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Response of Sulphur and Spacing on Growth and Yield of Toria (*Brassica campestris* L.)

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted during *Rabi* season of 2022 at the Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology And Sciences, Prayagraj (U.P.) India. To study the Response of Sulphur and Spacing on growth and yield of Toria. The treatments consist of Sulphur 15, 30, 45 kg/ha and Spacing 20×15, 20×20, 25×20 cm. There were 10 treatments each replicated thrice. The soil of experimental plot was sandy loamy in texture, nearly neutral in soil reaction pH (7.2) with EC-0.187 (dS/m), low in organic carbon (0.72%) available N (178.48 kg/ha), available P (27.80 kg/ha) and available K (233.24 kg/ha). Results revealed that the higher plant height (105.93 cm), higher plant dry weight (17.70 g), higher crop growth rate (13.8 g/m^2/day), higher number of siliquae/plant (216.19), higher seeds/ siliquae (23.67), higher test weight (3.64 g), higher seed yield (1.76 kg/ha), higher stover yield (3.21 kg/ha) and higher harvest index (35.39%) were significantly influenced with application of Sulphur 45 kg/ha + Spacing 25×20 cm.

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1. INTRODUCTION

Rapeseed (*Brassica campestris var*. toria), sometimes known as raya, rai or lahi, is an important oilseed crop of the Brassica genus. Indian oil seed group. It is India's second-largest edible oilseed crop after peanuts, contributing close to 30% of all oilseeds farmed there.

Rapeseed-mustard, a significant group of edible oil seed crops, accounts for nearly 85% of all rapeseed-mustard produced in India and contributes roughly 26.1% of all oil seed output [1]. In terms of area and production, it comes in second place to China [2]. Rapeseed and mustard crops are grown in 53 different countries. encompassing a total area of 24.2 million hectares throughout the six continents. India contributes 28.3 and 19.8 percent of the world's hectares and production, respectively.

Minerals like calcium, manganese, copper, iron, selenium, zinc, vitamin A, B and C, as well as proteins, are abundant in rapeseed. 100g of mustard seed has 508 kcal of calories, 12.2 g of dietary fibre, 26.08 g of total fat, 26.08 g of total protein, and 28.09 g of carbs.

Because the amino acids cystine (27%), cysteine (26%) and methionine (21%), which are sulfur-containing and essential for both protein and oil production in plants as well as vegetative development, are needed by oil seed crops, Sulphur was required in substantial quantities. Sulphur is principally important for the creation of chlorophyll, which gives things their green colour, glucosides, and glucosinolates (found in rapeseed and mustard oil). it responsible for triggering the sulphydryl linkage, which mostly enhances the flavour of oil crops like rapeseed and mustard.

Oil seed produces more of it in response to sulphur [3]. Brassica family crops are particularly prone to sulphur deficiency, which shows symptoms like leaves that cup or curl inward and have crimson undersides. In severe cases, this illness also affects the stem and both sides of leaves.

Row spacing is an important agronomic practise for increasing rapeseed and mustard production potential. Crop plant spacing is mostly determined by their growth patterns; however, the quantity of growth is influenced by edaphic and climatic conditions. Spacing is a non-monetary input that has a substantial impact on productivity. Plant density per unit area and yield per plant are the two most essential and interdependent elements influencing agricultural yield (Singh and Dhillon, 1991). A large plant population may reduce agricultural output due to interplant competition for nutrients, moisture, light, and space, whereas a low plant population may not fully use supplied resources.

Keeping these points in view, the present study entitled “Influence of Sulphur and spacing on growth and yield of Toria (*Brassica campestris* L.)”, was conducted at Crop Research Farm, Department of Agronomy, Naini Agriculture Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh during *Kharif* season of 2022.

2. MATERIALS AND METHODS

The experiment was conducted during *Rabi* of 2022, Crop Research Farm, Department of Agronomy, Naini Agriculture Institute, Sam Higginbottom University of Agriculture Technology And Sciences, Prayagraj, Uttar Pradesh. Which is located at 25.24 42'' N latitude, 81°50' 56” E longitude and 98m altitude above the mean sea level (SL). The experiment was conducted in Randomized Block Design with 10 treatments each replicated thrice. The plot size of each treatment was 3m x 3m. Factors are three levels of Sulphur (15,30,45 kg/ha) and the spacing 20×15 cm, 20×20 cm, 25×20 cm. The Toria crop was sown on 20 Sept 2022. All plots were fertilized with the basal dose of 60 kg N/ha, 40 kg P_2O_5/ha and 40 kg K_2O/ha in the form of Urea, SSP and Muriate of Potash, respectively. Two irrigation are carried out at 30 and 60 DAS interval and two weeding (hand hoeing) were carried out at 20 and 40 DAS respectively. Harvesting was done by taking $1m^2$ area from each plot and from it five plants were randomly selected for recording yield parameters. Harvesting was done by taking $1m^2$ area from each plot. And from it five plants were randomly selected for recording growth and yield parameters. The treatment details are as follows, T_1 -(Sulphur 15 kg/ha + Spacing 20×15 cm), T_2 -(Sulphur 15 kg/ha + Spacing 20×20 cm), T_3 –(Sulphur – 15 kg/ha + Spacing 20×15 cm), T_4 -(Sulphur – 30 kg/ha + Spacing 20×15 cm), T_5 -(Sulphur – 30 kg/ha + Spacing 20×20 cm), T_6 -(Sulphur – 30 kg/ha + Spacing 25×20 cm), T_7 -(Sulphur – 45 kg/ha + Spacing 20×15 cm), T_8 -(Sulphur – 45 kg/ha + Spacing 20×20 cm), T_9 -

(Sulphur – 45 kg/ha + Spacing 25×20 cm) and Control Plot. The observations were recorded for plant height (cm), dry weight (g), Crop growth rate (g/m^2/day), number of siliqua/plant, number of seeds/siliqua, test weight (g), seed yield (kg/ha) and stover yield (kg/ha). The data was subjected to statistical analysis by analysis of variance method [4].

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

Plant height: At 60 DAS, the significantly higher plant height (105.93 cm) was observed in treatment-9 (Sulphur 45 kg/ha + Spacing 25×20 cm) However, treatment-8 (Sulphur 45 kg/ha + Spacing 20×20 cm) was found to be statistically at par with treatment- 9 (Sulphur 45 kg/ha + Spacing 25×20 cm). Sulphur 45 kg/ha application resulted in significantly greater plant height. This could be attributed to enough nutrients, which aid in rapid vegetative growth of plants and, as a result, enhance plant height through cell elongation, cell division, photosynthesis, and plant cell turbidity Tripathi et al. [5]. Furthermore, continued growth in plant height could be attributable to plant spacing. Row spacing in mustard varies greatly over the world, depending on cultivar, production system, and prevailing environmental conditions. Maintaining adequate row spacing is critical to improving crop growth and the time required for canopy closure. Svecnjak et al. [6] observed similar findings.

Plant dry weight (g): At 60 DAS, the significantly higher plant dry weight (18.76 g) was observed in treatment-9 (Sulphur 45 kg/ha + Spacing 25×20 cm). However, treatment-8 (Sulphur 45 kg/ha + Spacing 20×20 cm) was found to be statistically at par with treatment- 9 (Sulphur 45 kg/ha + Spacing 25×20 cm). The significantly higher plant dry weight (18.76 g) was observed with the application of Sulphur 45 kg/ha. This could be due to Sulphur levels, which aid in promoting and hastening the metabolic process, physiological activities, and increasing the photosynthesis process related to growth as a result of increasing plant height, number of branches and leaves, and other above ground and below ground plant structures, which were the probable reason for hastening the dry matter accumulations in plant Mallick et al. [7] and also, further increase in dry matter due to maximum spacing, which results in a higher number of leaves and a larger leaf area, resulting in more photosynthetic activities and carbohydrate accumulation, and thus an increase in dry matter production, and soybean crop fix atmospheric nitrogen, which is why plant growth was better than cereal crop Prasad et al. [8].

3.2 Yield Attributes

Number of siliqua/ plant: The significant higher number of siliquae/plant (216.19) were observed in treatment-9 (Sulphur 45 kg/ha + Spacing 25×20 cm), which was significantly superior over rest of the treatments. However, treatment-8 (Sulphur 45 kg/ha + Spacing 20×20 cm) was found to be statistically at par with treatment- 9 (Sulphur 45 kg/ha + Spacing 25×20 cm). This could be due to the synergistic impact of sulphur, which promotes flower and seed production in siliqua. One of the explanations could be that an increase in leaf area, plant height, and photosynthetic rate leads to an increase in sink size. This is consistent with the findings of Saini et al. [9]. Furthermore, Higher number of Siliqua/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. Goutham et al., (2022) [10].

Number of seeds/ siliqua: The significant higher number of seeds/siliqua (23.67) was observed in treatment-9 (Sulphur 45 kg/ha + Spacing 25×20 cm), which was significantly superior over rest of the treatments. However, treatment-8 (Sulphur 45 kg/ha + Spacing 20×20 cm) was found to be statistically at par with treatment- 9 (Sulphur 45 kg/ha + Spacing 25×20 cm). The significant higher number of seeds/siliqua (23.67) was observed with the application of Sulphur. The increase in seeds/siliqua (No.) and test weight (g) was attributed to the favourable effect of Sulphur at greater levels, which is responsible for floral stimulation, siliqua formation, and seed formation in siliqua. Sulphur boosted the translocation of photosynthates product towards seed and sink strength, as well as the formation of assimilates, which could explain the rise in seeds/siliqua (No.) and test weight (g). Similar findings were reported by Nath et al. [11].

Test weight (g): The significant higher number of test weight (3.64 g) was observed in treatment-9 (Sulphur 45 kg/ha + Spacing 25×20 cm), which was significantly superior over rest of the treatments. However, treatment-8 (Sulphur 45 kg/ha + Spacing 20×20 cm) was found to be statistically at par with treatment- 9 (Sulphur 45

Table 1. Influence of Sulphur and Spacing on growth parameters of Toria

S. No.	Treatment combinations	Plant height (cm)	Dry weight (g)
1.	Sulphur 15 kg/ha + Spacing 20×15	90.02	13.59
2.	Sulphur 15 kg/ha + Spacing 20×20	93.93	14.58
3.	Sulphur 15 kg/ha + Spacing 25×20	95.84	14.83
4.	Sulphur 30 kg/ha + Spacing 20×15	93.87	15.84
5.	Sulphur 30 kg/ha + Spacing 20×20	98.07	16.36
6.	Sulphur 30 kg/ha + Spacing 25×20	99.07	16.79
7.	Sulphur 45 kg/ha + Spacing 20×15	101.33	17.25
8.	Sulphur 45 kg/ha + Spacing 20×20	103.39	17.75
9.	Sulphur 45 kg/ha + Spacing 25×20	105.93	18.76
10.	Control (N:P:K 60-40-40 kg/ha)	95.55	15.64
	F-test	S	S
	SE m (±)	1.04	0.73
	CD (P=0.05)	3.10	2.18

Table 2. Influence of Sulphur and Spacing on yield attributes of Toria

S. No.	Treatment combinations	No. of Siliqua/plant	No. of Seeds/Siliqua	Test weight (g)	Oil Content (%)	Seed yield (kg/ha)	Stover yield (kg/ha)
1.	Sulphur 15 kg/ha + Spacing 20×15	162.36	19.19	2.80	37.24	1470.00	2366.67
2.	Sulphur 15 kg/ha + Spacing 20×20	167.47	18.77	2.88	38.97	1100.00	2563.33
3.	Sulphur 15 kg/ha + Spacing 25×20	169.98	19.91	3.05	39.81	1146.67	2680.33
4.	Sulphur 30 kg/ha + Spacing 20×15	175.03	21.19	3.21	38.87	1230.00	2803.33
5.	Sulphur 30 kg/ha + Spacing 20×20	182.47	22.32	3.32	40.32	1306.67	2893.33
6.	Sulphur 30 kg/ha + Spacing 25×20	189.65	22.69	3.41	41.29	1376.67	3053.33
7.	Sulphur 45 kg/ha + Spacing 20×15	201.83	21.35	3.47	40.80	1480.00	3103.33
8.	Sulphur 45 kg/ha + Spacing 20×20	209.75	23.17	3.58	41.94	1610.00	3180.00
9.	Sulphur 45 kg/ha + Spacing 25×20	216.19	23.67	3.64	42.70	1756.67	3206.67
10.	Control (N:P:K 60-40-40 kg/ha)	180.17	19.18	3.12	37.56	1190.00	2723.33
	F test	S	S	S	S	S	S
	SEm(±)	1.87	0.23	0.06	0.27	133.39	98.35
	CD (P=0.05)	5.57	0.69	0.19	0.80	396.10	4.22

kg/ha + Spacing 25×20 cm). Sulphur at higher levels is responsible for flower stimulation, siliqua formation, and seed formation in siliqua, as well as the maximum amount of phosphorus nutrient found in the seed and siliqua of yellow mustard plant, which is responsible for seed formation and seed thickness, and the favorable effect of Sulphur enhanced the translocation of photosynthates product towards seed and sink strength, and assimilate production was increased, which may be the reason of increase test weight (g). similar results are conformity with Chauhan et al. [12].

Oil Content (%): The significant higher percentage of oil content (42.70 %) was observed in treatment-9 (Sulphur 45 kg/ha + Spacing 25×20 cm), which was significantly superior over rest of the treatments. However, treatment-8 (Sulphur 45 kg/ha + Spacing 20×20 cm) was found to be statistically at par with treatment- 9 (Sulphur 45 kg/ha + Spacing 25×20 cm). Sulphur was discovered to be more effective in enhancing the oil content of mustard seeds due to its active participation in glucoside production. These findings are consistent with those of Sahoo et al. [13].

Seed Yield (kg/ha): The significant higher seed yield (1756.67 kg/ha) was observed in treatment-9 (Sulphur 45 kg/ha + Spacing 25×20 cm), which was significantly superior over rest of the treatments. However, treatment-8 (Sulphur 45 kg/ha + Spacing 20×20 cm) was found to be statistically at par with treatment- 9 (Sulphur 45 kg/ha + Spacing 25×20 cm). Because of the reduced competition, root and leaf dispersion became more uniform. This improves more efficient light utilisation by increasing PAR interception during the flowering stage and radiation interception during the seed filling stage. Plants with equal distances between their leaves intercepted more sunlight per leaf. This could be because higher leaf area for interception of sunlight and equidistant spacing between plants improve Toria crop's ability to convert solar energy into seed production [14]. Sulphur spraying may result in an increase in seed production. Mustard is a crop that requires a lot of sulphur. Sulphur increases oil synthesis and is a component of seed protein, amino acids, enzymes, and glucosinolates [15]. Higher oil content in seed with increasing dosages of sulphur as SSP may be owing to higher SSP solubility in such soils favouring higher sulphur uptake. These findings agreed with those of previous researchers Kumar et al. [3].

Stover Yield (kg/ha): The significant higher seed yield (3206.67 kg/ha) was observed in treatment-9 (Sulphur 45 kg/ha + Spacing 25×20 cm), which was significantly superior over rest of the treatments. However, treatment-8 (Sulphur 45 kg/ha + Spacing 20×20 cm) was found to be statistically at par with treatment- 9 (Sulphur 45 kg/ha + Spacing 25×20 cm). The favourable effect of Sulphur treatment most likely triggered the manufacture of growth promoting chemicals, which stimulated root growth, cell elongation, and protein synthesis, resulting in enhanced plant growth and, as a result, increased stover yield. These findings agreed with those of Kumar et al. [16]. Furthermore, the bigger the number of plants per unit area, the greater the stover production. Toria's final stover yield is an expression of the combined influence of numerous components. The findings are consistent with those of Famda et al. [17][18].

4. CONCLUSION

It was concluded that with the application of Sulphur 45kg/ha along with the spacing 20 x 25 cm (Treatment-9), has performed positively and improved growth and yield parameters. Higher grain yield, gross returns, net returns and benefit cost ratio were also recorded with application of with Sulphur 45kg/ha along with the spacing 20 x 25 cm (Treatment-9).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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