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# Effect of planting geometry on yield attributes and yield of Indian mustard, *Brassica juncea* L.

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## Abstract
The experiment was conducted in *rabi* 2017-18 at Research Farm, College of Agriculture, Tikamgarh, J.N.K.V.V. (M.P.). The experiment was laid out in split plot design allocating three varieties to main plots and five planting geometries to sub-plots and replicated thrice. Pusa bold, RH-749 and RGN-73 with five planting geometries *viz.,* 30 x 10, 30 x 15, 45 x 10, 45 x 15 and 60 x 10 cm were taken. Among varieties, RGN-73 produced significantly higher number of siliquae (plant$^{-1}$) followed by RH-749 and Pusa bold. RGN-73 resulted into significantly higher seed, stover, biological yield and Harvest index. Among different planting geometries, 45 cm x 15 cm produced significantly a greater number of siliquae (plant$^{-1}$), number of seeds, higher 1000-seed weight and higher harvest index (g). However, planting geometry 30 cm x 10 cm produced significantly higher seed yield and biological yield. RGN-73 under plant geometry 45 x 15 cm led to significantly higher yield of mustard and can be recommended.

**Keywords:** Mustard, planting geometry, varieties, yield

## Introduction
Indian mustard (*Brassica juncea* L.) belonging to family Cruciferae is one of the most important winter oilseed crops. It is fairly a high remunerative crop with a major source of high-quality edible oil. Rapeseed and mustard are the major oilseed crops, traditionally grown everywhere in the country due to their high adaptability in conventional farming systems. Indian mustard accounts for about 75–80% of the total area under this crop in the country. Among many factors responsible for achieving higher yield, cultivars with higher yield potential and a wide range of adaptability to edaphic and climatic conditions is essential for increasing yield per unit area, ultimately boosting up total production. So, variety selection is the most important decision for producer to achieve high crop yield by improving the fertilizer use efficiency and water use efficiency. Producers must select high-yielding varieties with agronomic traits that match the ever-changing stresses in each field. Thus, improved cultivar is an important tool, which has geared production of mustard in many countries of the world**.** Planting geometry plays a vital role in the production of rapeseed and mustard under irrigated condition. Spacing is a non-monetary input, but it plays a vital role by changing the magnitude of competition. The competitive ability of a mustard plant depends greatly upon the density of plants per unit area and soil fertility status (Shekhawat *et al*., 2012) [4]. Uniform distribution of crop plants over an area results in efficient use of nutrients, moisture, and suppression of weeds leading to high yield. Establishment of optimum plant population by maintaining proper row spacing is one of the important factors to secure a better translocation of photosynthates, which render better yield of crop (Alam, 2004) [2]. Hence, keeping this in view, the present investigation was planned with effect of planting geometry on yield attributes and yield of Indian mustard varieties.

## Materials and methods
The experiment was conducted in *rabi* 2017-18 at Research Farm, College of Agriculture, Tikamgarh, J.N.K.V.V. (M.P.). Tikamgarh district lies in the Bundelkhand Zone (Agro-climatic Zone-VIII). It is situated in the north-eastern part of Madhya Pradesh at 24° 43' North latitude and 78° 49' East longitude at an altitude of 358 metre mean sea level. The experiment was laid out in split plot design allocating three varieties (Pusa Bold, RH-749 and RGN-73) to main plots and five planting geometries (30 cm x 10 cm, 30 cm × 15 cm, 45 cm x 10 cm, 45

cm´ 15 cm and 60 cm × 10 cm) to sub-plots and replicated thrice, comprising 15th treatments combinations. The gross plot size (5.4 m x 3.0 m) and net plot size ($P_1$ & $P_2$= 4.2 m x 2.0 m, $P_3$ & $P_4$ = 3.6 m x 2.0 m and $P_5$= 3.0 m x 2.0 m) was maintained. The mustard crop was sown in October in lines having crop geometry as per treatments using a seed rate of 4 kg $ha^{-1}$. The crop was harvested manually. Before harvesting, five tagged plants were pulled out from every plot to record post-harvest observations on yield attributes. The crop in net plots was harvested separately and left in the respective plots for sun dry. The crop was threshed by manual laborers and was weighed to get seed yield, stover yield and biological yield kg $plot^{-1}$. Thereafter, these yields were converted into kg $ha^{-1}$. The yield attributes listed below were studied from the plant sample collected for dry biomass observation at the time of harvest.

**Number of siliquae ($plant^{-1}$):** Total number of siliquae were counted on five randomly selected plants and then converted into number of siliquae $plant^{-1}$.

**Number of seeds ($siliqua^{-1}$):** Fifty siliquae were drawn randomly from five selected plants and were threshed and cleaned. The number of seeds was counted by numeral seed counter and then the average number of seeds $siliqua^{-1}$ was calculated.

**1000-seed weight (g):** 1000 seed (randomly drawn seed sample out of net plot produce) were counted on numeral seed counter and then weighed by electronic balance to record 1000-seed weight (test weight) in grams.

**Seed yield (kg $ha^{-1}$):** The crop harvested from net plot area as per treatments was threshed after 4-5 days of sun drying. Seed yield was then converted into kg $ha^{-1}$.

**Biological yield (kg $ha^{-1}$):** Before threshing of the crop harvested from net plot, the sun-dried whole plant samples (biological yield) were weighed and then converted into kg $ha^{-1}$.

**Stover yield (kg $ha^{-1}$):** Stover yield is obtained by subtracting seed yield (kg $ha^{-1}$) from biological yield (kg $ha^{-1}$).

**Harvest index (%):** The harvest index (HI) was calculated as per formula given below:

$$\text{H.I. (\%)} = \frac{\text{Seed yield (kg ha}^{-1})}{\text{Biological yield (kg ha}^{-1})} \times 100$$

**Statistical analysis:** The statistical methods given by Panse and Sukhatme (1961) [11] were used for analysis and interpretation of experimental results. In order to evaluate comparative performance of various treatments, the data was analyzed by the technique of analysis of variance given by Fischer (1950) [4].

## Results and Discussion

### Number of siliquae ($plant^{-1}$)

The data pertaining to number of siliquae ($plant^{-1}$) is presented in Table 1. The results clearly indicated that the number of siliquae ($plant^{-1}$) was significantly affected by varieties. RGN-73 produced significantly higher number of siliquae (221.4 $plant^{-1}$) followed by RH-749 (202.9 $plant^{-1}$) and the lowest under Pusa Bold (202.3 $plant^{-1}$). Among different planting geometries, 45 cm x 15 cm produced significantly a greater number of siliquae (236.7 $plant^{-1}$) followed by 60 cm x 10 cm (221.3 $plant^{-1}$), 45 cm x 10 cm (209.3 $plant^{-1}$), 30 cm x 15 cm (192.9 $plant^{-1}$) and 30 cm x 10 cm (184.1 $plant^{-1}$). The interaction between varieties and planting geometries for number of siliquae ($plant^{-1}$) was found non-significant.

### Number of seeds ($siliqua^{-1}$)

The data pertaining to number of seeds ($siliqua^{-1}$) as influenced by varieties and planting geometries are summarized in Table 2. Varieties were failed to influence the number of seeds ($siliqua^{-1}$) significantly. However, numerical value was recorded higher under RGN-73 (14.40 $siliqua^{-1}$) followed by RH-749 (14.34 $siliqua^{-1}$) and Pusa Bold (14.05 $siliqua^{-1}$). Among different planting geometries, 45 cm x 15 cm produced significantly a greater number of seeds (15.57 $siliqua^{-1}$) followed by 60 cm x 10 cm (14.72 $siliqua^{-1}$), 45 cm x 10 cm (14.06 $siliqua^{-1}$), 30 cm x 15 cm (13.83 $siliqua^{-1}$) and 30 cm x 10 cm (13.14 $siliqua^{-1}$). However, number of seeds ($siliqua^{-1}$) between planting geometries of 30 cm x 15 cm and 45 cm x 10 cm were found non-significant. The interactional effects of between varieties and planting geometries were also significant for number of seeds ($siliqua^{-1}$). Seeds (15.69 $siliqua^{-1}$) was registered significantly higher under Pusa Bold with planting geometry of 45 cm x 15 cm. The lowest (12.95 $siliqua^{-1)}$ was recorded under Pusa Bold with planting geometry of 30 cm x 10 cm.

### 1000-seeds weight (g)

The data pertaining to 1000-seed weight (g) by different varieties and planting geometries are presented in Table 3. Among different varieties, it is clear from the data that varieties did not differ significantly. However, numerical value of higher 1000-seed weight was recorded in RGN-73 (6.04 g) followed by RH-749 (6.36 g) and Pusa Bold (5.95 g). The planting geometry of 45 cm x 15 cm produced significantly higher 1000-seed weight (6.68 g) as compared to other planting geometries and found at par with planting geometries of 60 cm x 10 cm (6.62 g) and 45 cm x10 cm (6.43 g). The significantly lowest 1000-seed weight (5.36 g) was recorded under crop geometry of 30 cm x10 cm. The interaction between varieties and planting geometries for 1000-seed weight (g) was found significant. 1000-seed weight of 6.89 g was registered significantly higher under RGN-73 with planting geometry of 45 cm x 10 cm. The lowest 1000-seed weight (4.71 g) was recorded under RGN-73 with planting geometry of 30 cm x 15 cm.

### Seed yield (kg $ha^{-1}$)

The data pertaining to seed yield (kg $ha^{-1}$) by varieties and planting geometries is summarized in Table 4. The resultant data revealed that seed yield (kg $ha^{-1}$) was found to be significantly affected by different varieties. Among the different varieties, RGN-73 resulted into significantly higher seed yield (2570 kg $ha^{-1}$) followed by RH-749 (2309 kg $ha^{-1}$) and Pusa Bold (2299 kg $ha^{-1}$). However, seed yield between varieties Pusa Bold and RH-749 did not differ significantly. Among different planting geometries, 30 cm x 10 cm produced significantly higher seed yield (2648 kg $ha^{-1}$) followed by 30 cm x 15 cm (2536 kg $ha^{-1}$), 45 cm x 10 cm (2435 kg $ha^{-1}$), 45cm x 15 cm (2182 kg $ha^{-1}$) and the lowest seed yield with planting geometry of 60 cm x 10 cm (2162 kg $ha^{-1}$). However, seed yield (kg $ha^{-1}$) between planting geometries of 45 cm x 15 cm and 60 cm x 10 cm were found non-significant. Interactional between varieties and planting geometries for seed yield (kg ha$^{-1}$) was found non-significant.

**Biological yield (kg ha$^{-1}$)**

Biological yield (kg ha$^{-1}$) by different varieties and planting geometries are presented in Table 4. Bological yield (kg ha$^{-1}$) was found significantly affected by different varieties. Among the different varieties, significantly higher biological yield (10364 kg ha$^{-1)}$ was recorded in RGN-73 followed by RH-749 (9973 kg ha$^{-1}$) and the lowest under Pusa Bold (9928 kg ha$^{-1}$). However, biological yield (kg ha$^{-1}$) was found non-significant between RH-749 and Pusa Bold. Among different planting geometry, 30 cm x 10 cm produced significantly higher biological yield (10992 kg ha$^{-1}$) followed by 30 cm x 15 cm (10607 kg ha$^{-1}$), 45 cm x 10 cm (9820 kg ha$^{-1}$), 45 cm x 15 cm (9624 kg ha$^{-1}$) and the lowest biological yield with 60 cm x 10 cm (9401 kg ha$^{-1}$). The interaction between varieties and planting geometries for biological yield (kg ha$^{-1}$) was found significant. Biological yield (11376 kg ha$^{-1}$) was registered significantly higher under RGN-73 with planting geometry of 30 cm x 10 cm. The lowest biological yield (9122 kg ha$^{-1}$) was recorded under Pusa Bold with planting geometry of 60 cm x 10 cm.

**Stover yield (kg ha$^{-1}$)**

The stover yield (kg ha$^{-1}$) by different varieties and planting geometry are presented in Table 5. The stover yield (kg ha$^{-1}$) was found to be significantly affected by different varieties. Among the different varieties, RGN-73 resulted into significantly higher stover yield (7794 kg ha$^{-1}$) followed by RH-749 (7664 kg ha$^{-1}$) and Pusa Bold (7629 kg ha$^{-1}$). However, stover yield (kg ha$^{-1}$) between varieties Pusa Bold and RH-749, and between RH-749 and RGN-73 was found non-significant. Among different planting geometries, 30 cm x 10 cm produced significantly higher stover yield (8345 kg ha$^{-1}$) followed by 30 cm x 15 cm (8071 kg ha$^{-1}$), 45 cm x 15 cm (7443 kg ha$^{-1}$) 45 cm x 10 cm (7385 kg ha$^{-1}$) and the lowest stover yield with planting geometry of 60 cm x 10 cm (7238 kg ha$^{-1}$). However, stover yield (kg ha$^{-1}$) between planting geometries of 45 cm x 15 cm and 45 cm x 10 cm were found non-significant. Interaction between varieties and planting geometries for stover yield (kg ha$^{-1}$) was found significant. Stover yield (8670 kg ha$^{-1}$) was registered significantly higher under Pusa Bold with planting geometry of 30 cm x 10 cm. The lowest stover yield (6980 kg ha$^{-1}$) was recorded under Pusa Bold with planting geometry of 60 cm x 10 cm.

**Harvest index (%)**

The harvest index (%) by different varieties and planting geometries are given in Table 5. Harvest index was found significantly affected by different varieties. Among different varieties, RGN-73 exhibited significantly higher harvest index (25.72%) followed by RH-749 (23.20%) and Pusa Bold (23.15%). However, harvest index between RH-749 and Pusa Bold did not differ significantly. Among different planting geometries, 45 cm x 10 cm recorded significantly higher harvest index (24.80%) followed by 30 cm x 10 cm (24.18%), 30 cm x 15 cm (23.98%), 60 cm x 10 cm (23.06%) and the lowest harvest index (22.68%) was recorded with planting geometry of 45 cm x 15 cm. However, harvest index among 30 cm x 10 cm (24.18%) and 30 cm x 15 cm (23.98%), 60 cm x 10 cm (23.06%) and 45 cm x 15 cm were (22.68%) found non-significant. The interaction between varieties and planting geometries for harvest index (%) was found significant. Harvest index (27.86%) was registered significantly higher under RGN-73 with planting geometry of 30 cm x 10 cm. The lowest harvest index (21.30%) was recorded under RH-749 with planting geometry of 45 cm x 15 cm.

In the present investigation, the number of siliquae plant$^{-1}$, number of seeds siliqua$^{-1}$, 1000-seed weight, seed yield (kg ha$^{-1}$), biological yield (kg ha$^{-1}$) and harvest index (%) were significantly affected by different mustard varieties and planting geometry. The better yield attributing characters of the varieties could be attributed to their genetic constitution. The higher number of siliquae (plant$^{-1}$), number of seeds (siliqua$^{-1}$) and seed yield in variety RGN-73 might be due to strong sink components. Similarly, the present study, the differences in yield attributes of different *Brassica* species had been well documented by Singh *et al.* (2002) [15], Kumar *et al*. (2008) [8] and Patel (2013). The significant behavior of varieties in relation to seed yield (kg ha$^{-1}$) could also be attributed to the differential trend in respect of biomass partitioning towards reproductive parts. Another probable reason for the significant difference in seed yield (kg ha$^{-1}$) among the varieties could be due to fact that the varieties have different compensation mechanisms which affect the seed yield. The varietal differences in seed yield had also been reported by Adak *et al*. (2011), Kumari *et al*. (2012) [9], Patel (2013) and Patel *et al*. (2015). Similarly, the varietal differences in biological yield and harvest index had also been reported by Kumari *et al*. (2012) [9] and Patel (2013) [13].

Furthermore, the significant difference was found in number of siliquae (plant$^{-1}$) and 1000-seed weight, seed yield (kg ha$^{-1}$), biological yield (kg ha$^{-1}$) and stover yield (kg ha$^{-1}$) among different planting geometries. Because of less plant's population per unit area in case of planting geometry 45 cm x 15 cm, the plants could get adequate nutrients, moisture and space to produce a greater number of branches and number of siliquae with highest dry biomass production. Whereas, due to more plant population in case of planting geometry 30 cm x 10 cm, the shortage of space and higher competition for space, nutrients and moisture reduced the number of branches and siliquae number with dry biomass production (Hasanuzzaman, 2008) [5]. The present results can be confirmed with the similar findings by Misra and Rana (1992) [10], Chauhan *et al*. (1993) [3] and Hasanuzzaman and Karim (2007) [6]. The decreased in seed yield with planting geometry of 45 cm x 15 cm was mainly due to less plant population per unit area. On the other hand, planting geometries of 30 cm x 10 cm and 30 cm x 15 cm had higher plant population per unit area resulted into higher seed yield (kg ha$^{-1}$). These results were supported by Alam (2004) [2], Hasanuzzaman (2008) [5] and Kardgara *et al.* (2010) [7]. Similar trend was also observed for biological yield (kg ha$^{-1}$) and stover yield (kg ha$^{-1}$). Similarly, harvest index was also found significantly higher with planting geometry of 45 cm x 10 cm probably due to higher seed yield (kg ha$^{-1}$) as compared to other planting geometries. These results were supported by Kardgara *et al.* (2010) [7].

**Table 1:** Effect of different treatments on number of siliquae (plant$^{-1}$) of Indian mustard varieties

| Treatments | Number of siliquae plant$^{-1}$ | | | | | Mean |
|---|---|---|---|---|---|---|
| | 30x10 (cm) | 30x15 (cm) | 45x10 (cm) | 45x15 (cm) | 60x10 (cm) | |
| Pusa Bold | 178.1 | 179.9 | 204.1 | 228.9 | 220.5 | 202.3 |
| RH-749 | 179.8 | 190.5 | 198.9 | 229.7 | 215.5 | 202.9 |
| RGN-73 | 194.6 | 208.3 | 225.0 | 251.4 | 228.0 | 221.4 |
| Mean | 184.1 | 192.9 | 209.3 | 236.7 | 221.3 | |
| | S.Em± | | | C.D. (P = 0.05) | | |
| Variety | 2.34 | | | 7.02 | | |
| Planting geometry | 2.06 | | | 6.05 | | |
| Varietyx Geometry | 3.63 | | | NS | | |

**Table 2:** Effect of different treatments on number of seeds (siliqua$^{-1}$) of Indian mustard varieties

| Treatments | Number of seed siliqua$^{-1}$ | | | | | Mean |
|---|---|---|---|---|---|---|
| | 30x10 (cm) | 30x15 (cm) | 45x10 (cm) | 45x15 (cm) | 60x10 (cm) | |
| Pusa Bold | 12.95 | 13.88 | 13.17 | 15.69 | 14.56 | 14.05 |
| RH-749 | 13.46 | 13.75 | 14.26 | 15.46 | 14.76 | 14.34 |
| RGN-73 | 13.00 | 13.86 | 14.76 | 15.56 | 14.84 | 14.40 |
| Mean | 13.14 | 13.83 | 14.06 | 15.57 | 14.72 | |
| | S.Em± | | | C.D. (P = 0.05) | | |
| Variety | 0.16 | | | NS | | |
| Planting geometry | 0.12 | | | 0.37 | | |
| Varietyx Geometry | 0.25 | | | 0.87 | | |

**Table 3:** Effect of different treatments on 1000-seed weight (g) of Indian mustard varieties

| Treatments | 1000-seed weight (g) | | | | | Mean |
|---|---|---|---|---|---|---|
| | 30x10 (cm) | 30x15 (cm) | 45x10 (cm) | 45x15 (cm) | 60x10 (cm) | |
| Pusa Bold | 5.167 | 5.643 | 5.883 | 6.773 | 6.297 | 5.953 |
| RH-749 | 5.770 | 6.113 | 6.513 | 6.713 | 6.697 | 6.361 |
| RGN-73 | 5.147 | 4.717 | 6.897 | 6.573 | 6.870 | 6.041 |
| Mean | 5.361 | 5.491 | 6.431 | 6.687 | 6.621 | |
| | S.Em± | | | C.D. (P = 0.05) | | |
| Variety | 0.09 | | | NS | | |
| Planting geometry | 0.13 | | | 0.40 | | |
| Varietyx Geometry | 0.23 | | | 0.72 | | |

**Table 4:** Effect of different treatments on seed and biological yield of Indian mustard varieties

| Treatments | Seed yield (kg ha$^{-1}$) | | | | | | Biological yield (kg ha$^{-1}$) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 30x10 (cm) | 30x15 (cm) | 45x10 (cm) | 45x15 (cm) | 60x10 (cm) | Mean | 30x10 (cm) | 30x15 (cm) | 45x10 (cm) | 45x15 (cm) | 60x10 (cm) | Mean |
| Pusa Bold | 2,555 | 2,414 | 2,238 | 2,144 | 2,142 | 2,299 | 11,225 | 10,873 | 9,282 | 9,138 | 9,122 | 9,928 |
| RH-749 | 2,494 | 2,444 | 2,372 | 2,117 | 2,117 | 2,309 | 10,376 | 10,096 | 9,949 | 9,797 | 9,650 | 9,973 |
| RGN-73 | 2,894 | 2,750 | 2,694 | 2,283 | 2,227 | 2,570 | 11,376 | 10,852 | 10,229 | 9,937 | 9,429 | 10,364 |
| Mean | 2,648 | 2,536 | 2,435 | 2,182 | 2,162 | | 10,992 | 10,607 | 9,820 | 9,624 | 9,401 | |
| | | S.Em± | C.D. (P = 0.05) | | | | | S.Em± | C.D. (P = 0.05) | | | |
| Variety | | 31.33 | 94.05 | | | | | 57.70 | 173.6 | | | |
| Planting geometry | | 32.53 | 95.51 | | | | | 47.65 | 139.9 | | | |
| Variety x Geometry | | 55.53 | NS | | | | | 85.47 | 274.7 | | | |

**Table 5:** Effect of different treatments on stover yield and harvest Index of Indian mustard varieties

| Treatments | Stover yield (kg ha$^{-1}$) | | | | | | Harvest index (%) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 30x10 (cm) | 30x15 (cm) | 45x10 (cm) | 45x15 (cm) | 60x10 (cm) | Mean | 30x10 (cm) | 30x15 (cm) | 45x10 (cm) | 45x15 (cm) | 60x10 (cm) | Mean |
| Pusa Bold | 8,670 | 8,459 | 7,044 | 6,994 | 6,980 | 7,629 | 22.76 | 22.20 | 24.10 | 23.43 | 23.50 | 23.20 |
| RH-749 | 7,882 | 7,652 | 7,577 | 7,680 | 7,533 | 7,664 | 21.93 | 22.50 | 23.23 | 21.30 | 22.46 | 22.28 |
| RGN-73 | 8,482 | 8,102 | 7,535 | 7,654 | 7,202 | 7,794 | 27.86 | 27.26 | 27.06 | 23.33 | 23.06 | 25.72 |
| Mean | 8,345 | 8,071 | 7,385 | 7,443 | 7,238 | | 24.18 | 23.98 | 24.80 | 22.68 | 23.06 | |
| | | S.Em± | C.D. (P = 0.05) | | | | | S.Em± | C.D. (P = 0.05) | | | |
| Variety | | 49.12 | 147.7 | | | | | 0.275 | 0.836 | | | |
| Planting geometry | | 48.91 | 143.6 | | | | | 0.306 | 0.897 | | | |
| Variety x Geometry | | 84.16 | 264.6 | | | | | 0.517 | 1.609 | | | |

## Conclusion

From the results planting geometries, 45 cm x 15 cm can be recommended for significantly a greater number of siliquae (plant$^{-1}$), number of seeds, higher 1000-seed weight and higher harvest index (g) in point of view of production per unit area (kg ha$^{-1}$).

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**References**

1. Adak T, Bhaskar N, Chakravarty NVK. Response of *Brassica* to micro environment modification under semi-arid agro ecosystem. Indian Journal of Agricultural Sciences 2011; 81(8):744-750.
2. Alam MM. Effect of variety and row spacing on the yield and yield contributing characters of rapeseed and mustard, M.Sc. Thesis, Bangladesh Agriculture University, Bangladesh 2004.
3. Chauhan AK, M Singh, KS Dadhwal. Effect of nitrogen level and row spacing on the performance of rape. Indian Journal of Agronomy 1993;37(4):851-853.
4. Fischer RA. Statistical methods for agricultural research workers. 11th edition Oliver and Boyad, London, 1950.
5. Hasanuzzaman M, Siliqua and seed development in rapeseed (*Brassica campestris* L.) as affected by different irrigation levels and row spacing, *Agriculturae Conspectus Scientificus (Poljoprivredna Znanstvena Smotra)* 2008;73(4):221-226.
6. Hasanuzzaman M, Karim MF. Performance of rapeseed (*Brassica campestris* L.) cv. SAU sarisha-1 under different row spacings and irrigation levels. Research Journal Agriculture and Biology Science 2007;3(6): 960-965.
7. Kardgara V, Delkhoshb B, Noormohammadic G, Shiraniradd AH. Effects of nitrogen and plant density on yield of field mustard (*Brassica campestris*). Plant Ecophysiology 2010;2:157-164.
8. Kumar R, Singh RP, Yeshpal. Yield and quality of *Brassica* species as influenced by different dates of sowing and varieties. Pantnagar Journal of Research 2008;6(1):6-11.
9. Kumari A, Singh RP, Yeshpal. Productivity, nutrient uptake and economics of mustard hybrid (*Brassica juncea*) under different planting time and row spacing. Indian Journal of Agronomy 2012;57(1):61-67.
10. Misra BK, Rana NS. Response of yellow sarson (*Brassica napus* var. *glauca*) to row spacing and nitrogen fertilization under late sown condition. Indian Journal of Agronomy 1992;37(4):847-848.
11. Panse VG, Sukhatme PV. Statistical methods for Agriculture Workers. IInd Edn. ICAR, New Delhi, 1961.
12. Patel N, Tyagi PK, Shukla KC. Effect of sowing dates and varieties on total dry matter and its partitioning in different plant parts and yield of Indian mustard. Annals of Plant and Soil Research 2015;17(4):413-417.
13. Patel N. Effect of sowing dates and varieties on growth, development and yield of Indian mustard under irrigated conditions. M.Sc. (Ag.) Thesis, JNKVV, Jabalpur 2013, 128.
14. Shekhawat K, Rathore SS, Premi OP, Kandpal BK, Chauhan JS. Advances in Agronomic Management of Indian Mustard (*Brassica juncea* (L.) Czernj. Cosson): An Overview, Hindawi Publishing Corporation. International Journal of Agronomy 2012, 14.
15. Singh A, Dhingra KK, Singh J, Singh MP. Effect of sowing time and plant density on growth, yield and quality of Ethopian mustard (*Brassica carihata* L. Br.). Journal of Research 2002;39(4):471-475.