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Effect of nitrogen and row spacing on growth and yield of mustard (*Brassica juncea* L.)

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Abstract
A field experiment was conducted during *Rabi* 2021 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P). The soil of experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 7.1), low in organic carbon (0.36%), available N (171.48 kg/ha), available P (15.2 kg/ha) and available K (232.5 kg/ha). The experiment was laid out in Randomized Block Design with nine treatments each replicated thrice on the basis of one year experimentation. The treatments which are T_1: Nitrogen 40 kg/ha + 30 x 15 cm, T_2: Nitrogen 40 kg/ha + 40 x 15 cm, T_3: Nitrogen 40 kg/ha + 50 x 15 cm, T_4: Nitrogen 60 kg/ha + 30 x 15 cm, T_5: Nitrogen 60 kg/ha + 40 x 15 cm, T_6: Nitrogen 60 kg/ha + 50 x 15 cm, T_7: Nitrogen 80 kg/ha + 30 x 15 cm, T_8:Nitrogen 80 kg/ha + 40 x 15 cm,T_9: Nitrogen 80 kg/ha + 50 x 15 cm are used. The results showed that application of Nitrogen 80 kg/ha + 50 x 15 cm was recorded significantly higher Plant height (149.10 cm), No. of Branches/plant (12.18), Plant dry weight (22.13 g/plant) Siliuae/plant (179.24), Seeds/siliquae (29.37), Test weight (3.26 g), Harvest index (34.13%). However, significantly highest Crop growth rate (11.01 g/m^2/day) was recorded with the treatment of Nitrogen 80 kg/ha + 30 x 15 cm, highest Seed yield (1609.13 kg/ha), gross returns (Rs.99766.07/ha), net return (Rs.67503.03/ha) and benefit cost ratio (2.09) was obtained in the treatment of Nitrogen 80 kg/ha + 30 x 15 cm as compared to other treatments.

Keywords: Nitrogen, spacing, yield

Introduction
Oilseeds are backbone of agricultural economy of India since long and considered as the second largest agricultural commodity in India after cereals (Yadav, 2011) [22]. Oilseeds are rich source of energy and nutrition. At an estimated per capita consumption of 16 kg edible oil/person/year, 21.12 million tonnes of edible oil will be required for an estimated Indian population of about 1.32 billion, by the end of 12th five year plan in 2017. This demand can only be fulfilled by producing about 63.4 million tonnes of total oilseeds, out of which, about 20 per cent (12.7 million tonnes) has to be meet by rapeseed-mustard (Annon, 2011). India's rank is first in area (20.2%) and second in production (10.7%) after China in rapeseed and mustard growing countries of the world (Annon, 2014). Mustard occupies an area of 6.5 million hectare with the total production of 7.8 million tonnes and productivity of 1208 kg ha-1 during 2013 among the different oilseed crops (Annon, 2013).

Major mustard growing states in India Rajasthan (40.82%), Haryana (13.33%), Madhya Pradesh (11.76%), Uttar Pradesh (11.40%) and West Bengal (8.64%) according to 2018-19 year (Rathi *et al.*, 2019) [18]. The seeds are highly nutritive containing 38-57% erucic acid, 5-13% linoleic acid and 27% oleic acid. They are not only rich sources of energy and carriers of fatsoluble vitamins A, D, E and K but they form the ingredients of foods and flavors, cosmetics and condiments, soap and detergents, lubricants and laxatives and also known for their medical and therapeutic use

The mustard oil is used in preparing vegetable ghee, hair oil, medicines, soaps, lubricating oil and in tanning industries. The oil content in mustard seeds varies from 37-49 per cent (Bhowmik *et al.*, 2014) [4]. The oil cake is left after extraction is utilized as cattle feed and manure.

Nitrogen is considered to be the most important nutrient for the crop to activate the metabolic activity and transformation of energy, chlorophyll and protein synthesis. Nitrogen also affects uptake of other essential nutrients and it helps in the better partitioning of photosynthates to reproductive parts which increased the seed: stover ratio (Singh *et al.*, 2004) [19]. The importance of nitrogen fertilization to achieve the higher production potential in mustard is well recognized it is the basic constituent of plant life. It tends to encourage vegetative growth and governs a considerable degree the utilization of other nutrients.

The competitive ability of a rapeseed-mustard plant depends greatly upon the density of plants per unit area and soil fertility status. Uniform distribution of crop plants over an area results in efficient use of nutrients, moisture, and suppression of weeds leading to high yield. In wider row spacing, solar radiation falling within the rows gets wasted particularly during the early stages of crop growth, whereas in closer row spacing upper part of the crop canopy may be well above the light saturation capacity but the lower leaves remain starved of light and contribute negatively towards yield. The dense plant population reduces the yield due to reduction in the photo- synthetically active leaf area caused by mutual shading. The productivity of individual plant is limited under late sown conditions owing to poor growth and development (Rathi *et al.*, 2019) [18].

Planting patterns play an important role in enhancing overall productivity of crops as it is likely to affect interception, absorption, penetration and utilization of incoming solar radiation. Plant density is another important character, which can be manipulated to attain the maximum production from per unit land area. The optimum plant density with proper geometry of planting is dependent on variety, its growth habit and agro-climatic conditions (Sondhiya *et al.*, 2019) [20]. It is imperative to adjust plant population through planting method which may help in avoiding excessive crowding. Higher plant population per unit area beyond an optimum limit results in competition among the plants for natural resources, resulting weaker plant and may cause severe lodging (Jangir *et al.*, 2017) [11].

Materials and Methods

This experiment was carried out during *Rabi* 2021 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj, UP, which is located at 25.28ºN latitude, 81.54ºE longitude and 98 m altitude above the mean sea level. This area situated on the right side of the river Yamuna by the side of Allahabad Rewa Road about 5 km away from Prayagraj city. All the facilities required for crop cultivation were met out from the department. The experiment laid out in Randomized Block Design which consisting of nine treatments which are T_1: Nitrogen 40 kg/ha + 30 x 15 cm, T_2: Nitrogen 40 kg/ha + 40 x 15 cm, T_3: Nitrogen 40 kg/ha + 50 x 15 cm, T_4: Nitrogen 60 kg/ha + 30 x 15 cm, T_5: Nitrogen 60 kg/ha + 40 x 15 cm, T_6: Nitrogen 60 kg/ha + 50 x 15 cm, T_7: Nitrogen 80 kg/ha + 30 x 15 cm, T_8:Nitrogen 80 kg/ha + 40 x 15 cm,T_9: Nitrogen 80 kg/ha + 50 x 15 cm are used. Nine treatments were replicated thrice in Randomized Block Design. The recommended dose of fertilizer (N;P;K) is 80:40:40 kg/ha.

Chemical analysis of soil

Composite soil samples are collected before layout of the experiment to determine the initial soil properties. The soil samples are collected from 0-15 cm depth and were dried under shade, powdered with wooden pestle and mortar, passed through 2 mm sieve and were analyzed for organic carbon by rapid titration method by Nelson (1975) [14]. Available nitrogen was estimated by alkaline permanganate method by Subbiah and Asija (1956) [21], available phophorus by Olsen's method as outlined by Jackson (1967), available potassium was determined by using the flame photometer normal ammonium acetate solution and estimating by using flame photometer (ELICO Model) as outlined by Jackson (1973) [10] and available $ZnSO_4$ was estimated by Atomic Absorption Spectrophotometer method as outlined by Lindsay and Norvell (1978).

Statistical analysis

The data recorded were different characteristics were subjected to statistical analysis by adopting Fishers the method of analysis of variance (ANOVA) as described by Gomez and Gomez (2010) [9]. Critical difference (CD) values were calculated the 'F' test was found significant at 5% level.

Results and Discussion

Plant height

Data in table 1 tabulated that significantly highest plant height (149.10 cm) was recorded in the treatment with Nitrogen 80 kg/ha + 50 x 15 cm over all the other treatments. However, the treatments with application of Nitrogen 60 kg/ha + 50 x 15 cm (148.21 cm) and Nitrogen 80 kg/ha + 40 x 15 cm (148.75 cm) which were found to be at par with treatment Nitrogen 80 kg/ha + 50 x 15 cm as compared to all the treatments.

The significant increase in plant height due to increasing levels of nitrogen fertilizer throughout the measurement period. The increase in plant height in response to application of N fertilizers is probably due to enhanced availability of nitrogen through fertilizer means and by SNF. The results were in accordance with Dabi *et al*. (2015) [6].

The spacing practices had significant effects on plant height (cm); however, an increasing trend with optimum geometry level could be noticed. This may be due to the competition between the inter and intra plants for sun light, water, nutrients and space at closer spacing, whereas optimum spacing helped in significantly highest plant height. Significant results were obtained due to the optimum spacing of 50x15 cm and similar results were obtained by Rameti *et al.*, (2017) [17].

Branches/plant

Treatment with Nitrogen 80 kg/ha + 50 x 15 cm was recorded with significantly highest No. of Branches /plant (12.18) over all the treatments. However, the treatments with Nitrogen 60 kg/ha + 50 x 15 cm (11.87) and Nitrogen 80 kg/ha + 40 x 15 cm (12.05) which were found to be statistically at par with Nitrogen 80 kg/ha + 50 x 15 cm.

The optimum (increased) plant spacing between plants resulted in enhanced space, sun-light, nutrients and soil moisture for increased photosynthesis, metabolic activities, growth and development which resulted in higher number of branches Gadade *et al*. (2018) [8].

Plant dry weight (g/plant)

Treatment with Nitrogen 80 kg/ha + 50 x 15 cm was recorded with significantly maximum dry weight (22.13 g/plant) over all the treatments. However, the treatments Nitrogen 60 kg/ha + 50 x 15 cm (21.75 g/plant) and Nitrogen 80 kg/ha + 40 x 15 cm (21.94 g/plant) which were found to be statistically at par with Nitrogen 80 kg/ha + 50 x 15 cm.

The significant increase in dry weight might be due to adequate supply of Nitrogen allowed the plant tissue to grow large and increase the chlorophyll formation and stimulated rapid rate of photosynthetic activity, consequently recorded more dry matter accumulation in comparison to its lower level as stated by Raghuvanshi *et al*. (2018) [16].

Higher dry matter production is observed in 30 x10 cm spacing due to better photosynthetic activity due to greater exposure to light and increased availability of nutrients to plants have also resulted in higher dry weight, the treatment showed the increasing trend in dry weight up to harvest stage, Rameti *et al.*, (2017) [17] also reported similar results.

Table 1: Effect of Nitrogen and Row spacing on Growth parameters of mustard.

Treatments		Plant height (cm)	Branches/plant	Dry weight (g)
1.	Nitrogen 40 kg/ha + 30 x 15 cm	145.00	10.84	20.44
2.	Nitrogen 40 kg/ha + 40 x 15 cm	145.41	10.94	20.55
3.	Nitrogen 40 kg/ha + 50 x 15 cm	146.71	11.35	21.04
4.	Nitrogen 60 kg/ha + 30 x 15 cm	146.02	11.16	20.74
5.	Nitrogen 60 kg/ha + 40 x 15 cm	147.05	11.58	21.47
6.	Nitrogen 60 kg/ha + 50 x 15 cm	148.21	11.87	21.75
7.	Nitrogen 80 kg/ha + 30 x 15 cm	147.38	11.68	21.64
8.	Nitrogen 80 kg/ha + 40 x 15 cm	148.75	12.05	21.98
9.	Nitrogen 80 kg/ha + 50 x 15 cm	149.10	12.18	22.13
F test		S	S	S
S.Em (±)		0.17	0.12	0.13
CD (P = 0.05)		0.49	0.35	0.39

Yield attributes and Yield

Significantly maximum Number of Siliquae/plant (179.24) was recorded with the treatment of application of Nitrogen 80 kg/ha + 50 x 15 cm over all the treatments. However, the treatments Nitrogen 60 kg/ha + 50 x 15 cm (177.56) and Nitrogen 80 kg/ha + 40 x 15 cm (178.30) which were found to be statistically at par with Nitrogen 80 kg/ha + 50 x 15 cm.

Higher number of Siliquae/plant might have been possible due to more vigour and strength attained by the plants as a result of better photosynthetic activities with sufficient availability of light, and supply of nutrients in balanced quantity of the plants at growing stages. Anjana *et al.,* (2020) observed the similar results.

Significantly Maximum Number of Seeds/Siliquae (29.37) was recorded with the treatment of application of Nitrogen 80 kg/ha + 50 x 15 cm over all the treatments. However, the treatments Nitrogen 60 kg/ha + 50 x 15 cm (28.72) and Nitrogen 80 kg/ha + 40 x 15 cm (29.16) which were found to be statistically at par with Nitrogen 80 kg/ha + 50 x 15 cm.

Application of N increased the Number of Siliquae/plant and Number of Seeds/Siliquae might be due to the enhanced early vegetative growth in terms of higher leaf area, dry matter accumulation and vigorous root system resulted in more branches which consequently increased the number of pod bearing branches significantly. Similar findings were observed b Application of N along with P increased the number of pods per plant might be due to the enhanced early vegetative growth in terms of higher leaf area, dry matter accumulation and vigorous root system resulted in more branches which consequently increased the number of pod bearing branches significantly. Similar findings were observed by Duval *et al*. (2015) [7].

Significantly highest Test weight (3.26 g) was recorded with the treatment of application of Nitrogen 80 kg/ha + 50 x 15 cm over all the treatments. However, the treatments Nitrogen 60 kg/ha + 50 x 15 cm (3.06 g) and Nitrogen 80 kg/ha + 40 x 15 cm (3.16 g) which were found to be statistically at par with Nitrogen 80 kg/ha + 50 x 15 cm.

Higher vigour and growth attained by the plants due to sufficient absorption of nutrients might have resulted in higher test weight Keerthi *et al*. (2017) [12]. Better availability of moisture and moderation of soil temperature which led to greater uptake of nutrients and reduced number of days taken to meet the required heat units for proper growth and development of plants and ultimately the yield attributes. The results were recorded similar with Patil *et al.* (2007) [15].

Significantly highest Seed yield (1609.13 kg/ha) was recorded with the treatment application of Nitrogen 80 kg/ha + 30 x 15 cm over all the treatments. However, the treatments with (1562.64 kg/ha) in Nitrogen 60 kg/ha + 30 x 15 cm and with (1581.76 kg/ha) in Nitrogen 80 kg/ha + 40 x 15 cm which were found to be statistically at par with Nitrogen 80 kg/ha + 30 x 15 cm.

Seed yield was increased due to application of higher doses of nitrogen, which increases the photosynthetic activity and might have increased vegetative growth and yield attributes also improved ultimately increased grain yield. Similar findings have been observed by Dabi *et al*. (2015) [6].

The optimum spacing helped plant to receive sufficient amount of heat, water and nutrients from soil which increased number of siliqua/plant, seeds/siliqua and test weight which directly helped in increase of seed yield in mustard. The results were similar to Chandrasekaran *et al.* (2007) [5].

Significantly highest Harvest index (34.13%) was recorded with the treatment application of Nitrogen 80 kg/ha + 50 x 15 cm. However, the treatments Nitrogen 40 kg/ha + 30 x 15 cm (33.49%) and Nitrogen 60 kg/ha + 40 x 15 cm (33.92%) which were found to be statistically at par with Nitrogen 80 kg/ha + 50 x 15 cm.

Highest harvest index was observed due to improved cell activities, enhanced cell multiplication and enlargement and luxuriant growth and yield attributes of the crops probably due to more absorption and utilization of available nutrients leading to overall improvement of crop growth reflected to source-sink relationship, which in turn enhanced the yield attributes that ultimately more yield which was reported by Keivanrad and Zandi (2012) [13].

Table 2: Effect of Nitrogen and Row spacing on Yield attributes and Yield of Mustard.

Treatments		Siliquae/plant	Seeds/siliquae	Test Weight (g)	Seed yield (kg/ha)	Harvest Index (%)
1.	Nitrogen 40 kg/ha + 30 x 15 cm	170.55	26.92	2.48	1419.00	33.49
2.	Nitrogen 40 kg/ha + 40 x 15 cm	171.80	27.28	2.51	1296.58	32.47
3.	Nitrogen 40 kg/ha + 50 x 15 cm	173.66	27.77	2.68	1258.34	32.87
4.	Nitrogen 60 kg/ha + 30 x 15 cm	172.28	27.59	2.59	1562.64	33.36
5.	Nitrogen 60 kg/ha + 40 x 15 cm	174.50	28.26	2.87	1477.27	33.92
6.	Nitrogen 60 kg/ha + 50 x 15 cm	177.56	28.72	3.06	1362.97	33.37
7.	Nitrogen 80 kg/ha + 30 x 15 cm	175.73	28.48	2.97	1609.13	33.15
8.	Nitrogen 80 kg/ha + 40 x 15 cm	178.30	29.16	3.16	1581.76	33.19
9.	Nitrogen 80 kg/ha + 50 x 15 cm	179.24	29.37	3.26	1526.95	34.13
F test		S	S	S	S	S
S.Em (±)		0.64	0.22	0.07	16.17	0.22
CD (P = 0.05)		1.91	0.66	0.22	48.49	0.65

Conclusion

It is concluded that application of treatment Nitrogen 80 kg/ha + 30 x 15 cm was recorded significantly higher Seed yield (1609.13 kg/ha), higher gross returns (Rs.99766.07/ha), net returns (Rs.67503.03/ha) and benefit cost ratio (2.09)as compared to other treatments.

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