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Assessment of System of Mustard Intensification (SMI) with Plant Geometry and Age of the Seedlings in Enhancing Growth and Yield Attributes of Mustard (*Brassica juncea* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The field experiment entitled "Assessment of system of mustard intensification (SMI) with plant geometry and age of the seedlings in enhancing growth and yield attributes of mustard (*Brassica juncea* L.)" was conducted at College Farm, Agricultural College, Polasa, Jagtial in *Rabi*, 2022. The experiment was laid out in randomized block design with eleven treatment combinations by replicating thrice. The treatment includes T_1: Conventional sowing (dibbling) with spacing 45 x 15 cm without gap filling,T_2: Conventional sowing (dibbling) with spacing 45 x 15 cm with gap filling, T_3:

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15 days old seedlings with spacing 30×30 cm, T_4: 15 days old seedlings with spacing 45×45 cm, T_5: 15 days old seedlings with spacing 60×60 cm, T_6: 20 days old seedlings with spacing 30×30 cm, T_7: 20 days old seedlings with spacing 45×45 cm, T_8: 20 days old seedlings with spacing 60×60 cm, T_9 : 25 days old seedlings with spacing 30×30 cm, T_{10} : 25 days old seedlings with spacing 45×45 cm, T_{11}: 25 days old seedlings with spacing 60×60 cm. Thus from results obtained from present investigation it can be concluded that transplanting 25 days old seedling with 30 x 30 cm spacing under System of Mustard Intensification (SMI) resulted in higher plant height (182.5) and dry matter production (4660 kg ha^{-1}) while Transplanting 25 days old seedling with 60×60 cm resulted in higher no. of primary and secondary branches $plant^{-1}$(9.0 and 24.6), no. of siliqua $plant^{-1}$ (656.3) and no. of seeds $siliquae^{-1}$(14.7).

Keywords: Mustard; plant geometry; age of the seedlings; transplanting; system of mustard intensification.

1. INTRODUCTION

Oilseed production has increased at a pace of 4.1% per year over the past three decades, exceeding that of the total agriculture and animal industries, making it one of the most active sectors of global agriculture. India has the fourth-largest edible oilseed economy in the world, behind the USA, China and Brazil. Oilseeds are India's second-largest agricultural product after cereals, making up 13% of the country's gross cultivated area, 5% of the GNP and 10% of the value of all agricultural products sold here [1].

Oilseed Brassica share 27.8% of India's oilseed economy and account for 35% of all oilseed output, with an average productivity of 1497 kg ha^{-1} [2]. It is grown on 7.99 million hectares of land in India, where it produces an average of 11.9 million tonnes with a productivity of 1497 kg ha^{-1} [2]. Rajasthan is the leading producer of mustard followed by Uttar Pradesh. In Telangana, mustard is grown over an area of 2000 hectares with a production of 1.84 million tonnes and productivity of 922 kg ha^{-1} [2]. Mustard mostly farmed as a *rabi* crop in the Northern Telangana Zone districts of Jagtial, Nizamabad, Nirmal and Kamareddy (Department of Agriculture, 2021).

Oilseeds crops have an added advantage due to their nutritional quality along with varying industrial, pharmaceutical and medicinal uses. Mustard (*Brassica juncea* L.) belongs to the family of Cruciferae. The seed contains 40 - 45% oil and 20 - 25% protein. The seed and oil of mustard are used as a condiment in the preparation of pickles, flavoring curries and vegetables as well as for cooking and frying purposes. Mustard oil is used in many industrial products, oil cake is used as cattle feed and also as manure while the green leaves are used as vegetable and green fodder [3].

Planting geometry i.e., row to row and plant to plant distance 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 [4]. Uniform distribution of crop plants over an area result in efficient use of space, nutrients, moisture and suppression of weeds leading to high yield.

Transplanting the crop rather than normal drilling may be a costlier method of crop establishment, however, the labour requirement for sowing and then thinning the crop twice, to remove extra plants, may be costlier. Transplanted crop has the exact plant population with mathematical precision and there is also some time benefit after harvest of the kharif crops. Through transplanting, the full potentiality of individual plants can be realized and yield more than drilling of seeds. 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 option to minimize the yield losses in mustard.

Although there are many benefits of transplanting in mustard production systems, the optimal age of mustard seedling for transplanting remains unknown. Furthermore, inappropriate seedling age is always misleading in terms of whether older or younger seedlings are employed for transplanting in practice. Thus, it necessitates seeking an optimal seedling age and evaluating its effect on seed yield.

in view of above considerations, the present investigation entitled "Effect of plant geometry and age of the seedlings on growth and yield of mustard (*Brassica juncea L.*) under system of mustard intensification (SMI)" was proposed.

2. MATERIALS AND METHODS

The experiment was carried out at the College Farm, Agricultural College, Polasa, Jagtial, Professor Jayashankar Telangana State Agricultural University. The experimental site was located between 18^{o} 50' 58" N latitude and 78^{o} 56' 97" E longitude at an altitude of 243.4 meters above mean sea level (MSL) (Plate 1). It is assigned to the Northern Telangana Zone of Telangana. The soil was sandy clay loam, low in nitrogen (179.2), phosphorous (13.8) and high in potassium (310) with pH (7.53).

The weekly mean maximum temperature during the crop growth period ranged from 30.4°C to 34.2°C with an average of 31.34°C. The weekly mean minimum temperature during the crop period ranged from 13.4°C to 19.6°C with an average of 15.92°C (Plate 2).

The seedlings were raised on a nursery bed of size 3m **×**1m **×** 15 cm. The soil was made friable and mixed well with 15 kg vermicompost, 5 kg farmyard manure, 2 kg red soil and 2 kg sand. The seeds were treated with captan @ 4g/kg of seed. After sowing was done nursery bed is covered with straw for mulching purpose. Frequent irrigation was given after the emergence of the seedlings based on the visual symptoms. On 12th November 2022, the 15, 20 and 25 days aged seedlings were transplanted as one seedling per one hill at a spacing of 30 × 30 cm, 45 × 45 cm and 60 × 60 cm in the respective plots (as per the treatment details).

Plate 1. Satellite view of experimental site

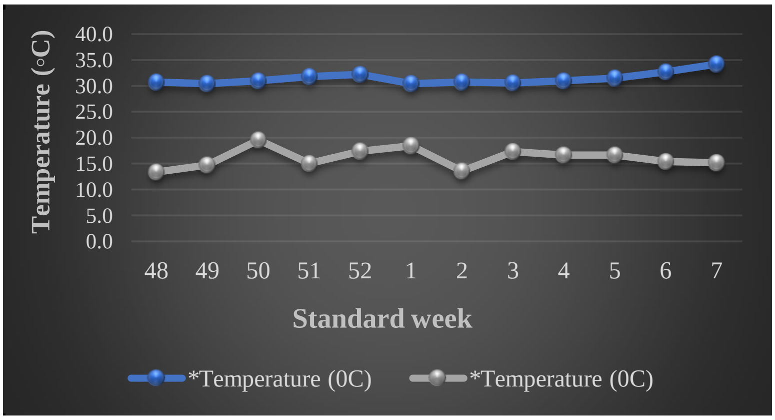

Plate 2. Weekly weather data on maximum and minimum temperature (℃) during crop growth period of Mustard

The seeds were manually planted using the dibbling method @ 3- 4 seeds hill^{-1} at a spacing of 45 cm between the rows and 15 cm between the plants for the optimal plant stand development. To retain optimum plant stand gap filling was taken up in the field at 10 DAS. Thinning of excess seedlings to maintain 1-2 seedlings per hill was done at 25 days after sowing regarding conventional sown treatments. A recommended dose of fertilizer for mustard was Nitrogen @ 60 kg ha^{-1}, Phosphorous @ 40 kg ha^{-1} and Potassium @ 40 kg ha^{-1}. The N, P and K fertilizers were applied as urea (46% N), single super phosphate (16% P_2O_5) and muriate of potash (60% K_2O), respectively. The field was irrigated five times during the entire crop period. To prevent the early weed rivalry, pre-emergence application of pendimethalin @ 2.5 L ha^{-1} was applied in the field one day after sowing and manual weeding was done in case of transplanting at 20 days after transplanting and 45 days after transplanting. Crop growth parameters recorded were Plant height (cm), no. of primary and secondary branches plant^{-1} and dry matter accumulation. Yield attributes recorded were

No. of siliqua plant^{-1}: Total number of siliquae present on the branches was counted from the five tagged plants and the mean was calculated.

No. of seeds siliquae^{-1}: The mean number of seeds siliqua^{-1} was worked out from randomly drawn fifty siliquae out of total siliquae of five tagged plants.

3. RESULTS AND DISCUSSION

3.1 Crop Growth Parametets

Plant height (cm): Plant height is an imperative morphological growth parameter. It exhibits the vigour of the plant. It has a significant role in capture of light and sun-oriented radiation. Plant height increased with advance in duration of mustard crop. Critical observation of data revealed that the plant height of mustard crop varied significantly at branching initiation stage, flowering stage, siliqua development stage and at maturity stage. Among the treatments, the 25 days old seedlings with spacing 30×30 cm (T_9) resulted in significantly highest plant height (44.7 cm, 146.7 cm, 177.6 cm and 193.2 cm) at branching initiation, flowering, siliqua development and at maturity stage respectively which was on par with T_6 and T_3 treatments. Lowest plant height recorded in T_1 i.e. conventional sowing (dibbling) with spacing 45 x 15 cm without gap filling (29.0, 98.6, 112.8 and 145.7) at branching initiation stage, flowering stage, siliqua development stage and at maturity stage respectively.

The enhanced plant height in mustard under 30 cm × 30 cm spacing over other plant geometry might be due to competition for light at closer spacing as compared to wider spacing under transplanting. Similar results were also reported by Kumar et al. [5], Singh et al. [6] and Singh et al. [7]. The significantly higher plant height under transplanting of 25 days old seedlings may be owing to the fact that optimum age of seedlings performed active growth which might have contributed to more vigorous growth and development. Transferring plants that are too young will slow down their growth, because the seedlings have not been able to cope with unfavourable environmental conditions in the field. Similar results were also reported by Aragie et al. [8].

Dry matter accumulation (kg/ha): Drymatter accumulation by plant was recorded from five plants samples from second row of each plot. The sampling was done by uprooting the plants carefully at branching initiation, flowering, siliqua development and at maturity stage.The plant sampleswere shade dried for one day before being placed in a hot air oven at 65^{o}C to achieve a constant weight. Dry matter was averaged to calculate the dry weight plant^{-1}. The mean dry weight of plant samples was expressed as g m^{-2} or kg/ha.

Dry matter is the accretion of photosynthates after respiration and anabolic process. The results illustrated that there is a steady increase in the dry matter accumulation in every stage of crop growth until harvest. Among different treatments T_9 - 25 days old seedlings with spacing 30×30 cm recorded significantly highest dry matter accumulation (605 kg ha^{-1}, 1421 kg ha^{-1}, 3002 kg ha^{-1}, 4660 kg ha^{-1}) at branching initiation stage, flowering stage, siliqua development stage and at maturity stage respectively which is on par with T_6. The minimum dry matter accumulation was recorded in treatment T_1 - Conventional sowing (dibbling) with spacing 45 x 15 cm without gap filling at all the growth stages i.e., at branching initiation (335 kg ha^{-1}), flowering stage (832 kg ha^{-1}), siliqua development stage (1822 kg ha^{-1}) and at maturity stage (2916 kg ha^{-1}). Similar results were recorded by Mamun et al. [9] and Das et al. [10].

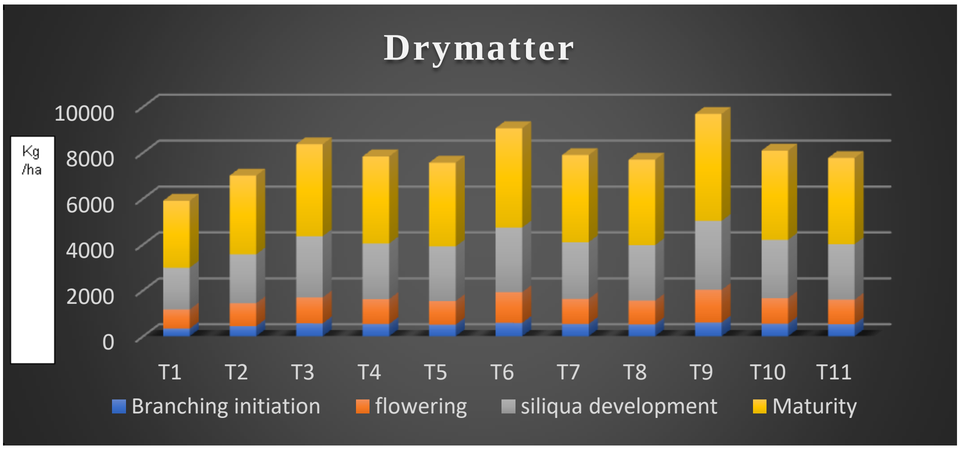

Plate 3. Graphical distribution of dry matter accumulation in various treatments

With wider spacing and transplanting resulted in better root proliferation and root activities *i.e.,* more uptake of water and nutrients accumulating more dry matter over the conventional planting which restricted the root growth resulting in less accumulation of dry matter in the latter. Similar findings were observed in Chaudhary et al. [11], Singh et al. [12] and [7].

Significantly higher dry matter accumulation in 25 days old seedlings is due to more age of the seedling can do better utilization of natural resources effectively viz., solar radiation, soil moisture, space and nutrients and more amount of chlorophyll content which leads to high rate of photosynthesis as a result greater amount of dry matter accumulation takes place. similar results observed in Fatematuzzohora et al. [13].

Number of primary branches plant^{-1}: Number of branches is the major character that directly relates to yield. Significantly higher number of primary branches plant^{-1} was recorded in treatment T_{11} *i.e.,* 25 days old seedlings with spacing 60×60 cm (6.5, 8.4, 8.9 and 9.0) at branching initiation stage, flowering stage, siliqua development stage and at maturity stage respectively. Lowest number of primary branches plant^{-1} recorded in Treatment T_1 *i.e.,* conventional sowing (dibbling) with spacing 45 x 15 cm without gap filling (3.7, 5.6, 6.1and 6.2) at branching initiation stage, flowering stage, siliqua development stage and at maturity stage respectively.

Number of secondary branches plant^{-1}: Number of secondary branches plant^{-1} play an important role in increasing seed yield of mustard. A perusal of the data revealed that number of secondary branches per plant followed the same trend as primary branches. The highest number of secondary branches plant^{-1} was observed in T_{11} - 25 days old seedlings with spacing 60×60 cm (23, 24.3 and 24.6) at flowering stage, siliqua development stage and at maturity stage respectively. Less number of secondary branches per plant recorded in T_1 - Conventional sowing (dibbling) with Spacing 45 x 15 cm without gap filling (7.4, 8.4 and 8.8) at flowering stage, siliqua development stage and at maturity stage respectively. It could be ascribed to less space for lateral growth and inter plant competition for sunlight, moisture and nutrients under narrow spacing more compared to wider spacing.

Higher number of branches might be due to lesser competition for resource exploitation among plants [14]. Similar results were reported by Singh et al. [12], Paraye et al. [15] and Kumari et al. [16]. 25 days old seedling Transplanted with wider spacing resulted in more number of primary and secondary branches over the conventionally sown plants, due to minimum transplantation shock observed in older age of the seedlings with that they establish in the field quickly than younger seedlings. Similar findings reported by Ashok and Sajjan [17].

3.2 Yield Attributes

Number of siliqua plant^{-1}: Number of siliquae plant^{-1} is one of the important yield attributing traits that contributes to increasing seed yield of mustard**.** Significantly highest number of siliqua plant^{-1} was recorded with T_{11} - 25 days old seedlings with spacing 60×60 cm (656.3) which was on par with T_8 and T_5. The reduction in the number of siliqua plant^{-1} under narrow spacing

Table 1. Effect of plant geometry and age of the seedlings on growth and yield attributes of mustard

Treatment	Plant height (cm)	No. of primary branches/plant	No. of secondary branches/plant	Dry matter Production (kg ha^{-1})	No. of siliqua/plant	No. of seeds/siliquae
T_1 - Conventional sowing + 45 x 15 cm without gap filling	116.5	6.2	8.8	2916	130.4	11.4
T_2 – Conventional sowing + 45 x 15 cm with gap filling	152.6	6.4	11.7	3433	140.3	11.7
T_3 -15 Days + 30 X 30 cm	179.4	6.7	19.4	4004	204.8	11.8
T_4-15 Days + 45 X 45 cm	170.1	8.0	20.4	3791	312.5	12.4
T_5 -15 Days+ 60X 60 cm	155.2	8.4	22.5	3647	474.7	13.5
T_6 -20 Days + 30 X 30 cm	181.7	7.6	19.5	4325	267.4	11.9
T_7 -20 Days + 45X 45 cm	168.8	8.1	21.4	3796	323.4	12.5
T_8 -20 Days + 60 X 60 cm	156.1	8.6	23.7	3720	526.1	14.5
T_9 -25 Days + 30 X 30 cm	182.5	7.9	20.2	4660	275.3	12.3
T_{10} -25 Days + 45 X 45 cm	172.7	8.2	21.7	3888	471.7	12.7
T_{11} -25 Days + 60 X 60 cm	158.0	9.0	24.6	3753	656.3	14.7
S.Em+	2.5	0.2	0.7	127.2	53.0	0.6
CD@5% LSD (p=0.05)	7.4	0.7	1.9	375.2	156.3	1.8

might be due to decline in light interception by plant canopy in comparison to higher spacing. Therefore, initiation of constituent buds on the secondary branches declined. The decrease in the number of secondary branches is the main cause of decline in number of siliqua plant^{-1}. In addition, the diminishing carbohydrate supply with exceeding competition among the plants at the time of flowering time is another reason [18]. Significantly higher no. of siliquae per plant in 25 days old seedlings is due to having more no. of lateral growth of the branches which produce the more siliqua per plant. This result was in consistent with those of Hosseini et al. [19], Ozer [20]. The lowest number of siliquae plant^{-1} was noticed in T_1 - Conventional sowing (dibbling) with Spacing 45 x 15 cm without gap filling (130.4). Similar findings observed in Singh et al. [12].

Number of seeds siliqua^{-1}: Since seeds are generated as storage organs, the number of filled seeds is thought to be a significant component that directly contributes to utilizing potential yield recovery in oilseed crops. Among the treatments T_{11} - 25 days old seedlings with spacing 60×60 cm (14.7) has recorded significantly higher number of seeds siliqua^{-1} which was on par with T_8 and T_5 and the lowest with T_1 - Conventional sowing (dibbling) with Spacing 45 x 15 cm without gap filling (11.4). The lower seeds siliqua^{-1} in closer spacing might be due to the more plant competition for absorbing environmental resources exceeds resulting in decrease in the production of photosynthetic materials and its transfer to seeds. Similar results were reported by Ozoni Davaji [21] and Hasanuzzaman et al. [22]. Significantly more no. of seeds per siliqua recorded in 25 days [23] old transplants might be due to efficient utilization of soil moisture, plant nutrients and they have more no. of siliquae per plant. Similar findings observed in Kumar et al. [24].

4. CONCLUSION

From the above results transplanting 25 days old seedlings with 30 x 30 cm spacing recorded higher values of plant growth parameters and regarding yield attributes 25 days old seedlings transplanted with 60 x 60 cm recorded highest values per plant.Finally it can be concluded that transplanting of 25 days old mustard seedlings with spacing 30 x 30 cm through system of mustard intensification (SMI) due to vigorous growth of 25 days old seedlins and high plant population resulted in higher biological productivity and better monetary returns in mustard cultivation during *rabi* season in Northern Telangana Zone (NTZ).

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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