Original Research Article

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

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/plant), 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 gm), higher seed yield (1.76 t/ha), higher stover yield (3.21 t/ha) and higher harvest index (35.39 %) were significantly influenced with application of Sulphur 45 kg/ha + Spacing 25×20 cm.

Keywords:*Toria, Sulphur, Spacing, growth parameters, and yield attributes.*

INTRODUCTION

In the Brassica family, rapeseed (*Brassica campestrisvar*. toria), sometimes known as raya, rai, or lahi, is a significant oilseed crop. oil seed group in India. After peanuts, it is the second-most significant edible oilseed crop in India and produces close to 30% of all oilseeds grown there.

A major category of edible oil seed crops, rapeseed-mustard accounts for around 85% of all rapeseed-mustard produced in India and provides about 26.1% of all oil seed output **(Meena *et al.*, 2011).** After China, it holds the top spot in terms of area and production **(Anonymous, 2009)**. In 53 nations, rapeseed and mustard crops are grown. Spreading over the six continents across the globe covering an area of 24.2 million hectare. Indians' contribution to world hectare and production is 28.3 and 19.8 percent respectively.

Rapeseed is rich in minerals like calcium, manganese, copper, iron, selenium, zinc, vitamin A, B, C and proteins. 100g mustard seed contains 508 kcal energy, 28.09g carbohydrates, 26.08g proteins, 26.08 g total fat and 12.2g dietary fiber.

Oil seed crops needed Sulphur in significant part because they require the amino acids cystine (27%), cysteine (26%) and methionine (21%), which are Sulphur-containing and necessary for both protein and oil production in plants as well as vegetative development. Sulphur is primarily responsible for the synthesis of glucosinolates (found in rapeseed and mustard oil), glucosides, and chlorophyll, which gives things their green colour.is accountable for activating the sulphydryl linkage, which mostly adds flavor to oil crops like mustard and rapeseed.

Sulphur causes oil seed to produce more of it **(Kumar and Trivedi 2012**). Crops of the Brassica family are particularly susceptible to Sulphur deficiency, which manifests as symptoms such leaves that cup or curl inward and have crimson undersides; in extreme situations, this condition extends to the stem and both sides of leaves.

Among agronomic practices, row spacing plays a vital role in augmenting production potential of rapeseed and mustard. Spacing of crop plants mainly depends on their growth habits, however, the magnitude of growth is governed by edaphic and climatic factors. Spacing is a non-monetary input, but it plays significant role in production. The plant density per unit area and the yield per plant are two most important and inter-dependent factors responsible for crop yield **(Singh and Dhillon,1991)**. Too high plant population

may cause adverse effect on crop yield through interplant competition for nutrient, moisture, light and space, while low plant population may not take full advantage of applied nutrients.

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.

MaterialsandMethods

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. 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 20×15 cm), T_3 – (Sulphur – 15 kg/ha + Spacing 20×15 cm), T_4 -(Sulphur – 30 kg/ha + Spacing 20×20 cm), T_5 -(Sulphur – 30 kg/ha + Spacing 20×20 cm), T_6 -(Sulphur – 30 kg/ha + Spacing 20×20 cm), T_7 -(Sulphur – 45 kg/ha + Spacing 25×20 cm), T_8 -(Sulphur – 45 kg/ha + Spacing 25×15 cm), T_9 -(Sulphur – 45 kg/ha + Spacing 25×15 cm), and Control Plot. The observations were recorded for plant height, dry weight, Crop growth rate, 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 **(Gomez and Gomez, 1976).**

Comment [HUR1]: It seems that the combinations of the amount of sulphur and space are incorrect, they are repeated.

ResultsandDiscussion

Growthparameters:

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) However, treatment-8

Comment [HUR2]: What does DAS stand for?

(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 significantly higher plant height was observed with the application of Sulphur 45 kg/ha. this might be due to adequate nutrients which are turns help in vigorous vegetative growth of plants and subsequently increase the plant height through cell elongation cell division photosynthesis and turbidity of plant cell. **Tripathi *et al.*, (2011).**And also, further increase in plant height is could be due to plant spacing. In mustard, row spacing varies significantly across the world, subject to the cultivar, production system and prevailing environmental conditions of a particular region. Maintaining a proper row spacing is a vital factor to improve the growth of the crop and the time essential for canopy closure.Similar results were reported by **Svecnjak*et al.*, (2006).**

Comment [HUR3]: The combinations Sulphur-space do not coincide with those described in materials and methods

Dry weight/plant- At 60 DAS, the significantly higher plant dry weight (17.70 gm) was observed in treatment-9 (Sulphur 45 kg/ha + Spacing 25×20) 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 significantly higher plant dry weight (17.70 gm) was observed with the application of Sulphur 45 kg/ha. This might be due to Sulphur levels which helps in promoting and hastening the metabolic process, physiological activities and increasing the photosynthesis process related to growth as a result of increasing in height in plant, number of branches of plant and leaves and others above ground and below ground structures of plant which were the probable reason of hastening the dry matter accumulations in plant**Mallick *et al.* (2015).**and also, further increase in dry matter due to with maximum spacing these leads in higher number of leaves and larger leaf area resulted in more photosynthetic activities and more accumulation of carbohydrates and thereby increase in dry matter production and soybean crop fix atmospheric nitrogen that's why the plant growth was better than cereals crop. **Prasad *et al.* (1993).**

Comment [HUR4]: The combinations Sulphur-space do not coincide with those described in materials and methods

Crop growth rate - At 45-60 DAS, the significantly higher plant dry weight (13.6 g/m^2 /day) was observed in treatment-1 (Sulphur 15 kg/ha + Spacing 20×15) However, treatment-2 (Sulphur 15 kg/ha + Spacing 20×20) was found to be statistically at par with treatment- 1 (Sulphur 15 kg/ha + Spacing 20×20). Sulphur levels which help in promoting and hastening the metabolic process, physiological activities and increasing the photosynthesis process related to growth as a result of increasing in height in plant, number of branches of plant and leaves and others above ground and below ground structures of plant which were the probable reason to ultimate increase in crop growth rate **Mallick *et***

Comment [HUR5]: The combinations Sulphur-space do not coincide with those described in materials and methods

***al.* (2015).**

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), 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. That could be possibly due to synergistic effect of sulphur which encourages flower and seed formation in siliqua. One of the reasons might be due to increase in leaf area, plant height and increased photosynthesis rate lead to increase sink size. This is in accordance with the findings of **Saini *et al.*, (2020).** And also, withWider plant spacing of 45 x 10cm markedly influenced the yield attributes over closer spacings owing to better geometric arrangement, resulted in better absorption of moisture and nutrients and more photosynthesis which consequently resulted in better manifestation of yield attributes. **Ramanathan and Chandrashekharan (1998).**

Comment [HUR6]: The combinations Sulphur-space do not coincide with those described in materials and methods

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 Sulphur. Increase in seeds/siliqua (No.) and test weight (g) were due to the positive effect of Sulphur at higher levels which is responsible for stimulating of flower, formation of siliqua and formation of seed in siliqua. Sulphur enhanced the translocation of photosynthates product toward seed and sink strength and production of assimilates was increased which may be the reason of increase seeds/siliqua (No.) and test weight (g). similar results were reported with **Nath *et al.*, (2018).**

Comment [HUR7]: The combinations Sulphur-space do not coincide with those described in materials and methods

Test weight (gm)

The significant higher number of test weight (3.64 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

Comment [HUR8]: The combinations Sulphur-space do not coincide with those described in materials and methods

levels which is responsible for stimulating of flower, formation of siliqua and formation of seed in siliqua and also the maximum amount of phosphorus nutrient found in the seed and siliqua of yellow mustard plant which is responsible for formation seed and thickness of seed and the favorable effect of Sulphur enhanced the translocation of photosynthates product toward seed and sink strength and production of assimilates was increased which may be the reason of increase test weight (g). similar results are conformity with **Chauhan *et al.* (2020).**

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 found more efficient in increasing the oil content of the mustard seeds due to intensive participation of Sulphur in glucoside synthesis. These results are in close conformity with the findings of **Sahoo *et al.* (2018).**

Comment [HUR9]: The combinations Sulphur-space do not coincide with those described in materials and methods

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). This reduced competition resulted more uniform root and leaf distribution. Which promotes more effective utilization of light by enhancing interception of PAR at flowering stage and radiation interception during seed filling stage. Equal distance plants orientation of leaves allowed more interception of sunlight by per leaf. That also might be due to more leaf area for interception of sun light and equidistant spacing between plants increase the ability of Toria crop to transform solar radiation into seed production **(Beenish *et al.*, 2019).** Further increase in seed yield might be due sulphur application. Mustard is a high sulphur demanding crop. Sulphur promotes oil synthesis and it is an important constituent of seed protein, amino acid, enzymes and glucosinolate**(Shekhawat et al. 2012).** Comparatively higher oil content in seed with increasing doses of sulphur as SSP might be due to higher solubility of SSP in such soils favouring higher uptake of sulphur. These results corroborated with the findings of the earlier researchers **Kumar and Trivedi (2012).**

Comment [HUR10]: The combinations Sulphur-space do not coincide with those described in materials and methods

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), 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 beneficial effect of Sulphur application probably induced the synthesis of growth promoting substances which would stimulate the root growth, cell elongation and protein synthesis resulting in better plant growth which in turn increases the stover yield. These results corroborated with findings of **Kumar and Yadav (2007).** And the greater number of plants per unit area contributed more stover yield. Final stover yield of Toria is expression of combined effects of various components. The results are in conformity with the findings of **Famda*et al.*, (2017).**

Comment [HUR11]: The combinations Sulphur-space do not coincide with those described in materials and methods

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). These findings are based on one season therefore; further trials may be required for further confirmation.

Table 1. Influence of Sulphur and Spacingon growth parameters of Toria.

S. No.	Treatment combinations	Plant height	Plant Dry Weight	Crop growth rate
1.	Sulphur 15 kg/ha + Spacing 20×15	90.02	14.28	13.6
2.	Sulphur 15 kg/ha + Spacing 20×20	93.93	14.45	13.1
3.	Sulphur 15 kg/ha + Spacing 25×20	95.84	15.11	13.0
4.	Sulphur 30 kg/ha + Spacing 20×15	93.87	15.54	12.8
5.	Sulphur 30 kg/ha + Spacing 20×20	98.07	15.99	12.7
6.	Sulphur 30 kg/ha + Spacing 25×20	99.07	16.63	11.8
7.	Sulphur 45 kg/ha + Spacing 20×15	101.33	16.80	9.8
8.	Sulphur 45 kg/ha + Spacing 20×20	103.39	17.14	10.1
9.	Sulphur 45 kg/ha + Spacing 25×20	105.93	17.70	10.6
10.	Control	95.55	14.56	10.3
	F test	**S**	S	S
	SE m (±)	1.04	0.22	0.73
	CD (P=0.05)	3.10	**0.65**	2.16

Comment [HUR12]: Here the combinations Sulphur-Spacing if they are correctly described

Table 2. Influence of Sulphur and Spacingon 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	36.95
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	NS
	SEm(±)	1.87	0.23	0.06	0.27	133.39	98.35	2.09
	CD (P=0.05)	5.57	0.69	0.19	0.80	396.10	4.22	-

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