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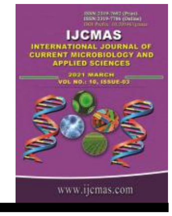

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Effect of Different Levels of Sulphur on Growth and Yield of Gobhisarson (*Brassica napus* L.)

Vishal and Ratnesh Kumari*

Department of Agricultural Science, UISH, Sant Baba Bagh Singh University, Khiala, Punjab, India

**Corresponding author*

ABSTRACT

Keywords

Gobhisarson, Growth, Parameters, Yield, Sulphur

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A field experiment entitled "Effect of different levels of sulphur on growth and yield of Gobhi sarson (*Brassica napus* L.)" was conducted during the *rabi* season 2019-2020 in the experimental field of Sant Baba Bagh Singh University, Khiala, Punjab. The experiments were conducted with seven treatments (T1: control, T2: 5 kg S/ha, T3: 10 kg S/ha, T4: 15 kg S/ha, T5: 20 kg S/ha, T6: 25 kg S/ha, T7: 30 kg S/ha) in RBD (Randomized Block Design) with three replications of each treatment. Different observations were recorded on the growth parameters like plant height and number of leaves and branches before the harvesting of the crop at an interval of 30, 60, 90, 120, 150 DAS (Days After Sowing). And after the harvesting of the crop, the parameters on yield and yield attributes viz; number of siliqua per plant, length of siliqua (cm), number of grains per siliqua, 1000 seed weight (gm), grain yield (q/ha), stover yield (q/ha), and harvesting index (%) were recorded. The results showed that the application of sulphur @ 25-30 kg was better in obtaining higher yield and yield parameters.

Introduction

India is one of the largest producers of Rapeseed-mustard in the world. India holds the third rank inthe area and second in production after China. Rapeseed-mustard occupies an important position among oilseed crops that are grown in India. In eastern India, especially in southern parts of West Bengal, where winter is short and mild, rapeseed crop is preferred by the farmers as with one or two life-saving irrigation(s) it gives good yield (Rana *et al.*, 2005). Many states in India produce a high yield of mustard. Punjab produces more than 8 lakh tonnes of the total production of India. States like Rajasthan, U.P, and Haryana is 32 lakh, 8.48 lakh tonnes production in (2016-17) (Anonymous 2016). The low productivity of crops is due to soils becoming deficient in N, P, K along with sulphur, zinc, and boron due to the increased use of fertilizers and intensive cultivation (Srivastava *et al.*, 2006).

The yield and performance of brassica oilseeds depend upon various factors. Stubble types or crop residues from the previous cropping year significantly impact the performance of oil seeds in the following year (Hossain *et al.,* 2019). Zn and Fe enriched FYM enhanced the uptake of N, S, and other micronutrients by mustard, and improved the oil and protein content of the mustard seeds (Meena *et al.*, 2016). Sulphur (S) has emerged as the third important plant nutrient for oilseed crops and plays a vital role in the metabolic activities of the plant. Deficiency of sulphur may result in poor flowering and fruiting, cupping of leaves, reddening of stem and petiole, and stunted growth (Singh *et al.*, 2020). The non-food oil-seed crop, *Brassica carinata* shows potential for biofuel feedstock (Seepaul *et al.,* 2021).

Sulphur deficiencies in India are widespread and scattered. The deficiency of sulphur in Indian soils is on increase due to the intensification of agriculture with high-yielding varieties. Multiple cropping coupled with the use of sulphur-free fertilizers along with the strict or no use of organic manures has accrued in depletion of the soil sulphur reserve (Chattopaddhyay *et al.*, 2009). Keeping this information in mind on gobhisarson the present study was planned to find the optimum dose of sulphur which will give higher yields in the crop.

Materials and Methods

The present investigation was carried out at Research Farm, Department of Agriculture, Sant Baba Bagh Singh University during *Rabi* season 2019-2020. The experimental design was Randomized Block Design (RBD) with seven different treatments with three replications each making a total of 21 plots. The composite soil samples were taken from 0-15 cm and 15-30 cm depth from the experimental field before sowing of the crop to determine the mechanical characteristics, native-fertility, and texture of the soil of the experiment field. The results of the above parameters reveal that soil texture was sandy loam (fine sand, 66.3%; silt, 17.6%; and clay, 15.6%), pH (8.1), EC (0.13 dsm^{-1}), OC (0.14%), available nitrogen (442.88 kg ha^{-1}), available phosphorus (9.3 kg ha^{-1}), and available potassium (221.60 kg ha^{-1}). The variety of Gobhi-sarson used for this experiment was Hayola PAC 401. The sowing of the crop was done after the first fortnight of October. The application of fertilizers was done at the time of sowing of the crop so that the crop should get maximum nutrients for growth. The other inter-cultural operations such as bunds preparation, field preparation, thinning, weeding and fertilization were also carried out as per packages and practices of PAU (Anonymous, 2019). The observation to be recorded were of growth attributes, yield, and yield attributes were recorded before or at the time of harvesting of the crop from five randomly selected plants from each replication of each treatment. The plant height, number of leaves per plant, and number of branches per plant were recorded at an interval of 30, 60, 90, 120, 150 DAS. The yield and yield parameters were measured in form of number of siliqua per plant, siliqua length (cm), number of grains per siliqua, 1000 seed weight (gm), grain yield (q/ha), stover yield (q/ha), and harvesting index (%).

Statistical analysis: Data were analyzed using SPSS (Version16.0 SPSS) statistical software.

Results and Discussion

Growth attributes

Plant growth was determined in the form of plant height (Table 1), number of leaves per plant (Table 2), and number of branches (Table 3). The plant height was measured at five different growth stages of the crop viz. 30, 60, 90, 120, and 150 DAS. The plant height which was measured at 30 DAS showed that the maximum height of the plant was found in the control (13.03 cm) when the application of any kind of fertilizer was not given. This may be because of the effect of fertilizers that were used in the previous crop season (Hocking *et al.,* 1997). The lowest plant height among all treatments was found with the application of 20 kg of S/ha (9.87 cm). This may be because of any living or non-living factor which may affect the growth of the plant at that plot. The plant height which was measured at 60 days after sowing showed maximum plant height in T5 (25.53 cm) followed by T1 (25.50 cm). The lowest was found with the application of T3 (10kg S/ha) (23.10 cm). The plant height measured after 90 days of sowing showed that the maximum plant height was with the application of 30 kg/ha sulphur, T7 (46.87 cm) which is followed by T3 (46.47 cm) and then by T6 (46.47 cm). The lowest plant height was found with the application of 5 kg of S/ha, T2 (42.93 cm) at 90 DAS. At 120 DAS, the maximum plant height was found with the application of 30 kg S/ha (69.00 cm) followed by application of 25 kg S/ha (65.77 cm), and the lowest plant height was found in T1- control (60.63 cm). The same pattern of plant height was followed at 150 DAS. This pattern of the plant height indicates that the more amount of sulphur application positively correlated with the plant height. This result is supported by (Patel *et al.,* 2009).

The maximum number of leaves corresponds to the maximum photosynthetic ability. The number of leaves counted at 30 DAS showed that the maximum number of leaves were present in T1- control (6.00 leaves/plant) followed by T6 (25 kg S/ha) (5.67 leaves/plant). The lowest number of leaves were found in T3 (10 kg S/ha) (4.33 leaves/plant). The maximum number of leaves counted at 60 DAS were observed with T6 (25 kg S/ha) and T7 (30 kg S/ha) with 9.00 leaves/plant. The lowest number of leaves were found in T2 (5 kg S/ha) and T3 (10kg S/ha). Leaves counted at 90 DAS shows that the maximum number of leaves was found in T5 (20 kg S/ha) (14.00 leaves/plant) followed by T2 (5 kg S/ha) and T3 (10 kg S/ha) at par 13.00 leaves/plant. At 120 and 150 DAS, the maximum number of leaves were found in T7 (30 kg S/ha) (26.00 leaves/plant) followed by T6 (25 kg S/ha) (25.00 cm, 25.33 leaves/plant, respectively). The lowest number of leaves was found in T1 (control) (Kaur *et al.,* 2019)

Table.1 Effect of different level sulphur on plant height (cm) in gobhi-sarson

Treatments	Plant height at 30 DAS	Plant height at 60 DAS	Plant height at 90 DAS	Plant height at 120 DAS	Plant height at 150 DAS
T1	13.03^{a}± 1.32	25.5^{a}± 0.86	41.17^{d}± 1.27	60.63^{c}± 0.92	62.37^{b}± 1.52
T2	11.1^{b}± 1.13	24.43^{a}± 0.67	42.93^{c}± 1.38	63.93^{b}± 0.96	66.13^{b}± 1.59
T3	10.77^{b}± 0.80	23.1 ^{a}± 0.96	46.47^{a}± 1.05	63.57^{b}± 0.95	63.53^{b}± 1.54
T4	11.5^{b}± 1.01	25.1^{a}± 1.51	46.23^{a}± 1.61	63.63^{b}± 1.20	64.9^{b}± 1.55
T5	9.87^{b}± 0.95	25.53^{a}± 1.8	44.87^{b}± 1.52	65.00^{b}± 0.91	66.7^{b}± 0.98
T6	10.57^{b}± 1.31	24.03^{a}± 1.56	46.37^{a}± 1.39	65.77^{b}± 0.98	68.87^{b}± 0.99
T7	10.63^{b}± 0.92	24.77 ^{a}± 1.90	46.87^{a}± 1.38	69.00^{a}± 1.52	70.43^{a}± 1.58
CD (0.05)	1.03	1.67	1.11	1.83	1.56

Note: T1- Control, T2- 5 kg S/ha, T3- 10 kg S/ha, T4- 15 kg S/ha, T5- 20 kg S/ha, T6- 25 kg S/ha, T7- 30 kg S/ha

Table.2 Effect of different level sulphur on number of leaves per plant in gobhi-sarson

Treatments	No. of leaves at 30 DAS	No. of leaves at 60 DAS	No. of leaves at 90 DAS	No. of leaves at 120 DAS	No. of leaves at 150 DAS
T1	6.00[a] ± 1.02	8.33[a] ± 0.56	12.33[a] ± 1.37	18.33[b] ± 0.92	17.33[c] ± 1.52
T2	5.33[a] ± 1.23	7.33[a] ± 0.87	13.00[a] ± 1.38	23.33[a] ± 0.96	23.00[a] ± 1.53
T3	4.33[a] ± 0.98	7.33[a] ± 0.96	13.00[a] ± 1.35	18.00[b] ± 0.95	19.33[b] ± 1.54
T4	5.00[a] ± 1.10	7.67[a] ± 1.10	12.67[a] ± 1.41	24.67[a] ± 0.99	24.33[a] ± 1.55
T5	4.67[a] ± 0.95	7.67[a] ± 1.58	14.00[a] ± 1.42	25.00[a] ± 0.91	25.00[a] ± 1.61
T6	5.67[a] ± 1.20	9.00[a] ± 1.51	12.00[a] ± 1.39	25.00[a] ± 0.98	25.33[a] ± 1.59
T7	5.33[a] ± 0.90	9.00[a] ± 1.59	12.33[a] ± 1.38	26.00[a] ± 0.93	26.00[a] ± 1.58
CD (0.05)	1.09	1.03	1.03	1.49	1.68

Note: T1- Control, T2- 5 kg S/ha, T3- 10 kg S/ha, T4- 15 kg S/ha, T5- 20 kg S/ha, T6- 25 kg S/ha, T7- 30 kg S/ha

Table.3 Effect of different level sulphur on no. of branches per plant in gobhi-sarson

Treatments	Number of branches/plants
T1	5.33[a] ± 0.52
T2	6.00[a] ± 0.90
T3	6.00[a] ± 0.78
T4	6.33[a] ± 0.43
T5	5.00[a] ± 0.95
T6	6.67[a] ± 0.61
T7	6.33[a] ± 0.72
CD (0.05)	1.29

Note: T1- Control, T2- 5 kg S/ha, T3- 10 kg S/ha, T4- 15 kg S/ha, T5- 20 kg S/ha, T6- 25 kg S/ha, T7- 30 kg S/ha

Table.4 Effect of different level sulphur on yield attributes of gobhi-sarson

Treatments	Number of siliqua/plants	Number of grains/siliquas	Length of siliqua	1000 Seed weight
T1	87.67[c] ± 0.56	13.67[c] ± 0.92	5.53[b] ± 0.37	4.03[b] ± 0.52
T2	94.67[b] ± 0.87	16.67[b] ± 0.96	5.80[b] ± 0.38	4.07[b] ± 0.53
T3	94.67[b] ± 0.96	18.00[a] ± 0.95	6.27[a] ± 0.35	4.30[b] ± 0.56
T4	113.67[a] ± 1.10	18.33[a] ± 0.99	6.40[a] ± 0.41	4.23[b] ± 0.59
T5	109.33[a] ± 1.58	19.67[a] ± 0.91	6.67[a] ± 0.42	4.33[b] ± 0.61
T6	113.67[a] ± 1.51	19.00[a] ± 0.98	6.93[a] ± 0.39	4.40[b] ± 0.62
T7	117.33[a] ± 1.59	20.33[a] ± 0.93	7.37[a] ± 0.38	4.70[a] ± 0.58
CD (0.05)	5.49	1.95	0.45	0.26

Note: T1- Control, T2- 5 kg S/ha, T3- 10 kg S/ha, T4- 15 kg S/ha, T5- 20 kg S/ha, T6- 25 kg S/ha, T7- 30 kg S/ha

Table.5 Effect of different level sulphur on grain yield in gobhi-sarson

Treatments	Grain Yield	Harvest index	Stover Yield
T1	14.00[b]± 1.02	21.02[a]± 1.37	52.50[b]± 0.56
T2	15.53[b]± 1.23	21.18[a]± 1.39	54.13[b]± 0.87
T3	15.63[b]± 0.98	21.47[a]± 1.35	57.20[b]± 0.96
T4	15.87[b]± 1.10	22.13[a]± 1.41	55.77[b]± 1.10
T5	16.63[b]± 0.95	21.50[a]± 1.42	60.67[b]± 1.58
T6	16.67[b]± 1.20	22.29[a]± 1.38	62.03[b]± 1.51
T7	19.07[a]± 0.90	22.09[a]± 1.38	67.27[a]± 1.59
CD (0.05)	1.73	2.06	3.66

Note: T1- Control, T2- 5 kg S/ha, T3- 10 kg S/ha, T4- 15 kg S/ha, T5- 20 kg S/ha, T6- 25 kg S/ha, T7- 30 kg S/ha

The number of branches per plant was counted before harvesting and the number of branches was maximum in T6 (6.67 per plant) with the application of 25 kg S/ha followed by T4 (15 kg S/ha) and T7 (30 kg S/ha). The lowest number of branches per plant was found in T1-control (5.33 per plant). This result is supported by (Tomar *et al.*, 1996).

Yield attributes

Yield attributes that are directly related to the yield were also recorded in this experiment. The number of siliqua per plant was maximum for T7 (117.33 per plant) in which sulphur was supplied at 30 kg/ha followed by T6 (113.67 per plant) and T4 (113.67 cm). The lowest number of siliqua was found in T1- Control (87.67 per plant). The results are supported by (Kumar and Singh 2006). The length of the siliqua was measured before the harvesting which is a good indicator of number of seeds in asiliqua. The maximum length was found with the application of 30 kg S/ha (7.37 cm) followed by T6 (6.93 cm) i.e., 5 kg /ha. This may indicate that the maximum supply of sulphur may increase the siliqua length. The lowest siliqua length was found in T1-Control (5.53 cm). Sipai (2015) also supports the results. The number of grains inside the siliqua was counted after the harvest and it was observed that the maximum number of seeds were in T7 (30 kg S/ha) (20.33 grains/siliqua). This result was expected when the maximum height of the siliqua was more in the same treatment. T5 (20 kg S/ha) also performed better having 19.67 gains/siliqua. The lowest number of grains per siliqua was found in T1- control (13.67gains/siliqua). The beneficial effects of sulphur on yield attributes were also reported by Khanpara (1993) and Sharma (2020). The highest seed weight for 1000 seeds was for T7 (30 kg S/ha) i.e, 4.70 gm followed by T6 (25 kg S/ha) i.e., 4.40 gm. The lowest weight of 1000 seeds was reported in T1- control i.e., 4.03 gm. As all the other parameters were increased with this treatment, this was expected. The same is supported by Mehriyaand Khangarot (2000) (Table 4).

Grain yield

Grain yield is one of the major factors which determine the effect of sulphur on the growth and yield of the crop (Table 5). The highest grain yield was found in T7 (30 kg S/ha) (19.07 q/ha) followed by T6 (25 kg S/ha) (16.67 q/ha) then by T5- 20 kg S/ha (16.63 q/ha). The lowest grain yield was found in T1- control (14.00 q/ha). Khan and Husain (1999) also proved that seed yield may increase with the sulphur application. The maximum stover yield was produced by T7- 30 kg S/ha (67.27q/ha) followed by T6- 25 kg S/ha (62.03q/ha) and then by T5- 20 kg S/ha

(60.67q/ha). The lowest yield was found in T1- control (52.50q/ha). Similar results have been reported by Sharma and Chopra (2020). The maximum harvest index was found in T6- 25 kg S/ha (22.29%) followed by T4- 15 kg/ha (22.13%). The lowest harvest index was found in T1- control (21.02%). The essential role of sulphur increased the grain and stover yield and thus it affected the harvest index too. Sharma and Chopra (2020) also supported this result.

In conclusion, The application of Sulphur increases cell elongation and multiplication along with the chlorophyll synthesis and this, in turn, helps the plant to increase photosynthesis. The maximum plant height was observed in control at 30 DAS. The number of branches per plant was also counted and it was observed that the application of 25 kg S/ha increased the number of branches as compared to the application of 30 kg S/ha. And the number of siliqua per plant was highest at 30 kg S/ha. Grain yield followed the pattern of increasing order. While the stover yield increased in T7 and the same was observed for the harvesting index. From the above results, it may be concluded that the application of Sulphur was better in terms of yield and yield parameters. The combination of Sulphur with fertilizer is good for the yield when it comes to environmental pollution. Thus, for better results, the combination can be used.

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