



## Productivity enhancement of Indian mustard (*Brassica juncea*) through innovative crop establishment technique

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### ABSTRACT

A field experiment was carried-out for two consecutive years 2016-17 and 2017-18 during winter at ICAR-Directorate of Rapeseed and Mustard Research, Bharatpur, Rajasthan to evaluate the performance of Indian mustard (*Brassica juncea* L.) under innovative transplanting technique of crop establishment. The experiment was laid out in randomized block design with two factors, i) planting geometries, i.e. 30 × 30 cm (T<sub>1</sub>), 45 × 30 cm (T<sub>2</sub>) and 60 × 30 cm (T<sub>3</sub>) and ii) transplanting dates, i.e. 13<sup>th</sup> October (D<sub>1</sub>), 22<sup>nd</sup> October (D<sub>2</sub>) and 01<sup>st</sup> November (D<sub>3</sub>) with three replications. The maximum plant height (199.2 cm), leaf area index (5.82) and chlorophyll content (43.29) were recorded with T<sub>2</sub> and D<sub>1</sub> during both the years. The significantly higher value of yield attributes, i.e. length of siliquae, number of seeds/siliquae, test weight and oil content were also recorded with T<sub>2</sub>D<sub>1</sub> treatment during both years. Seed yield was recorded maximum with T<sub>2</sub>D<sub>1</sub> treatment during both the years. Seed yield improved significantly with T<sub>2</sub> by 9.1 and 19.5% over T<sub>1</sub> and T<sub>3</sub> respectively, whereas, yield improvement with D<sub>1</sub> also recorded significantly higher by 8.3 and 32.2% over D<sub>2</sub> and D<sub>3</sub>, respectively. The maximum net returns (₹ 100835) and B:C ratio (3.77) was also found with T<sub>2</sub> than the other treatments. Among the date of transplanting treatments, D<sub>1</sub> recorded the maximum values of these monetary parameters. Thus, we can conclude that transplanting of mustard on 13<sup>th</sup> October with 45 × 30 cm planting geometry is beneficial for getting higher yield as well as net monetary returns in the Rajasthan.

**Key words:** Chlorophyll content, Economics, Leaf area index, Mustard, Planting geometry, Transplanting, Yield

Indian mustard (*Brassica juncea* L.) is a winter oilseed crop which thrives best in light to heavy loam soils in areas having 25–40 cm rainfall. Among the several reasons responsible for low productivity of mustard, non-adoption of good agronomic practices like optimum date of sowing and planting geometry are the most important. The plant population and date of sowing much affected the yield and yield parameters. Very often the farmers have to sow the crop late due to delayed monsoon, which result in poor yield because of its depressing effect on the plant growth, flowering duration, seed formation and productivity (Bali *et al.* 2000). Kumari *et al.* (2012) reported that late sown mustard has the shorter growing period due to the high temperature during the reproductive phase which led to concomitant reduction in yield. In general, it was observed that the mustard crop sown after October 30<sup>th</sup> resulted in

lower yields due to genetic potential limitation (Panda *et al.* 2004).

The competitive ability of a rapeseed-mustard plant depends greatly upon the density of plants per unit area and soil fertility status (Shekhawat *et al.* 2012). Uniform distribution of crop plants over an area results in efficient use of nutrients, moisture, and suppression of weeds leading to high yield. Thus, optimum row spacing's are necessary for interception of sunlight to each of leaves. This will enhance the rate of photosynthesis and consequently, the dry matter production which can ultimately increase the crop yield.

The late sowing of mustard cultivars resulted in yield losses and thus affected the supply-chain of the oil in the market. The forceful late sowing conditions of the crop are mainly because of delayed harvesting of *kharif* crops. Therefore, early crop establishment through transplanting technique could be a better alternative to minimize the yield losses in mustard.

### MATERIALS AND METHODS

The experiment was conducted during 2016–17 and 2017–18 at research farm of Directorate of Rapeseed-Mustard Research, Bharatpur located at 77°30' E longitude, 27°15' N latitude and at an altitude of 178.37 m amsl. The

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climate of this zone is typically semi-arid, characterized with wide range of temperature between summer and winter. The mean weekly maximum and minimum temperature during the crop growing seasons of fluctuated between 18.3–40.9°C and 3.5–22.1°C. The mean daily evaporation from USWB class a pan evaporimeter ranged 1.0 to 9.7 mm/day. The average relative humidity fluctuated between 20.4–57.8% at noon. The bright sunshine h varied from 5.9 in January to 9.3 in April. Rainfall received during 2016–17 and 2017–18 was 55.8 mm and 26.6 mm. The experimental site was silty clay loam in texture (19.2% sand, 51.3% silt and 29.4% clay) with 8.3 pH (1:2 soil water suspension), 1.52 g/cm<sup>3</sup> bulk density, 12.5% field capacity (by weight) and 2.35% permanent wilting point. It had 0.24% organic carbon and 126.3, 17.23 and 149.3 kg/ha available N, available P and available K content, respectively at the start of the experiment.

The experiment was laid out in randomized block design with two factors, i) planting geometries, i.e. 30 × 30 cm (T<sub>1</sub>), 45 × 30 cm (T<sub>2</sub>) and 60 × 30 cm (T<sub>3</sub>) and ii) transplanting dates, i.e. 13<sup>th</sup> October (D<sub>1</sub>), 22<sup>nd</sup> October (D<sub>2</sub>) and 01<sup>st</sup> November (D<sub>3</sub>) with three replications. The nursery of RH 406 variety was raised in the transplanting trays before 8–10 days of date of transplanting. At 2–3 leaves stage plants were transplanted in to field in evening. After transplanting a light irrigation was given to get established the plants. A buffer nursery was prepared for gap filling of the same cultivar and gap filling was taken up after 8 days of transplanting. To eliminate weeds in experimental area, one hoeing was done at 25 DAS. The crop was harvested at 80% silique turned down yellowish brown. Thereafter, plants from each net plot area (6 m × 6 m) were harvested carefully and seed yield from each plot was recorded.

Observation on plant height, leaf area index (LAI) and SPAD chlorophyll meter reading (SCMR) were recorded from the net plot area at 45, 60 and 90 days after transplanting (DAT). The yield attributes, i.e. silique length and seeds/silique were measured at physiological

maturity from five randomly tagged plants. The 1000 seeds were randomly taken from the finally cleaned produce of each plot and their weight was presented as test weight. The total biomass harvested from each plot was threshed and cleaned. The seeds so obtained were weighed and then converted in to q/ha. Harvest index was calculated by:

$$\text{Harvest index (\%)} = \frac{\text{Economic yield (q/ha)}}{\text{Biological yield (q/ha)}} \times 100$$

where, Economic yield, seed yield (q/ha); Biological yield, seed yield + stover yield (q/ha).

Seed samples from all treatments were collected and analyzed for oil content (%) with the help of Nuclear Magnetic Resonance Spectroscopy (New Port Analyzer). Economics of different treatments were worked out in terms of cost of cultivation, gross monetary returns (GMR), net monetary returns (NMR), and benefit-cost ratio (B:C) based on prevailed market prices of the input and outputs.

The data obtained on various observations were tabulated and analyzed in factorial randomized block design with three replications by analysis of variance (ANOVA) (Panse and Sukhatme 1967) and the treatment was tested by F-test shown their significance where critical difference (CD) at 5% level of significance was determined for each character to compare the differences among treatment means.

## RESULTS AND DISCUSSION

**Plant height:** It is evident from the data that plant height increased with the advancement of the plant growth in all three transplanting dates (Table 1). The October 13<sup>th</sup> transplanting date exhibited significantly ( $P=0.05$ ) higher plant height at all growth stages followed by October 22<sup>nd</sup> transplanting in all growth stages of plant. Further observation showed that 15<sup>th</sup> October transplanting had significantly higher plant height followed by 30<sup>th</sup> November. Similar types of observations were recorded by Afroz *et al.*

Table 1 Growth and physiological parameters influenced by different planting geometry and date of transplanting

| Treatment                    | Plant height (cm) |        |        | Leaf area index |        |        | Chlorophyll content (%) |        |        |
|------------------------------|-------------------|--------|--------|-----------------|--------|--------|-------------------------|--------|--------|
|                              | 45 DAT            | 60 DAT | 90 DAT | 45 DAT          | 60 DAT | 90 DAT | 45 DAT                  | 60 DAT | 90 DAT |
| <i>Planting geometry</i>     |                   |        |        |                 |        |        |                         |        |        |
| 30 × 30 cm (T <sub>1</sub> ) | 86.77             | 166.2  | 198.2  | 3.16            | 4.07   | 5.67   | 38.61                   | 40.92  | 42.38  |
| 45 × 30 cm (T <sub>2</sub> ) | 88.32             | 172.9  | 199.2  | 3.79            | 4.39   | 5.82   | 39.89                   | 41.93  | 43.29  |
| 60 × 30 cm (T <sub>3</sub> ) | 82.62             | 162.8  | 198.2  | 2.69            | 3.43   | 5.48   | 37.67                   | 40.35  | 40.77  |
| SEm±                         | 0.48              | 1.60   | 0.34   | 0.03            | 0.06   | 0.019  | 0.11                    | 0.12   | 0.04   |
| CD (P=0.05)                  | 1.96              | 6.48   | 1.31   | 0.15            | 0.25   | 0.078  | 0.44                    | 0.48   | 0.18   |
| <i>Date of transplanting</i> |                   |        |        |                 |        |        |                         |        |        |
| 13 Oct (D <sub>1</sub> )     | 73.52             | 188.2  | 204.1  | 3.20            | 4.22   | 5.75   | 42.75                   | 43.52  | 45.42  |
| 22 Oct (D <sub>2</sub> )     | 70.3              | 179.4  | 197.9  | 2.92            | 3.77   | 5.21   | 41.33                   | 41.26  | 42.44  |
| 1 Nov (D <sub>3</sub> )      | 63.01             | 124.2  | 196.1  | 2.73            | 2.95   | 4.82   | 36.94                   | 39.98  | 40.45  |
| SEm±                         | 1.20              | 1.88   | 0.55   | 0.01            | 0.019  | 0.019  | 1.41                    | 0.11   | 0.12   |
| CD (P=0.05)                  | 4.85              | 7.58   | 2.22   | 0.007           | 0.077  | 0.077  | 4.19                    | 0.47   | 0.50   |

(2011) and Bhuiyan *et al.* (2008). Crop geometry 45 × 30 cm had higher plant height at all stages of crop during both the years. Increasing the plant height with the increasing geometry and optimum growth was observed at 45 × 30 cm in mustard (Pandey *et al.* 2015).

**Leaf area index:** Data reveals that leaf area index (LAI) was significantly affected by different transplanting dates at different stages. Crop transplanted on October 13<sup>th</sup> produced highest leaf area followed by 22<sup>nd</sup> October and November 1<sup>st</sup>. Crop geometry of 45 × 30 cm recorded highest LAI at 90 DAS (5.82) followed by 30 × 30 and 60 × 30 cm crop geometry (Table 1). Similar results were also reported by Kumar *et al.* 1997.

**Chlorophyll content:** It was observed that change in planting geometry and date of transplanting significantly ( $P=0.05$ ) affected the chlorophyll content (SPAD) in mustard crop. Delayed transplanting of mustard crop significantly decreased the chlorophyll content. Early transplanting (13<sup>th</sup> October) recorded significantly higher chlorophyll content (45.42), which was higher over 22<sup>nd</sup> October and 1<sup>st</sup> November transplanted crop. Crop geometry of 45 cm × 30 cm recorded highest chlorophyll (43.29) at 90 DAS followed by 30 × 30 and 60 × 30 cm crop geometry (Table 1). Similar findings also reported by Singh *et al.* (2015).

#### Postharvest observations

**Length of siliquae:** Data showed that transplanting times had significant effect on length of siliquae. The length of siliquae was significantly ( $P=0.05$ ) higher under 13<sup>th</sup> October planted crop as compared to 22<sup>nd</sup> October and 1<sup>st</sup> November planted mustard (Table 2), similar findings were also reported by Kumari *et al.* (2012). Crop geometry of 45 cm × 30 cm recorded highest length of siliqua (5.79 cm) at harvest followed by 30 cm × 30 cm, and 60 cm × 30 cm crop geometry respectively.

**Number of seeds/Siliquae:** It is evident from data that the number of seeds/siliquae was drastically reduced with delayed planting. Planting of mustard on 13<sup>th</sup> October

produced significantly higher number of seeds/siliquae (19.18) as compared to delayed planting (22<sup>nd</sup> October and 1<sup>st</sup> November) (Table 2). 22<sup>nd</sup> October and 1<sup>st</sup> November planted crop produced less number of seeds/siliquae than 13<sup>th</sup> October planted crop. Crop geometry of 45 cm × 30 cm recorded highest number of seed (18.62 seeds per siliqua) at harvest followed by 30 cm × 30 cm and 60 cm × 30 cm crop geometry. Similar findings were also reported by Yadav *et al.* (1994).

**Test weight:** Data showed that different times of transplanting brought about significant effect on test weight (Table 2). Higher 1000 seeds weight was recorded in October 13<sup>th</sup> transplanted crop followed by 22<sup>nd</sup> October and 1<sup>st</sup> November planted crop. Similar findings were also reported by Kumari *et al.* (2012). Crop geometry of 45 cm × 30 cm recorded highest test weight (5.99 g) at harvest followed by 30 cm × 30 cm and 65 cm × 30 cm crop geometry. Similar findings were also reported by Masood *et al.* (2003) and Hasanuzzaman *et al.* (2008).

**Oil content (%):** Experimental data showed that the oil content of mustard was influenced by planting geometry and it was decreased by delayed sowing. Transplanting of mustard on 13<sup>th</sup> October recorded higher oil content in seed (41.41% respectively) than 22<sup>nd</sup> October and 1<sup>st</sup> November transplanted crop but the differences were not significant (Table 2). This significant decrease in oil yield might be due to low seed yield and less oil content (%) under delayed sowing, since the oil yield is product of seed yield and the oil content (%). This behavior could be ascribed to improper seed development and oil synthesis in seeds under delayed sowings, owing to restricted growth of plants as stated earlier and the rise in temperature during the seed development phase. Decrease in oil content in rapeseed with the rise in temperature was also observed by Angrej *et al.* (2002).

**Seed yield and harvest index:** Seed yield of the mustard was significantly ( $P=0.05$ ) influenced due to different planting geometry and date of transplanting during both the years (Table 3). Economic yield of crop depends on the

Table 2 Post harvest observations as influenced by different planting geometry and date of transplanting

| Treatment                    | Length of siliqua (cm) |         |      | No. of seeds/siliqua |         |       | Test weight (g) |         |      | Oil content (%) |         |       |
|------------------------------|------------------------|---------|------|----------------------|---------|-------|-----------------|---------|------|-----------------|---------|-------|
|                              | 2016-17                | 2017-18 | Mean | 2016-17              | 2017-18 | Mean  | 2016-17         | 2017-18 | Mean | 2016-17         | 2017-18 | Mean  |
| <i>Planting geometry</i>     |                        |         |      |                      |         |       |                 |         |      |                 |         |       |
| 30 × 30 cm (T1)              | 5.73                   | 5.69    | 5.71 | 18.53                | 17.75   | 18.14 | 5.99            | 5.71    | 5.85 | 40.69           | 40.21   | 40.45 |
| 45 × 30 cm (T2)              | 5.79                   | 5.72    | 5.76 | 18.98                | 18.25   | 18.62 | 6.06            | 5.92    | 5.99 | 41.25           | 41.24   | 41.25 |
| 60 × 30 cm (T3)              | 5.67                   | 5.51    | 5.59 | 18.34                | 17.50   | 17.92 | 5.94            | 5.64    | 5.79 | 40.62           | 40.08   | 40.35 |
| SEm±                         | 0.09                   | 0.027   |      | 0.24                 | 0.75    |       | 0.35            | 0.017   |      | 0.35            | 0.085   |       |
| CD ( $P=0.05$ )              | 0.28                   | 0.11    |      | 0.73                 | NS      |       | NS              | 0.068   |      | NS              | 0.34    |       |
| <i>Date of transplanting</i> |                        |         |      |                      |         |       |                 |         |      |                 |         |       |
| 13 Oct (D1)                  | 5.94                   | 5.91    | 5.93 | 19.50                | 18.85   | 19.18 | 6.67            | 6.61    | 6.64 | 41.49           | 41.32   | 41.41 |
| 22 Oct (D2)                  | 5.92                   | 5.79    | 5.86 | 19.23                | 19.11   | 19.17 | 6.03            | 5.94    | 5.99 | 40.92           | 40.81   | 40.87 |
| 1 Nov (D3)                   | 5.42                   | 5.26    | 5.34 | 18.66                | 18.71   | 18.69 | 5.97            | 5.81    | 5.89 | 40.78           | 40.23   | 40.51 |
| SEm±                         | 0.23                   | 0.019   |      | 0.21                 | 0.65    |       | 0.47            | 0.022   |      | 0.30            | 0.24    |       |
| CD ( $P=0.05$ )              | 0.68                   | 0.078   |      | 0.64                 | NS      |       | NS              | 0.087   |      | 0.89            | NS      |       |

Table 3 Yield and economics of the treatments influenced by different planting geometry and date of transplanting

| Treatment                    | Seed yield (q/ha) |         | Harvest Index (%) |         | Economics of the treatments (pooled) |            |            |           |
|------------------------------|-------------------|---------|-------------------|---------|--------------------------------------|------------|------------|-----------|
|                              | 2016-17           | 2017-18 | 2016-17           | 2017-18 | Cost of cultivation (₹/ha)           | GMR (₹/ha) | NMR (₹/ha) | B:C ratio |
| <i>Planting geometry</i>     |                   |         |                   |         |                                      |            |            |           |
| 30 × 30 cm (T1)              | 35.54             | 33.56   | 30.2              | 29.9    | 37300                                | 124005     | 86705      | 3.32      |
| 45 × 30 cm (T2)              | 39.34             | 36.04   | 30.8              | 30.6    | 36400                                | 137235     | 100835     | 3.77      |
| 60 × 30 cm (T3)              | 31.51             | 31.59   | 29.6              | 29.1    | 35500                                | 110565     | 75065      | 3.11      |
| SEm±                         | 0.36              | 0.29    | 0.34              | 0.39    |                                      |            |            |           |
| CD (P=0.05)                  | 1.45              | 1.18    | 1.02              | 1.21    |                                      |            |            |           |
| <i>Date of transplanting</i> |                   |         |                   |         |                                      |            |            |           |
| 13 Oct (D1)                  | 40.38             | 37.22   | 30.7              | 30.4    | 35500                                | 140420     | 104920     | 3.96      |
| 22 Oct (D2)                  | 36.37             | 35.27   | 30.5              | 29.82   | 35500                                | 129010     | 93510      | 3.63      |
| 1 Nov (D3)                   | 29.41             | 29.29   | 29.29             | 29.42   | 35500                                | 102375     | 66875      | 2.88      |
| SEm±                         | 0.12              | 0.02    | 0.11              | 0.19    |                                      |            |            |           |
| CD (P=0.05)                  | 0.49              | 0.11    | 0.34              | 0.59    |                                      |            |            |           |

source-sink relationship and also on the different components of source and sink. Seed yield was recorded comparatively higher during 2016–17 compared to 2017–18, which might be due to low rainfall and high temperature at the time of transplanting during the 2017–18. However, seed yield was recorded the maximum with T<sub>2</sub>D<sub>1</sub> (45 cm × 30 cm and 13<sup>th</sup> October) treatment during both the years. Seed yield improved significantly with T<sub>2</sub> by 9.1 and 19.5% over T<sub>1</sub> and T<sub>3</sub> respectively, whereas yield improvement with D<sub>1</sub> also recorded significantly higher by 8.3 and 32.2 % over D<sub>2</sub> and D<sub>3</sub>, respectively. Early transplanting on 13<sup>th</sup> October produced highest seed yield might be due to larger growing period and cumulative effect of effective rainfall and favorable weather conditions which helped in better growth and development of the mustard plants and resulted into better seed yield. Delayed transplanting decreased the yield attributes and yield as these parameters were adversely influenced in the present experiment as the sowing was delayed beyond 13<sup>th</sup> October. Adverse effect of low temperature on flowering, siliquae setting and seed development in rapeseed and mustard have also been reported by Adak *et al.* (2011), Biswas *et al.* (2011) and Kumari *et al.* (2012). The same trend was also noticed by Panda *et al.* (2004), and Khushu and Singh (2005) who noted that late sowing caused delayed flowering time, decreased flowering duration and reduced seed yield. Crop geometry of 45 cm × 30 cm recorded highest grain yield (37.69 q/h) at harvest followed by 30 cm × 30 and 60 cm × 30 cm crop geometry. Similar findings were also reported by Singh and Prasad (2003), Sahar *et al.* (2012) and Singh *et al.* (2019).

Crop geometry of 45 cm × 30 cm recorded highest harvest index (30.70 %) followed by 30 cm × 30 and 60 cm × 30 cm crop geometry. Mustard transplanted on 13 October had more harvest-index which was at par with 22 October and significantly least with 1<sup>st</sup> November. Further observation showed that November sowing caused the significant reduction in harvest index as compared to October

sowing (Panda *et al.* 2004, Lallu *et al.* 2010).

*Economics of treatments:* The common cost of cultivation for mustard was ₹ 35500/ha. The data reveals that transplanting on 13<sup>th</sup> October (D<sub>1</sub>) have maximum gross return (GMR, ₹ 140420/ha), while the lowest return (₹ 102375/ha) under transplanting on 1<sup>st</sup> November (D<sub>3</sub>). The net monetary returns (NMR) showed the similar trend as GMR. The B:C ratio was maximum (3.96) under transplanting on 13<sup>th</sup> October (D<sub>1</sub>), least recorded on 1<sup>st</sup> November transplanting (D<sub>3</sub>) (2.88). So, the transplanting on 13<sup>th</sup> October (D<sub>1</sub>) was more profitable (3.95) than 22 October (3.63) and 01 November (2.88). The similar findings have also been reported by Ram *et al.* (2008) and Kumari *et al.* (2012).

The significant difference was found in GMR, NMR and B:C ratio among different crop geometries (Table 3). These parameters gradually declined with the increase in number of plants per unit area due to optimum spacing. The significant greater GMR, NMR and B:C ratio observed with crop geometry of 45 cm × 30 cm. In total, GMR, NMR and B:C ratio per unit area increased with the density which was mainly resulted from the increase in seed yield per unit area. Similar results were also reported by Singh and Prasad (2003).

In present study, the maximum plant height, leaf area index, chlorophyll content, length of siliquae, number of seeds/siliquae, test weight, oil content, yield and harvest index was observed in planting geometry of 45 cm × 30 cm. The date of transplanting on 13<sup>th</sup> October was also found highly superior to growth, physiological parameters, yield and yield attributes compared to 22<sup>nd</sup> October and 01<sup>st</sup> November transplanting. Net monetary return and B:C ratio was also more in 45 cm × 30 cm planting geometry with 13<sup>th</sup> October transplanting. This study highlighted the standardization of planting geometry and appropriate sowing time in mustard. Overall, it can be concluded that the mustard transplanting on 13<sup>th</sup> October with planting

geometry of  $45 \times 30$  cm could be helpful in maximizing the productivity and profitability the mustard under delayed sowing conditions in Rajasthan.

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