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Influence of Sulphur and Spacing on Yield Attributes and Economics 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), available N (178.48 kg/ha). Results revealed that highest number of siliquae/plant (216.19), seeds/ siliquae (23.67), test weight (3.64 gm), seed yield (1756.67 kg/ha), stover yield (3206.67 kg/ha) and harvest index (35.39 %) were recorded with application of Sulphur 45 kg/ha + Spacing 25×20 cm. Maximum gross returns (INR 96,580.00/ha), net returns (INR 66,045.00/ha) and B:C ratio (2.16) were also recorded in treatment-9 (Sulphur 45 kg/ha + Spacing 25×20 cm).

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1. INTRODUCTION

Human life depends on oil seed crops. Food and have surpassed grains and legumes to become the third most important crop. They are an important source of vegetable oil, which offers 2.5 times the calories of proteins and carbohydrates. It contains vitamins E and D as well as fatty acids required for human physiology [1]. Edible oil is one of the most significant goods used by humans on a daily basis [2]. Rapeseed is a critical oilseed crop because it contains 40-46% good oil. Furthermore, each meal contains 38-40% protein and a significant number of amino acids such as lysine, methionine, and cysteine [3].

Toria is an annual herbaceous plant. The plant is not as tall as Mustard (Rai). The plant grows to a height of 45 to 150 cm. A waxy layer covers the stems in general. Rape's leaves are sessile and hairy. After China and Canada, India is third in the world in rape seed-mustard output. India accounts for around 35% of the total farmed land in the world, with 16% of the output share.

Sulphur deficiency has an impact on crop yield and quality since it is essential in protein and enzyme synthesis and is a constituent of amino acids such as methionine (21% S), cystein (26% S), and cystine (21% S). These amino acids include approximately 90% of plant Sulphur [4]. Sulphur is involved in the synthesis of chlorophyll, glucosides, glucosinolates, enzyme activation, and the sulphydryl (-SH) connections that give oil its pungency. As a result, oil seed crops require more Sulphur, which they absorb from the soil. According to Tandon [5], the removal of Sulphur per tonne of grain in cereals is 3 kg compared to 12 kg in oilseeds. Rapeseed and mustard have the highest Sulphur requirements of any oilseed crop [6]. Sulphur can be used to improve oil content in rapeseed and mustard (Brassica species).

Proper crop row spacing is an important agricultural aspect that has a large impact on yield and its numerous components [7]. Many researchers showed that narrow row spacing resulted in higher seed production than wider row spacing. Plants grown in extensive wider rows may not properly exploit natural growth factors such as light, water, and nutrients; nevertheless, crop planting in excessively narrower rows may result in intense inter and intra-row spacing competition [8]. Thus, it is critical to adopt the right row spacing for the specific crop in order to improve plant productivity and make optimum use of natural resources. Plant population is the most important element in determining the amount of radiation intercepted per plant. Row spacing in mustard varies greatly over the world, depending on cultivar, production system, and prevailing environmental conditions. Maintaining optimum row spacing is critical for crop growth and the time required for canopy closure, as well as the highest biomass and seed output [9].

Keeping these considerations in mind, the current study, titled “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.

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. 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. Harvesting was done by taking $1m^2$ area from each plot. And from it five plants were randomly selected for recording 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 25×20 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 number of siliqua/plant, number of seeds/siliqua, test weight, see yield and stover yield. The data was

subjected to statistical analysis by analysis of variance method [10].

3. RESULTS AND DISCUSSION

3.1 Yield Attributes

3.1.1 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), which was significantly superior over rest of the treatments. However, treatment-8 (Sulphur 45 kg/ha + Spacing 20×20) was found to be statistically at par with treatment- 9 (Sulphur 45 kg/ha + Spacing 25×20). The significant higher number of siliquae/plant (216.19) were recorded with the application of Sulphur. 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. [11]. Furthermore, wider plant spacing of 45 x 10cm significantly influenced yield attributes over closer spacings due to better geometric arrangement, which resulted in better absorption of moisture and nutrients and more photosynthesis, resulting in better manifestation of yield attributes [12].

3.1.2 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), which was significantly superior over rest of the treatments. However, treatment-8 (Sulphur 45 kg/ha + Spacing 20×20) was found to be statistically at par with treatment- 9 (Sulphur 45 kg/ha + Spacing 25×20). The significant higher number of seeds/siliqua (23.67) was observed with the application of SulphurThe 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. [13].

3.1.3 Test weight (gm)

The significant higher number of test weight (23.67 gm) was observed in treatment-9 (Sulphur 45 kg/ha + Spacing 25×20), which was significantly superior over rest of the treatments. However, treatment-8 (Sulphur 45 kg/ha + Spacing 20×20) was found to be statistically at par with treatment- 9 (Sulphur 45 kg/ha + Spacing 25×20). 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 favourable effect of Sulphur enhanced the translocation of photosynthates product towards seed and sink strength, and assimilate production was increased, which may be the r Similar findings are consistent with Chauhan et al. [14].

3.1.4 Oil content (%)

The significant higher percentage of oil content (42.70 %) was observed in treatment-9 (Sulphur 45 kg/ha + Spacing 25×20), which was significantly superior over rest of the treatments. However, treatment-8 (Sulphur 45 kg/ha + Spacing 20×20) was found to be statistically at par with treatment- 9 (Sulphur 45 kg/ha + Spacing 25×20). 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. [15].

3.1.5 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), which was significantly superior over rest of the treatments. However, treatment-8 (Sulphur 45 kg/ha + Spacing 20×20) was found to be statistically at par with treatment- 9 (Sulphur 45 kg/ha + Spacing 25×20).

As a result, 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 [16]. 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 [17]. 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 and Trivedi [18].

3.1.6 Seed yield (kg/ha)

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3.1.7 Stover yield (kg/ha)

The significant higher stover yield (3206.67 kg/ha) was observed in treatment-9 (Sulphur 45 kg/ha + Spacing 25×20), which was significantly superior over rest of the treatments. However, treatment-8 (Sulphur 45 kg/ha + Spacing 20×20) was found to be statistically at par with treatment-9 (Sulphur 45 kg/ha + Spacing 25×20).

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 and Yadav [19]. 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. [20].

Table 1. Influence of sulphur and spacing on yield attributes of toria

S. No.	Treatment combinations	No. of. Siliqua /plant	No. of. Seeds/ Siliqua	Test weight (gm)	Oil Content (%)	Seed yield (kg/ha)	Stover yield (kg/ha)	Harvest Index (%)
1.	Sulphur 15 kg/ha + Spacing 20×15	162.36	19.19	2.80	37.24	1470.00	2366.67	30.61
2.	Sulphur 15 kg/ha + Spacing 20×20	167.47	18.77	2.88	38.97	1100.00	2563.33	30.02
3.	Sulphur 15 kg/ha + Spacing 25×20	169.98	19.91	3.05	39.81	1146.67	2680.33	30.04
4.	Sulphur 30 kg/ha + Spacing 20×15	175.03	21.19	3.21	38.87	1230.00	2803.33	30.54
5.	Sulphur 30 kg/ha + Spacing 20×20	182.47	22.32	3.32	40.32	1306.67	2893.33	31.11
6.	Sulphur 30 kg/ha + Spacing 25×20	189.65	22.69	3.41	41.29	1376.67	3053.33	31.08
7.	Sulphur 45 kg/ha + Spacing 20×15	201.83	21.35	3.47	40.80	1480.00	3103.33	32.24
8.	Sulphur 45 kg/ha + Spacing 20×20	209.75	23.17	3.58	41.94	1610.00	3180.00	34.52
9.	Sulphur 45 kg/ha + Spacing 25×20	216.19	23.67	3.64	42.70	1756.67	3206.67	35.39
10.	Control	180.17	19.18	3.12	37.56	1190.00	2723.33	30.41
	F test	S	S	S	S	S	S	S
	SEm(±)	1.87	0.23	0.06	0.27	133.39	98.35	0.71
	CD (P=0.05)	5.57	0.69	0.19	0.80	396.10	4.22	2.12

Table 2. Influence of sulphur and spacing on economics of toria

S. No.	Treatment combinations	Cost of cultivation (INR/ha)	Gross return (INR/ha)	Net return (INR/ha)	B:C Ratio
1.	Sulphur 15 kg/ha + Spacing 20×15	28720.00	60213.00	31493.00	1.09
2.	Sulphur 15 kg/ha + Spacing 20×20	28420.00	60500.00	32080.00	1.13
3.	Sulphur 15 kg/ha + Spacing 25×20	28120.00	63030.00	34910.00	1.24
4.	Sulphur 30 kg/ha + Spacing 20×15	29935.00	67650.00	37715.00	1.26
5.	Sulphur 30 kg/ha + Spacing 20×20	29635.00	71830.00	42195.00	1.42
6.	Sulphur 30 kg/ha + Spacing 25×20	29335.00	75680.00	46345.00	1.58
7.	Sulphur 45 kg/ha + Spacing 20×15	31135.00	81400.00	50265.00	1.61
8.	Sulphur 45 kg/ha + Spacing 20×20	30835.00	92180.00	61345.00	1.99
9.	Sulphur 45 kg/ha + Spacing 25×20	30535.00	96580.00	66045.00	2.16
10.	Control	27220.00	65450.00	38230.00	1.40

3.2 Economic Analysis

3.2.1 Gross returns

Observations regarding the economics of treatments are given in table.

Highest gross return (96580.00 INR/ha) was obtained in treatment-9 (Sulphur 45 kg/ha + Spacing 25×20) as compared to other treatments.

3.2.2 Net returns

Net return (66045.00 INR /ha) was found to be highest in treatment-9 (Sulphur 45 kg/ha + Spacing 25×20) as compared to other treatments.

3.2.3 Benefit cost ration

Benefit Cost ratio (2.16) was found to be highest in treatment-9 with (Sulphur 45 kg/ha + Spacing 25×20) as compared to other treatments.

4. CONCLUSION

It was concluded that with the application of Sulphur 45kg/ha along with the spacing 25 x 20 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 Sulphur 45kg/ha along with the spacing 20 x 25 cm (Treatment-9). These findings are based on one season therefore; further trials may be required for further confirmation.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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