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

ABSTRACT

A field experiment was conducted during *Rabi* season of 2022-23 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 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: *Sulphur, Spacing, Toria, growth parameters and yield attributes.*

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 **(Meena *et al*., 2011)**. In terms of area and production, it comes in second place to China **(Anonymous, 2009)**. 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 **(Kumar and Trivedi, 2012)**. 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.

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. 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, 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).**

Results and Discussion

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.*, (2011).** 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.* (2006)** observed similar findings.

Dry Weight/plant- At 60 DAS, the significantly higher plant dry weight (17.70 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 (17.70 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.* (2015)** 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.*, (1993)**.

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 cm) However, treatment-2 (Sulphur 15 kg/ha + Spacing 20×20 cm) was found to be statistically at par with treatment- 1 (Sulphur 15 kg/ha + Spacing 20×20 cm). Sulphur levels that 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 that were the probable reason for the eventual increase in crop growth rate **Mallick *et 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 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 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.* (2020)**. Furthermore, wider plant spacing of 45 x 10 cm 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. **Ramanathan *et al.*, (1998)**.

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*. (2018)**.

Test weight (gm)

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 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 favourable 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.* (2020).**

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.* (2018)**.

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 **(Beenish *et al.*, 2019)**. 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 **(Shekhawat *et al.* 2012)**. 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.* (2012)**.

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.* (2007)**. 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. (2017)**.

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).

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

S. No.	Treatment combinations	Plant height (cm)	Dry weight (g)	Crop growth rate (g/m^2/day)
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

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	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

REFERENCES:

1. Abbas M, Singh MP, Nigam KB, Kandalkar VS (1994). Effect of phosphorus, plant densities and plant type on different growth and physiological parameter of soybean. *Indian Journal of Agronomy*, **39**(2):246-248.
2. Anonymous (2009-10) Economic survey, Ministry of Finance, *Government of India*.
3. Beenish, O., Singh, R., & Lal, E. P. (2019). Impact of nutrient management system on growth, yield and quality of Indian mustard (*Brassica juncea* L.) cv. Rani variety. *Journal. Pharmacogn. Phytochem*, **8**, 4391-4394.
4. Chauhan ZY, Patel DK, Bhabhor K (2020). Effect of Nitrogen, phosphorus and Sulphur on yield, nutrient uptake and soil fertility after harvest of mustard (*Brassica juncea* L.*). International Journal of Current. Microbiology and Applied Sciences*, **9**(6):3506-3512.
5. Famda L, Singh D, Jat L. (2017) Effect of phosphorus and sulphur nutrient on Brassica campestris L. variety toria under dry land condition. *Asian Journal of Environmental Science*, **12**(1):69-82.
6. Gomez, K. A and Gomez, A. A (1976). Three or more factor experiment. In: *Statistical Procedure for Agricultural Research* **2**nd edition, p. 139 -141.
7. Kumar R, Trivedi SK. (2012) Effect of levels and source of sulphur on yield, quality and nutrient uptake by mustard (*Brassica juncea*). *Progressive Agriculture*, **12**(1):69-73.
8. Kumar H, Yadav DS (2007). Effect of phosphorus and sulphur levels on growth, yield and quality of Indian mustard (*Brassica juncea*) cultivars. *Indian Journal of Agronomy*, **52**(2):154-157.
9. Meena, P.D., Chattopadhyay, C., Kumar, K., Awasthi, R.P., Singh, R., Kaur, S., Thomas, L., Goyal, P. and Chand. P. (2011) Comparative study on the effect of chemicals on Alternaria blight in Indian mustard – A multi-location study in India. *Journal of Environmental Biology*. **32**, 375-379.
10. Mallick RB, Raj A. (2015) Influence of phosphorus, sulphur and boron on growth, yield, nutrient uptake and economics of rapeseed (*Brassica campestris* L. Var. Yellow Sarson). *International Journal of Plant, Animal and Environmental Sciences* **5**(3):22-27.
11. Nath S, Patel BT, Meena O, Jat GP (2018). Effect of phosphorus and Sulphur on yield attributes, yield and economics of mustard (*Brassica juncea* L.). *Journal of Pharmacognosy and Phytochemistry*, **7**(5):438-500.
12. Prasad JVNS, Ramaiah NV, Satyanarayana V. (1993) Response of soybean (*Glycine*

max) to varying levels of plant densities and phosphorus. *Indian Journal of Agronomy*, **38**(3):494-495.

13. Ramanathan, S.P. and Chandrashekharan, B. (1998). Effect of nipping, plant geometry and fertilizer on summer sesame (*Sesamum indicum* L.). *Indian Journal of Agronomy*. **43** (2): 329-332.
14. Sahoo GC, Santra GH, Biswas PK, Mishra S (2018). Influence of doses and source of sulphur on yield, quality and economics of mustard (*Brassica campestris var*. toria) in red soil of Odisha. *Annals of Plant and Soil Research*, **20**(1):46-51.
15. Saini, L. B., Kakraliya, M. and Kumar, P. (2020). Effects of Different Levels of NPK and Sulphur on Growth and Yield Attributes of Rapeseed (*Brassica campestris var*. toria). Journal homepage: http://www. ijcmas. com, **9**(9), 2020.
16. Shekhawat, K., Rathore, S.S., Premi, O.P., Kandpal, B.K. and Chuhan, J.S. (2012). Advances in Agronomic Management of Indian mustard: An Overview. *International Journal of Agronomy*, **20**: 12-14.
17. Svecnjak, Z., Varga, B. and Butorac, J. (2006). Yield components of apical and subapical ear contributing to the grain yield responses of prolific maize at high and low plant populations. *Journal of Agronomy and Crop Science*. 192, 37-42.
18. Tripathi M. K., Chaturvedi, S. Shukla, D. K. Saini, S. K. (2011) Influence of integrated nutrient management on growth, yield and quality of Indian mustard (*Brassica juncea* L.) in tarai region of northern India. *Journal of Crop and Weed*, **7**(2):104-107.