling emergence, seedling emergence to flowering and flowering to maturity. Chauhan *et al.*[11], studied 22 cultivars of mustard under two different sowing dates *i.e* 9 November and 25 November and observed that high temperature at the time of seedling emergence and 50 % flowering in late sown Indian mustard on 25 November sowing time and reported that more days were taken to seedling of emergence and early flowering in late sown Indian mustard due to heat stress. Akhter *et al.*[4], studied *Brassica rapa* with 3 sowing dates (1 October, 15 October & 30 October) and 4 varieties (KOS- 1, Gulchein, Shalimar Brown Sarson-1 and P-3) and observed the effect of sowing dates on phenology of crop. They reported that days taken to various phenological stages *viz*., emergence, rosette stage, flower bud initiation, flower initiation, 80 % plants start flowering and physiological maturity differed significantly with respect to sowing time. 1st October sowing has taken lesser number of days to emergence (6.4 days) as compared to 15th October (7.4 days) and 30th October (12.4 days) sowing. In his study they concluded that early planting on 1st October has taken lesser number of days to seedling emergence as compared to later sowing dates. It might be due to favourable higher soil and air temperature on 1st October sowing and low soil and air temperature in delayed sowing. They also reported that among varieties, P-3 revealed best phenological performance as compared to KOS- 1, Gulchein, Shalimar Brown Sarson-1.

Alam *et al.*[5], studied 11 genotypes of *Brassica* on three different sowing dates i.e 25 November, 5 December & 25 December and observed that plants of early sowing, flowered later due to prevalence of favourable environment, especially low temperature during vegetative growth phase which enhanced flower initiation in the varieties/lines and delay sowing reduced to flowering due to high temperature. Solanki and Mundra[57] studied Indian mustard (variety Bio-902) at 4 different dates of sowing i.e 5 October, 20 October, 4 November & 19 November to evaluate the effect of varying sowing dates on phenology of Indian mustard. Their results revealed that days taken for vegetative and reproductive phase influenced by different dates of sowing as the vegetative phase of mustard was extended by 4 to 5 days in delayed sowing (4th November & 19th November) as compared to timely sown crop (5th October) and the reproductive phase of the crop was shortened by 8 to 10 days with delayed sowings.

2.2 Effect on growth

2.2.1 Plant height

Kumari *et al.*[33], conducted a field experiment to evaluate the effect of 3 dates of sowing (10 October, 20 October, & 30 October) on 3 *Brassica juncea* hybrids/varieties (Kranti, NRCHB-506 & DMH-1). They reported that highest plant height (209 cm) was found at 10 October sowing condition and minimum plant height (186 cm) was found at 30 October sowing and in his study they concluded that the decreased in plant height with delayed sowing may be due to less availability of mineral nitrogen due to unfavorable temperature during delayed sowing. They also reported that the plant height was significantly influenced by varieties. Among the varieties, hybrid ‘DMH-1’ recorded the highest plant height which was significantly superior to hybrid ‘NRCHB-506’ and variety ‘Kranti.

Abdul & their co-workers studied three cultivars of canola *viz*; Bulbul-98, Zafar-2000 and Rainbow were sown at three different sowing dates i.e early (15th October), late (30th October) and very late (15th November) to evaluate the effect of sowing dates on various growth parameters including plant height. Their results revealed that the canola planted on 15th of October attained maximum plant height (177.4 cm) which was statistically at par with canola planted on 30th of October while minimum plant height (161.8 cm) was recorded in late sown (15th November) canola. They reported that plant height was negatively influenced by delayed sowings and the increased plant height in early planting date may be attributed to more light, water and mineral absorption by plant canopies thus, increasing photosynthetic capacity. They also reported that among varieties the maximum height (171.7 cm) was observed in Bulbul-98 while minimum height (170.6 cm) was obtained in Rainbow due to genetic variation in varietals character

Alam *et al.*[5], conducted an experiment on 30 genotypes of *Brassica* with three different dates of sowing (25 November, 5 December & 25 December) and concluded that dates of sowing had significant effect on plant height. They observed that the highest plant height (114.4 cm) at harvesting was found at 25 November sowing condition and the shortest plant (91.1cm) was found at 25 December sowing time and reported that the decreased plant height on delayed sowing was due to high temperature stress at the time of harvesting.

Akhter *et al.*[4], studied *Brassica rapa* with 3 sowing dates (1 October, 15 October & 30 October) and 4 varieties (KOS- 1, Gulchein, Shalimar Brown Sarson-1 and P-3) and observed the effect of sowing dates on plant height of crop. Their results revealed that significant increase in plant height with 1st October sowing as compared to 15th and 30th October sowing. In his study they concluded that the 1st October sowing recorded significantly taller plants as compared to 15th October and 30th October sowing because of the fact that the early sown crop got longer time period to utilize available resources fully and favourable temperature at later growth stages which results in better accumulation of photosynthates. They also reported that among varieties, P-3 revealed highest plant height as compared to KOS- 1, Gulchein, Shalimar Brown Sarson-1.

Singh and their co-workers studied 43 cultivars of Indian mustard on two different dates of sowing *i.e* 26 October & 26 November to evaluate the effect of heat stress under late sown condition (26 November). They found that the decreased plant height in all the 43 cultivars on 26 November crop. Their results revealed that the highest plant height (276 cm) at harvesting was on 26 October sown crop while high temperature at the time of harvesting on 26 November sown crop caused the plant height to decrease by 22.8 % and the reduction in the plant height due to high temperature stress was probably related to decline in photosynthetic products as a result of soil moisture decreased which eventually causes the plant not to reach its genetic potential.

2.2.2 Crop growth rate (CGR) & Relative growth rate (RGR)

Crop growth rate (CGR) is slow at early growth stages because the plant cover is incomplete and the plants absorb just a part of the solar radiation. As the plants develop, their growth rate is quickly increased because of the expansion of leaf area and this trait is an index dealing with production potentiality of the plant and it is utilized in order to determine yield among different varieties[16]. while the ecological advantage of high RGR is very clear. Due to high RGR, a plant will rapidly increase in size and is able to occupy a large space, both below and above ground. A high RGR may also facilitate rapid completion of life cycle of a plant[2].

Alam *et al.*[5], studied 11 genotypes of *Brassica* on three different sowing dates *i.e* 25 November, 5 December & 25 December and observed the effect of temperature due to different sowing dates on plant growth and development. They concluded that on 25 November sowing condition the decreased crop growth rate due to low temperature at vegetative stage and on 25 December sowing condition the decreased crop growth rate due to high temperature at grain filling stage in mustard crop that results into reduction in crop growth rate .

Khayat *et al.*[27], conducted an experiment on canola with four planting dates (6 November, 21November, 6 December & 21 December) and four genotypes (Hyola401, PP401, RGS003 and Option500) and observed the effect of sowing date on growth parameters like crop growth rate (CGR) and relative growth rate (RGR). They reported that delayed plantings (because of insufficient vegetation cover, low amount of sunlight absorption and heat during end of the season) show a slow growth rate. The first planting date (with 22.34 g m^{-2} day^{-1}), had the maximum relative growth rate, and the fourth planting date (with 16.5 g m-2 day-1), had the minimum relative growth rate. They also reported that among varieties, Hyola401 had highest (21 g m^{-2} day^{-1}) crop growth rate on 6 November as compared to PP401, RGS003 and Option500.

2.3 Effect on physiology(Water potential, osmotic potential, RWC, RSI, CTD, chlorophyll a fluorescence)

The plant growth and development depend upon cell division and cell enlargement and both of these process are sensitive to water deficit. Among different parts of plant the leaf growth is generally more sensitive to water stress. Hence, it should be no longer assured that crop growth is not affected, if plant water deficit do not reach that can directly reduces the many physiological processes like photosynthesis[52]. Kumar & Srivastava[30]. reported that under late sown conditions there is reduced chlorophyll stability index, poor harvest index and consequently decreased seed yield. Extreme temperature leads to accumulation of certain organic compounds (osmolytes) like sugars, polyols, proline and glycine betaine[26,49].

The most important physiological parameter under field condition is leaf water potential. The leaf water potential was influenced by soil water status and evaporative demand[52]. Water loss is more frequent during the day than at night due to enhanced transpiration reducing water potential[62]. Early sowing at vegetative stage and late sowing at grain filling faces the high temperature that ultimately leads to heat stress and heat stress affects many physiological processes by affecting water availability, uptake, and its translocation along with ions and organic solutes across the plasma membrane resulting in impaired photosynthesis (especially damage to PSII) and reduced leaf osmotic potential[61].

During heat stress, the injury can be assessed by the loss of membrane integrity that is reflected in organic and inorganic ion leakage from cells[50]. Electrolyte leakage is thus a measure of cell membrane thermo-stability and reflects stress-induced changes[68]. Heat-induced electrolyte leakage has been reported in soybean[66], sorghum[59], potato and tomato[54], wheat[13,51], cowpea[23], cotton[42], barley[65], rice[36], and mungbean, Indian mustard[45].

Chlorophyll fluorescence is the ratio of variable to maximum fluorescence (Fv/Fm), and the base fluorescence (F0) have been shown to correlate with heat tolerance[67] and are related with PSII (photosystem II) and carbon fixation. PSII is highly thermolabile, and its activity is greatly reduced or even partially stopped under high temperatures[10]. Sudhir *et al.*[58], studied 15 genotypes of Indian mustard under 3 dates of sowing *i.e* 15 October, 1November & 15 November and observed the effect of dates of sowing on physiological parameters including relative water content (RWC), membrane stability index (MSI). They reported that 1 November & 15 November sowing condition had adverse effect on relative water content & membrane stability index as compared to 15 October sown condition due to heat stress with delayed sowings. Ram *et al.*[44], studied 796 germplasm of Indian mustard at early sowing (26 September) condition to check the thermo tolerance capacity of germplasm at early sown condition and concluded that the early sown *Brassica juncea* had the effect of heat stress on physiology of crop through various traits including relative water content, membrane stability index/relative stress injury & excised leaf water loss. They reported that in early sown *Brassica juncea* the decreased relative water content & increased relative stress injury due to heat stress. They also reported that among genotypes DRMR-1574, DRMR-1624, DRMR-1600, DRMR-1799 and Urvashi found to be tolerant to heat stress as compared to other. Ram *et al.*[46], studied 53 genotypes of Indian mustard on two different dates of sowing *i.e* 26 September & 23 October and concluded that the decreased relative water content (RWC) & increased relative stress injury (RSI) on early sown crop (26 September). Their results revealed that the heat-stress on 26 September sown crop had adverse effect on physiological parameters. They reported that among the 53 genotypes used for the study, BPR-349-9, Urvashi, BPR-541-2, BPR-605-40, Pusa Tarak (EJ9912-13), RGN-48, BPR-549-2, DRMR-729 and DRMR-1918 were identified as heat-tolerant on 26 September sown crop.

Basu *et al.*[7], studied 211 genotypes of chickpea on two different dates of sowing *i.e* 15 November (normal sown) and 15 January (late sown) and observed the effect of temperature in late sown crop on physiology of chickpea crop in terms of membrane stability and chlorophyll fluorescence (fv/fm). They reported that due to high temperature at pod formation in 15 January sown crop resulted into the decreased membrane stability & chlorophyll fluorescence as compared to 15 November sown crop. They also reported that among genotypes ICCV 92944, ICCV 37, ICC 67, JKG 1, GCP 101 & PG 12 identified as heat tolerant genotypes in terms of membrane stability and chlorophyll fluorescence.

Basu *et al.*[8], studied 5 varieties of wheat (PB 343, HD 2733, HW 2045, PB 533 & K 9107) on three different dates of sowing *i.e* 18 November, 3December & 18 December and observed the effect of dates of sowing on physiology of wheat crop in terms of canopy temperature depression at CRI, tillering, flowering & milking stages. They reported that the late sown crop (18 December) experienced highest canopy temperature at all the stages and among varieties K 9107 and HW 2045 recorded lowest and highest canopy temperature respectively.

2.4 Effect on biochemical traits (Proline & Glycine betaine)

High temperatures under late sown conditions induce significant alterations in plant biochemistry and metabolism so to increase plant tolerance to abiotic stresses and to maintain a high relative water content, plants may accumulates proline and glycine betaine[26,69]. When plants are exposed to excessive heat, a characteristic set of cellular and metabolic response is triggered. Plants accumulates various compounds of low molecular mass, known collectively as compatible solutes such as proline and glycine betaine as an adaptive mechanism against stress conditions. These solutes have several protective roles in heat-stressed cells[24,47].

Proline (Pro), a non-essential amino acid, *i.e.* having amino group (–NH) instead of the usual amino group (–NH2), is one of the most studied and extensively reported thermoprotectant. Proline is an amino acid, which appear most commonly in response to stress and play role as an osmolyte for osmotic adjustment, also proline contributes to stabilizing structures (e.g., proteins and membranes) in plant cells in many crops under stress conditions[38]. Proline has been reported to occur widely in higher plants and normally accumulates in large quantities in response to environmental stresses like heat stress[64].

Many studies have indicated a positive relationship between the accumulation of Proline and plant stress tolerance, chickpea[25], *Brassica*[60], wheat[3].

Glycine betaine (GB) (N, N, N-trimethylglycine), a quaternary ammonium compound, is one of the most effective osmolytes[12]. High GB accumulation under heat stress has been observed in various crops like sugarcane[64], but other crops such as rice, mustard, soybean, potato, tobacco do not accumulate GB or accumulates in very minute quantity.

Mousa and Abdel- Aziz[37]. conducted an experiment on maize crop with two genotypes differing in water stress sensitivity *i.e* Giza 2 (drought tolerant) and Trihybrid 321(drought susceptible) and water stress condition was created by irrigating with polyethylene glycol (PEG) solutions of 0.0, -5, -10 and -20 bars and observations were made on 21-day-old seedlings and observed the effect of drought stress in terms of accumulation of proline and glycine betaine content. They reported that the genotypes Giza 2 accumulated more proline and glycine betaine as compared to Trihybrid 321 under drought stress and they concluded that the accumulation of proline and glycine betaine in leaves increase the drought tolerane in maize genotypes.

Hasan *et al.*[18], conducted an experiment on 4 cultivars of wheat *i.e* Aghrani, Kanchan, CB-30 & Sonara on two different dates of sowing i.e 30 November & 30 December to evaluate the effect of heat stress with delayed sowings at post anthesis stage in relation to proline content. They reported that the more accumulation of proline content with delayed sowing due to the effect of heat stress at post anthesis stage in wheat cultivars. They also reported that among cultivars the highest proline content accumulated in cultivar CB-30 and lowest proline content was accumulated in Sonara cultivar and on the basis of proline content they concluded that cultivar CB-30 had highest tolerance capacity to heat stress as compared to other cultivars due to more accumulation of proline content.

Hayat *et al.*[20], studied 7 days old Indian mustard cultivars *i.e* Kranti by exposing the plants to 30 or 40 0C for 24 hours and observed the effect of high temperature stress after 24 hours on various traits of Indian mustard cultivars including proline content. They reported that the level of proline content significantly increased in response to high temperature stress.

Kumar *et al.*[31], conducted an experiment on chickpea crop with 4 genotypes differing in high temperature sensitivity *i.e* Pusa 1103 and BGD 72 (HT tolerant), Pusa 256 and Pusa 261 (HT susceptible) at late sown condition on 20 December and observed the effect of heat stress at reproductive stage on biochemical traits in terms of accumulation of compatible solutes like proline content. They reported that with late sown condition , under high temperature stress the tolerant genotypes Pusa 1103 and BGD 72 showed more accumulation of proline content as compared to susceptible genotypes i.e Pusa 256 and Pusa 261 and they concluded that more proline content accumulation was the reason of high temperature tolerance in genotypes Pusa 1103 and BGD 72.

2.5 Effect on yield and yield components (Number of primary & secondary branches, number of siliqua/plant, 1000 seed weight, biological yield, seed yield, harvest index)

Seed yield is a quantitative trait, which is the expression of the result of genotype, environmental effect and genotype-environment interaction[17]. The number of siliquae per plant is the most important component of the seed yield in rapeseed-mustard[6].

Kumar *et al.*[29], studied on Indian mustard at different dates of sowing and reported that crop sown on October 21 recorded higher number of primary and secondary branches per plant on stem as compared to October 7 and October 17 sowing.

Sudhir *et al.*[58], studied 15 genotypes of Indian mustard under 3 dates of sowing *i.e* 15 October, 1November & 15 November and reported that the reduction in seed yield per plant on 1 November & 15 November sowing condition, resulting in 13 % and 50 % reduction respectively ,over 15 October sowing condition. They also reported that among genotypes the Proagro, NDR 8801 and CS-52 showed lower decline in seed yield/plant, while Pusa Agrani, EJ-15 and PusaTarak showed comparatively greater decline in the seed yield/plant.

Abdul & their co-workers studied three cultivars of canola *viz*; Bulbul-98, Zafar-2000 and Rainbow were sown at three different sowing dates i.e early (15th October), late (30th October) and very late (15th November) to evaluate the effect of sowing dates on seed yield & yield attributing component like 1000 seed weight, biological yield and harvest index. Their results revealed that the canola planted on 30th of October attained maximum 1000 seed weight, biological yield, harvest index & seed yield while minimum 1000 seed weight, biological yield, harvest index & seed yield were recorded in late sown (15th November) canola. They reported that seed yield was negatively influenced by delayed sowings due to high temperature variation with delayed sowings at seed filling stages in canola and among varieties the maximum seed yield (2142.5 kg/ha) was observed in Zafar-2000 while minimum seed yield (2014.4 kg/ha) was obtained in Rainbow due to genetic variation in varietals character.

Ram *et al.*[44], studied 796 germplasm of Indian mustard at early sowing (26 September) condition to check the thermo tolerance capacity of germplasm through various parameters including seed yield under heat stress. They observed that reduction in 1000 seed weight & seed yield per plant in all the germplasm on early sown crop and among the germplasm tested, DRMR-1574, DRMR-1624 and DRMR-1600 produced higher seed yield per plant in the amount of 31, 20.5 and 19.4 g, respectively and DRMR-1313 (4.7g), BPR-541-4 (C) (5.8 g), DRMR-1998 (7.1 g) and DRMR-1077 (7.1 g) yielded the least seed yield per plant. The reduction in seed yield per plant might be attributed to reduction in total biomass of the plant as well as adverse effect of temperature on yield parameter in early sown crops.

Singh and their co-workers studied 43 cultivars of Indian mustard on two different dates of sowing *i.e* 26 October & 26 November to evaluate the effect of heat stress at terminal stage (grain filling) under late sown time (26 November). They observed the effect of high temperature on 26 November sown crop in terms of primary, secondary branches, siliqua length, seeds per siliqua, 1000 seed weight & seed yield per plant. Their results showed that the decreased seed yield & its component including number of primary, secondary branches, seeds per siliqua, 1000 seed weight on 26 November as compared to 26 October sowing due to heat stress.

Alam *et al.*[5], studied 11 genotypes of *Brassica* on three different sowing dates *i.e* 25 November, 5 December & 25 December and observed the effect of sowing dates on yield and yield component including number of silique per plant, seeds per siliqua, 1000 seed weight & seed yield. In his two year of study they concluded that the highest number of siliquae/plant found at 25 November sowing, which was significantly different from that of two other dates of sowing and the lowest number of siliquae/plant found at 15 December sowing and the highest seeds/siliqua, 1000-seed weight and seed yield obtained from 25 November sowing in both the years.

Solanki and Mundra[57] studied Indian mustard variety Bio-902 at 4 different dates of sowing *i.e* 5 October, 20 October, 4 November & 19 November to evaluate the effect of varying sowing dates on seed yield of Indian mustard. Their results revealed that 5th October and 20th October sown crop gave the maximum seed yield (17.01 q ha^{-1}) which was significantly superior over 4th November and 19th November sown crop . The crop sown on 4th November and 19th November resulted in the reduction in seed yield by 21.0 and 42.0%, respectively over 5th and 20th October sown crop due to heat stress with delayed sowings.

Khayat *et al.*[27], conducted an experiment on canola with four planting dates (6 November, 21November, 6 December & 21 December) and four genotypes (Hyola401, PP401, RGS003 and Option500) and observed the effect of sowing date on seed yield & yield attributing component like number of siliqua per plant, 1000 seed weight, biological yield & harvest index. They reported that the first planting date *i.e* 6 November had highest number of siliqua per plant, 1000 seed weight, seed yield, biological yield & harvest index. The first planting date had maximum grain yield (2611.6 t ha^{-1}) and after it another planting date showed decrease in amount (13.74, 31.36 and 41.97 % respectively). They also reported among varieties Hyola401 had highest number of siliqua per plant, 1000 seed weight, seed yield, biological yield & harvest index on 6 November and the lowest number of siliqua per plant, 1000 seed weight, seed yield, biological yield & harvest index was found in option500 on 21 December sowing condition.

Ram *et al.*[46], studied 53 genotypes of Indian mustard on two different dates of sowing *i.e* 26 September & 23 October and concluded that the decreased seed yield on early sown crop (26 September). Their results revealed that heat-stress on 26 September significantly reduced seed yield per plant. The reduction in seed yield per plant ranged from 64.0% in DRMR-2350 to 50.8% in NPJ-124 and genotype BPR-349-9 recorded the lowest (5.6%) reduction in seed yield per plant. The genotypes NPJ-112, NPJ-124, NRCDR-601 and DRMR-1350 recorded the maximum seed yield per plant on 23 October sowing time while genotypes NRCDR-601, BPR- 181-14 and RGN-12 showed the maximum seed yield per plant on 26 September sowing condition.

CONCLUSION

Optimum sowing time plays an important role to fully exploit the genetic potential of a variety as it provides optimum growth conditions such as temperature, light, humidity and rainfall. The accurate time of sowing and high yielding cultivars can boost the growth and yield of the crop. Ideal sowing dates for one or more variety allows for availability of a set of environmental factor that favour a desirable greening, establishment and survival of plantlet which as a result the plant encounters the favorable environmental conditions and avoid unfavorable ones during each stage of its growth.

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