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Effect of spacing and row orientation on yield attributes and economics of toria (*Brassica campestris* L.)

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Abstract
A field study was carried out during the Rabi season of 2024 at the Crop Research Farm, Department of Agronomy, SHUATS, and Prayagraj (U.P.) to evaluate the influence of plant spacing and row orientation on Toria. The experimental soil was sandy loam, with low organic carbon (0.72%), nearly neutral pH (7.2), and nutrient status of 178.48 kg/ha Nitrogen, 27.80 kg/ha Phosphorus, and 233.24 kg/ha Potassium. The trial included three levels of spacing (20 × 10 cm, 30 × 10 cm, and 40 × 10 cm) and three row orientations (East-West, North-South, and North East-South West as control), arranged in a Randomized Block Design with nine treatment combinations, each replicated thrice. Among the treatments, T_3 (40 × 10 cm + East-West orientation) exhibited superior performance, producing the tallest plants (135.16 cm), maximum branches per plant (14.86), highest dry weight per plant (19.74 g), greatest number of siliquae per plant (189.80), and highest seeds per siliqua (13.13). The study suggests that adopting wider spacing with East-West row orientation can effectively enhance Toria growth and yield under similar agro-climatic conditions.

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

Introduction

Rapeseed-mustard crops in India are cultivated across diverse agro-climatic zones, ranging from the north-eastern and north-western hills to southern regions, under both irrigated and rainfed conditions, as well as in timely or late-sown fields, saline soils, and mixed cropping systems. Indian mustard contributes approximately 75-80% of the total 6.23 million ha under rapeseed-mustard crops in the country during the 2018-19 season. It is a winter (Rabi) season crop, requiring relatively cool temperatures, adequate soil moisture during the growth period, and a dry period at harvest (Saini *et al.,* 2020) [5]. The crop is grown under irrigated conditions (79.2%) and rainfed conditions (20.8%) (Singh and Thenua, 2016) [6]. Among Indian states, Rajasthan recorded the largest cultivation area (10.60 lakh ha), followed by Madhya Pradesh (3.99 lakh ha) and Haryana (1.46 lakh ha).

Among agronomic factors, row spacing plays a critical role in enhancing the production potential of rapeseed-mustard. Proper row spacing combined with optimal environmental conditions can improve yield stability, whereas inappropriate spacing reduces seed yield due to lower siliqua formation and accelerated plant maturity (Nanjundan *et al*, 2020) [4]. Jha *et al.* (2015) [3] highlighted that the orientation of sowing influences the crop's ability to intercept solar radiation. While high plant populations may reduce yield due to interplant competition for nutrients, moisture, light, and space, low plant populations fail to utilize available resources efficiently.

The final grain yield is closely linked to the interception of photosynthetically active radiation (PAR), which drives food synthesis through photosynthesis. This process is influenced by temperature and radiation interception, while light-use efficiency is further determined by leaf area, which depends on temperature and water availability. Studies have shown that growth attributes under North-South row orientation with 40 cm spacing were significantly higher than other treatments. The likely reason for this improvement is better sunlight interception, leading to enhanced photosynthetic activity, consistent with findings reported by Bilgili *et al* (2003) [2].

Materials and Methods

The present study was carried out during the Rabi season of 2024 at the Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj (U.P.). The site is geographically situated at 25°30′42″ N latitude, 81°60′56″ E longitude, and an altitude of 98 m above mean sea level, located on the right bank of the Yamuna River along the Prayagraj-Rewa Road, approximately 12 km from the city.

The experiment was laid out in a Randomized Block Design (RBD) comprising nine treatments, each replicated three times, with a plot size of 3 m × 3 m. The treatments included three plant spacings (20 × 10 cm, 30 × 10 cm, and 40 × 10 cm) and three row orientations (East-West, North-South, and Control: North East-South West). The Toria variety T-9 was sown manually in lines, with seeds immediately covered with soil. Sowing was performed on 25th September 2024.

At maturity, harvesting was carried out from a 1 m² area in each plot, and five plants were randomly selected from this sample for recording growth and yield traits. The observations recorded included plant height, dry weight, crop growth rate, number of siliquae per plant, number of seeds per siliqua, test weight, seed yield, and stover yield. The experimental data were analyzed statistically using the analysis of variance (ANOVA) method to determine the significance of treatment effects.

Results and Discussion

Yield Attributes

Plant height

At 80 DAS, the tallest plants (135.16 cm) were observed in Treatment 3 (40 × 10 cm + East-West orientation). Treatment 9 (40 × 10 cm + Control: North East-South West) recorded a plant height of 131.04 cm, which was found to be statistically at par with Treatment 3.

Branches/plant

At 80 DAS, the maximum number of branches per plant (14.86) was observed in Treatment 3 (40 × 10 cm + East-West orientation). Treatment 2 (30 × 10 cm + East-West orientation), with 14.06 branches per plant, was statistically at par with Treatment 3.

Dry weight (g).

At 80 At 80 DAS, the highest plant dry weight (19.74 g) was recorded in Treatment 3 (40 × 10 cm + East-West orientation). Treatment 9 (40 × 10 cm + Control: North East-South West), with a dry weight of 19.59 g, was found to be statistically at par with Treatment 3.

Number of siliqua/plant

The data indicated significant differences among the treatments. The highest number of siliquae per plant (189.80) was recorded in Treatment 3 (40 × 10 cm + East-West orientation), while Treatment 9 (40 × 10 cm + Control: North East-South West), with 181.60 siliquae per plant, was found to be statistically at par with Treatment 3.

Number of seeds/siliqua.

The data revealed significant differences among the treatments. The maximum number of seeds per siliqua (13.13) was recorded in Treatment 3 (40 × 10 cm + East-West orientation), while Treatment 9 (12.87) was found to be statistically at par with Treatment 3.

Discussion

Sowing at a spacing of 40 × 10 cm generally resulted in higher yield attributes, including plant height, number of branches, siliquae per plant, and seeds per siliqua, compared to the North-South orientation, and also produced better seed yield. This improvement can be attributed to higher light interception under the East-West orientation, which enhances photosynthetic activity and prolongs the period of assimilate production (Bhan *et al*).

Specifically, East-West sowing increased seed and stick + straw yields by 8.3% and 5.1%, respectively, over North-South sowing. These gains are likely due to improved plant growth, reflected in plant stand at maturity, plant height, siliquae per plant, seeds per siliqua, and 1,000-seed weight, resulting from better light interception and extended photosynthetic activity. These findings are consistent with those reported by Pal (1995) [1].

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	Plant height (cm).	No. of branchess/plant.	Dry weight (g)	Number of siliqua/ plant	Number of Seeds/ Siliqua
1.	East- West + 20 x 10 cm	126.43	12.60	19.23	176.53	12.87
2.	East- West + 30 x 10 cm	118.13	14.06	18.95	178.67	12.67
3.	East- West + 40 x 10 cm	135.16	14.86	19.74	189.80	13.13
4.	North- South + 20 x 10 cm	123.63	12.66	19.08	175.07	11.87
5.	North- South + 30 x 10 cm	122.54	12.93	18.96	178.93	12.87
6.	North- South + 40 x 10 cm	128.73	13.33	18.80	178.93	11.93
7.	Control (North East-South West) + 20 x 10 cm	124.57	12.20	19.04	175.67	11.60
8.	Control (North East-South West)+ 30 x 10 cm	127.03	13.26	19.21	177.67	12.60
9.	Control (North East-South West)+ 40 x 10 cm	131.04	13.00	19.59	181.60	13.00
	S. Em (±)	3.05	0.37	0.12	2.72	0.25
	CD (p = 0.05)	9.15	1.10	0.38	8.15	0.75

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