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Jonathan Zomuansanga
M.Sc. Scholar, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj, Uttar Pradesh, India

Akankhya Pradhan
Ph.D. Scholar, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj, Uttar Pradesh, India

Kumar Raj
Ph.D. Scholar, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj, Uttar Pradesh, India

Rajesh Singh
Professor, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj, Uttar Pradesh, India

Corresponding Author:
Jonathan Zomuansanga
M.Sc. Scholar, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj, Uttar Pradesh, India

Effect of spacing and row orientation on yield attributes and estimation of economical gain in *Toria* cultivation (*Brassica campestris* L.)

Jonathan Zomuansanga, Akankhya Pradhan, Kumar Raj and Rajesh Singh

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Abstract
A field experiment was conducted during *Rabi* season 2024 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P) on *Toria*. The soil of experimental plot was sandy loam in texture, low in organic carbon (0.72%), nearly neutral in soil Ph (7.2), Nitrogen (178.48 kg/ha), Phosphorous (27.80 kg/ha), Potassium (233.24 kg/ha). The Treatment consist of Spacing (20 x 10 cm, 30 x 10 cm and 40 x 10 cm) and Row Orientation {East-West, North-South and Control (Plot Direction) North East-South West}. The experiment was carried out in a randomized block design with nine treatments and were replicated thrice. The results revealed that significantly higher number of Siliqua/plant (189.90), number of seeds/Siliqua (13.80), seed yield (0.94 t/ha), stover yield (6.22 t/ha), Maximum gross return (INR 72976.00/ha), net returns (INR 40046.00/ha) and benefit cost ratio (1.94) were obtained in the treatment T3 (40 x 10 cm + East-West) in *Toria* crop.

Keywords: *Toria*, spacing, row orientation, direction, growth, yield and economics

Introduction
Rapeseed and mustard crops in India thrive in a variety of agro-climatic conditions, from the hilly regions in the northeast and northwest to the southern areas, whether under irrigated or rainfed systems, timely or late sowing, and even in saline soils with mixed cropping practices. Indian mustard represents approximately 75-80% of the total 6.23 million hectares dedicated to these crops during the 2018-19 crop season. It is a winter (rabi) season crop that requires a relatively cool temperature, a fair supply of soil moisture during the growing season and a dry harvest period (Saini *et al.*, 2020) [5]. It is cultivated both under irrigated (79.2%) and rainfed (20.8%) conditions (Singh and Thenua, 2016) [6]. Highest area was recorded in Rajasthan (10.60 lakh ha) followed by Madhya Pradesh and Haryana 3.99 and 1.46 lakh ha, respectively.

Row spacing is a crucial agronomic practice for enhancing the production potential of rapeseed and mustard. Adhering to recommended row spacing, along with providing optimal environmental conditions, can significantly improve yield stability.Inappropriate row spacing reduced seed yield by inadequate siliqua yield and hastening plant maturity (Nanjundan *et al.* 2020). Jha *et al.* (2012) [3, 4] investigated how the Indian mustard's orientation of sowing affected its ability to intercept solar energy. A high density of plants can negatively impact agricultural yields due to competition among plants for nutrients, water, light, and space. Conversely, a low plant density may prevent the full utilization of available resources.

The ultimate grain yield of a crop is strongly linked to light, particularly photosynthetically active radiation, which is essential for food production. The photosynthesis process depends on temperature and the amount of light captured. The efficiency of light utilization is also influenced by the crop's leaf area, which is primarily affected by temperature and moisture levels. Observations indicated that growth characteristics were significantly greater when rows were aligned in a north-south direction with a spacing of 40 cm compared to other configurations. The probable reasons for higher growth attributes under north - south row direction sowing are better sunlight interception and thereby an increased

photosynthetic activity. These findings are in conformity with the findings of Bilgili *et al.* (2003) [2].

Materials and Methods: The experiment was conducted during the Rabi season 2024, at the Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj (U.P.) which is located at 250 30' 42''N latitude, 810 60' 56" E longitude and 98 m altitude above the mean sea level (MSL). This area is situated on the right side of the Yamuna River by the side of Prayagraj-Rewa Road about 12 km from the city. The experiment was conducted in Randomized Block Design with 9 treatments each replicated thrice. The plot size of each treatment was 3m x 3m. The factors are Spacing (20 x 10 cm, 30 x 10 cm and 40 x 10 cm) and Row Orientation {East-West, North-South and Control (Plot Direction) North East-South West}. *Toria* variety T-9 was selected for sowing. Seeds were sown in line manually. Seeds were covered with the soil immediately after sowing. The *Toria* crop was sown on 25 Sept. 2024. Harvesting was done by taking 1m2 area from each plot. And from it five plants were randomly selected for recording growth and yield parameters. The observations were recorded for plant height, dry weight, Crop growth rate, number of siliquae/plants, number of seeds/siliquae, test weight, see yield and stover yield. The data was subjected to statistical analysis by analysis of variance method.

Result and Discussion

1. Yield Attributes

Number of siliqua/plants

The data shown that there was a significant effect among treatments. However, highest number of siliqua/plant (189.80) was observed in treatment T_3 (40 x 10 cm + East-West). However, Treatment 9 {40 x 10 cm + Control (North East-South West) (181.60) was found to be statistically at par with Treatment 3 [40 x 10 cm + East-West].

Number of Seeds/siliqua

The data shown that there was a significant effect among treatments. However, highest number of seeds/siliqua (13.13) was observed in treatment T_3 (40 x 10 cm + East-West). However, Treatment 9 (13.00){40 x 10 cm + Control (North East-South West)} was found to be statistically at par with Treatment 3 [40 x 10 cm + East-West].

Seed Yield (t/ha): Maximum seed yield (0.94 t/ha) was observed in treatment T_3 (40 x 10 cm + East-West). However, Treatment 9 (0.93 t/ha) [40 cm x 10 cm + Control (North East-South West)] and Treatment 8 (0.92 t/ha) [30 cm x 10 cm + Control (North East-South West)], were found to be statistically at par with Treatment 3 [40 x 10 cm + East-West].

Stover Yield (t/ha)

Maximum stover yield (6.22 t/ha) was observed in treatment T_3 (40 x 10 cm + East-West). However, Treatment 9 (6.06) [40 cm x 10 cm + Control (North East-South West)] and Treatment 8 (6.02 t/ha) [30 cm x 10 cm + Control (North East-South West)] was found to be statistically at par with Treatment 3 [40 x 10 cm + East-West].

2. Economics

Gross Return (INR/ha)

The highest gross returns (72976.00 INR/ha) was recorded in Treatment 3 [40 cm x 10 cm + East - West] and the lowest gross returns (61583.00 INR/ha) was recorded in Treatment 4 [20 cm x 10 cm + North - South].

Net Return (INR/ha)

The highest net returns (40046.00 INR/ha) was recorded in Treatment 3 [40 cm x 10 cm + East - West] and the lowest net returns (28653.00 INR/ha) was recorded in Treatment 4 [20 cm x 10 cm + North - South].

Benefit Cost Ratio (B:C)

The highest benefit-cost ratio (1.22) was recorded in Treatment 3 [40 cm x 10 cm + East - West] and the lowest benefit-cost ratio (0.87) was recorded in in Treatment 4 [20 cm x 10 cm + North - South].

Discussion

Spacing of 40 x 10 cm sowing generally leads to higher yield attributes like plant height, number of branches, siliqua per plant and seeds per siliqua compared to North-South direction, while also showing better seed yield. One possible explanation for these enhancements is the higher light intensity obtained when facing east-west. Plant height, siliquae/plant, seeds/silique, as a result of improved light interception, which results in longer photosynthetic activity in the former than in the latter (Bhan *et al.*) [1].

However, East-west sowing increased the seed and stick + straw yields by 8.3 and 5.1% respectively over the sowing in North-south direction mustard. This could be at tributed to better plant growth as measured in terms of yield attributes, *viz*. plant 'stand at maturity, plant height, siliqua/plant, seeds/siliqua and 1,000-seed weight, due to better light interception leading to prolonged photosynthetic activity in former as compared to earlier. These findings are in accordance with the results observed by Pal (1995) [7].

Conclusion

It is concluded that 40 x 10 cm Spacing sowing along with East-West sowing direction recorded highest yield attributes and economics in *Toria*.

Table 1: Effect of Spacing and Row Orientation on yield attributes of *Toria* cultivation.

S No	Treatment combinations	Number of siliqua/ plant	Number of Seeds/ Siliqua	Seed yield (t/ha)	Stover yield (t/ha)
1.	East- West + 20 x 10 cm	176.53	12.87	0.86	5.22
2.	East- West + 30 x 10 cm	178.67	12.67	0.90	5.24
3.	East- West + 40 x 10 cm	189.80	13.13	0.94	6.22
4.	North- South + 20 x 10 cm	175.07	11.87	0.78	5.38
5.	North- South + 30 x 10 cm	178.93	12.87	0.87	5.23
6.	North- South + 40 x 10 cm	178.93	11.93	0.87	5.27
7.	Control (North East-South West) + 20 x 10 cm	175.67	11.60	0.85	5.56
8.	Control (North East-South West)+ 30 x 10 cm	177.67	12.60	0.92	6.02
9.	Control (North East-South West)+ 40 x 10 cm	181.60	13.00	0.93	6.06
	S. Em (±)	2.72	0.25	0.02	0.24
	CD (p = 0.05)	8.15	0.75	0.08	0.73

Table 2: Effect of Spacing and Row Orientation on Economics of *Toria* cultivation.

S No	Treatment combinations	Gross returns (INR/ha)	Net returns (INR/ha)	B:C ratio
1.	East- West + 20 x 10 cm	65733.33	32803.33	1.00
2.	East- West + 30 x 10 cm	67930.00	35000.00	1.06
3.	East- West + 40 x 10 cm	72976.67	40046.67	1.22
4.	North- South + 20 x 10 cm	61583.33	28653.33	0.87
5.	North- South + 30 x 10 cm	66150.00	33220.00	1.01
6.	North- South + 40 x 10 cm	66076.67	33146.67	1.01
7.	Control (North East-South West) + 20 x 10 cm	66786.67	33856.67	1.03
8.	Control (North East-South West)+ 30 x 10 cm	71916.67	38986.67	1.18
9.	Control (North East-South West)+ 40 x 10 cm	71216.67	38286.67	1.16

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