



The effects of foliar application of sulphur on yield and quality of rohi sarsoon (*Brassica juncea*) crop

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Abstract

This study aimed to investigate the impact of foliar application of sulphur element on the yield of *Brassica juncea*, specifically the Rohi Sarsoon cultivar. The study was conducted in Chak No. TDA 117 B Layyah, during the growing season on October 20, 2020, with four sulphur treatments groups designated as T1 (control), T2 (15 kg/ha), T3 (20 kg/ha), and T4 (25 kg/ha). The study used a Randomized Complete Block design with two replications for each treatment. The findings of this study suggest that the application of sulphur had a positive impact on both growth and yield of *Brassica juncea*, plant height, number of pods, and overall yield. Treatment T3 showed the maximum plant height, the highest number of pods, and the highest yield of 1.6 kg/ Marla, followed by T2 with a yield of 1.4 kg/Marla, T1 with a yield of 1.1 kg/ Marla, and T4 with a yield of 0.9 kg/ Marla. The study estimated the yield for each treatment in kg/ha, with 880 kg/ha, 1120 kg/ha, 1320 kg/ha, and 720 kg/ha showed for T1, T2, T3 and T4 respectively. The results of this study provide insights into the effects of foliar use of sulphur powder and its impact on both the yield and quality of *Brassica juncea*, contributing to a better understanding of the cultivation of this important crop.

1. INTRODUCTION

Mustard (*Brassica juncea* L.) is a significant oilseed crop that is typically cultivated during the winter season in Pakistan and India. Mustard is a member of the *Cruciferae* family which is known by other common names, such as Rai, Raya, or Laha. This plant is grown as a pure crop or intercrop and it is highly valued for its economic and nutritional benefits, due to the responsible various nutrients, including dietary fiber, vitamins, minerals, fats, proteins, carbohydrates, amino acids, ascorbic acid, and antioxidants (Rai et al., 2022). According to Singh et al., (2017), the growth and productivity of mustard are greatly influenced by the climate change during winter season. In India, mustard is the top-ranked crop in terms of area and the

third highest in term of production after China and Canada (Anonymous, 2015). This worldwide annual herb ranks third among different oilseed species (Kumar et al., 2011; Ahmad et al., 2016). *Brassica juncea* is a versatile crop that is widely used for its condiment, vegetable, and oil properties in various countries across the world. In India, China, and Pakistan, it holds significant importance as an oilseed crop, while in Canada; it is primarily used as a condiment crop. Recently, there has been a growing interest in *B. juncea* as a source of biodiesel production, owing to its high oil content and unsaturated fatty acids, specifically, the erucic fatty acid content, which accounts about 40%, (Jham et al., 2009; Moser, 2009; Sanjid et al., 2014). The extensively cultivation of *Brassica juncea* can be explained by

its adaptability to different environmental conditions, its richness on nutrient content, versatility as well as its significance in the agricultural sector (Singh et al., 2010).

Sulphur is a key element in chlorophyll synthesis as essential biological process, even in growth and development of oilseeds as nutrient crops. Sulphur holds unstable di- and poly-sulphide molecules that contribute to enhancing the sharp taste and aroma of vegetable oils (Barba and Orlien 2017). It is an essential micronutrient that is required in small quantities but is often deficient in soils. The utilization of nutrients in agriculture plays a critical role in crop growth and development. One nutrient that is often inefficiently used by crops is expensive to obtain, and that is the reason for its high cost. Therefore, it is imperative to optimize the utilization of this nutrient to maximize its benefits and minimize its costs in agriculture. Sulphur is vital for cell division and plays a crucial role in pod and seed formation and it can restrict the rate of water adsorption and carbohydrate transaction in deficiency (Kumar and Trivedi, 2021; Deb and Sakal, 2002).

The addition of sulfur to the soil can significantly boost mustard production, with yield improvements ranging from 12% to 48% under irrigation and 17% to 24% under rainfed conditions (Aulakh and Pasricha, 1988). According to a study conducted by Katyal et al., 1997, the addition of one kilogram of sulphur to the soil able to increase the yield of mustard crops by 7.7 kg/ha⁻¹. These findings highlight the remarkable agronomic effectiveness of sulphur as a growth promoter for this particular crop. In recent years, soil sulfur deficiency has become a growing concern due to several agricultural practices. Continuous crop cultivation, high-analysis fertilizers free of sulfur, reduced application of organic manure and sulfur-containing pesticides have been identified as contributing factors to this problem. Therefore, farmers and researchers are exploring various solutions to resolve this issue and maintain healthy soil fertility levels (Pasricha et al., 1972). This has further exacerbated the problem of sulphur deficiency in soils, particularly in light-textured soils in the North and Northwest regions of Gujarat, where the deficiency reached 81% (Sadasania, 1992). In conclusion, sulphur and other micronutrients are essential for crop growth and development. For this reason, their optimum utilization is crucial for sustainable agriculture, especially in regions where soil micronutrient depletion is a significant concern.

Therefore, it is important to adopt appropriate soil management practices to maintain adequate levels of these micronutrients in the soil for achieving optimal crop productivity.

The objective of this research is to examine the impact of sulphur foliar application on the yield and quality of the *Brassica juncea* crop, with a particular focus on the *Rohi Sarsoon* variety. The study was carried out in Chak No. TDA 117 B Layyah during the planting season in October, 2020. The experimental design included the application of sulphur on the crop using a foliar spray, while the control group was not treated. The yield and quality parameters such as plant height, germination percentage, and number of pods per plant were measured in both treated and untreated groups. The study results will enhance the general knowledge of *Brassica juncea* cultivation and its importance.

2. MATERIAL AND METHODS

This study aims to investigate the effects of foliar application of sulphur on the yield of *Brassica juncea* crop, specifically the *Rohi Sarsoon* cultivar. The study area was Chak No. TDA 117 B Layyah, with 30.96 latitude and 70.93 longitudes, during the sowing season on October 20, 2020. The total area used for the study was 5 Marla (1360 square feet). The study design included four treatments, each treatment cover 1 Marla area. An additional 1 Marla area was used for the layout design to maintain space between treatments. The treatments were designated as follows: T1 served as the control group without sulphur treatment, while T2, T3, and T4 were treated with 15 kg/ha, 20 kg/ha, and 25 kg/ha of sulphur powder, respectively (Table 1). In T2, T3, and T4, the first irrigation after sowing as flooding applied half of the sulfur, while the flowering stage applied the other half as a foliar spray. It was recommended to mix a certain quantity of sulphur powder with 10 liters of water in order to improve plant development and health. A solution was made once the sulphur powder had been added, and the plants were treated with it by foliar spray. A spray tank was used to apply the solution to the plants, paying close attention to the root zone while it was being pumped into the tank.

The study used a Randomized Complete Block design with two replications for each treatment, resulting in a total of eight experimental units. The parameters measured for the study were germination percentage, plant height, number of pods per plant, and the yield. Plant height and number of pods were recorded by selecting 20

Table 1. Optimization of Sulphur Application Rates at Different Crop Growth Stages: A Dose-Response Analysis"

Treatments	Sulphur kg/ha	Use in 1 marla	Time of apply
T1	Control	Control	-
T2	15	150 g	Half of the irrigation should be applied as flood irrigation after sowing, while the other half should be applied, as a foliar spray, during the flowering stage.
T3	20	200g	Half of the irrigation should be applied as flood irrigation after sowing, while the other half should be applied, as a foliar spray, during the flowering stage.
T4	25	250g	Half of the irrigation should be applied as flood irrigation after sowing, while the other half should be applied, as a foliar spray, during the flowering stage.

plants at random from per block or Marla, and the average was calculated for each treatment. The study also followed a predetermined irrigation schedule, with a total of five irrigation, including one pre-sowing irrigation, two irrigation at 20 days and 50 days after sowing, one irrigation during flowering, and one irrigation during pod development. The seed rate used for sowing was 3 kg/ha, using the broadcast method. Planking was performed once before sowing, and once after seed sowing, while cultivar plowing was performed once after seed sowing. *Brassica juncea* was manually harvested when the seed pods reached maturity and displayed a brown and dry appearance. In the present research, this stage was achieved approximately 97-100 days after the initial sowing of the seeds. The collected data underwent statistical analysis, which involved performing ANOVA. The means of the various treatments were then separated using the Honest Significance Difference test at a 5% probability level. All data analysis was conducted using appropriate software statistic 9.1, and the results were interpreted based on the predetermined significance level.

3. RESULTS

The findings of the current study indicate that the utilization of sulfur has a positive impact on both growth and yield parameters of *Brassica juncea*. The application of sulfur significantly influenced the plant's height, the number of pods, and the overall yield of *Brassica juncea*.

3.1. Germination Percentage:

The effect of sulphur application on the germination percentage of *Brassica juncea* was not significant among the different treatments (T1-T4). The highest germination percentage was observed in treatment T4 (94.5%) and T3 (94%), followed by T1 (93%) then T2 (92%), as observed in Table 2. After data analysis, it can be inferred that sulphur use did not demonstrate any noteworthy influence on the early growth stages of *Brassica juncea*. This is due to the fact that no sulphur was applied during the germination phase and the application was carried out after the completion of germination or during the first irrigation after sowing.

3.2. Plant Height

Sulphur application had a noteworthy impact on the growth of *Brassica juncea*, particularly on its plant height as presented in (Table 2). Plant with treatment T3 showed the highest plant height (119 cm) followed by T2 (107.5 cm), T1 (99.5 cm), and T4 (93.5 cm). These results suggest that the application of sulphur affected positively the growth of *Brassica juncea* plants, which leading to increase plant height.

3.3. Number of Pods per plant

There was a significant effect of sulphur application on the number of pods formed in *Brassica juncea*. Treatment T3 produced the highest number of pods (25) followed by T2 (21), T1 (17.5), and T4 (12.5) (Table 2). Based on the findings, it can be inferred that the use of

Table 2. Effect of different treatments on germination, growth, and number of pods and yield for *Brassica juncea*

Treatments	Germination % percentage	Plant height (cm)	No. of Pods	Yield kg/ marla
T3	94 ± 1.2	119 ± 4.5	25 ± 4.8	1.6 ± 0.25
T2	92 ± 1.1	107.5 ± 6.3	21 ± 3.2	1.4 ± 0.15
T1	93 ± 0.8	99.5 ± 5.1	17.5 ± 2.6	1.1 ± 0.05
T4	94.5 ± 1.4	93.5 ± 3.9	12.5 ± 1.9	0.9 ± 0.05

sulphur had an efficient impact on the pod development of *Brassica juncea*, which increase the quantity of pods being produced. It can be concluded that the addition of sulphur to the soil as fertilizers may be an effective method for enhancing the pod yield of *Brassica juncea*.

3.4. Yield

Grain crop contribute in the economy of any country. The application of sulphur had a significant impact on the yield of *Brassica juncea*, as evident tables. Treatment T3 produced the highest yield of 1.6 kg/Marla, followed by T2 with 1.4 kg/Marla, T1 with 1.1 kg/Marla, and T4 with 0.9 kg/ Marla (Table. 2). The findings suggest that the use of sulphur had a beneficial impact on the *Brassica juncea* yield, presented greater output. Additionally, upon examining the comprehensive yield statistics, treatment T3 yielded the highest amount with 3.3 kg/Marla, T2 with 2.8 kg/Marla, T1 with 2.2 kg/Marla, then T4 with 1.8 kg/Marla. In Table 3, treatment T1 had an anticipated yield of 880 kg/ha, T2 had 1120 kg/ha, T3 had 1320 kg/ha, and T4 had 720 kg/ha. These outcomes further reinforce the idea

Table 3. Comparative analysis of treatment effects on yield of *Brassica juncea* expressed as kg/marla and kg/ha

Treatment	Yield (kg/marla)	Estimated yield (kg/ha)
T1	2.2	880
T2	2.8	1120
T3	3.3	1320
T4	1.8	720

that the usage of sulphur had a positive influence on the yield of *Brassica juncea*. In conclusion, the application of sulphur had a significant impact on the yield of *Brassica juncea*, leading to a higher yield. Treatment T3 was found to be the most effective, followed by T2, T1, and T4. The estimated yield data in terms of kg/ha further supported these findings. These results have practical implications for farmers and researchers looking to improve the yield of *Brassica juncea* species.

4. DISCUSSIONS

The findings of this study indicate that the application of sulphur exerted a positive impact on the growth and yield of *Brassica juncea* such as the significant increase in plant height, pod number, and overall yield. These results are in line with previous research studies that have also documented the positive effects of sulphur on the growth and yield of *Brassica juncea*. It is noteworthy that the application of sulphur did not have a significant effect on the germination percentage of *Brassica juncea*. This may be attributed to the timing of sulphur application, which was carried out after the completion of germination or during the first irrigation following sowing. The study findings suggest that the application of sulphur does not influence the initial germination stage of *Brassica juncea*. Improper assimilation of fertilizer by the plant could be a result of the absence of necessary microorganisms in the soil, hindering the conversion of sulfur into the appropriate form. Notably, the implementation of the highest sulphur dosage of 250g/ Marla or 25kg/ha in the T4 treatment didn't lead to enhanced growth and yield compared to the remaining treatments. These findings contradicted the general expectation that the application of sulphur enhanced growth and

yield. Instead, this study suggests that excessive amounts of sulphur can lead to soil toxicity, thereby reducing the yield and growth of other parameters. It is possible that the soil in treatment T4 already contained an excess of sulphur, which contributed to negative effects.

In this research, we investigated the influence of sulphur application on the growth and productivity of Brassica juncea, a widely cultivated crop in various parts of the globe (Anonymous, 2015). The findings of our investigation revealed that the utilization of sulphur had a notable impact on the height of the plant, formation of pods, and yield of Brassica juncea. Furthermore, the results suggested that the application of sulphur may be a promising approach to enhance the growth and yield of this crop. Table 2 shows the mean plant height for each treatment, with a highest level for treatment T3 (119 cm). Followed by T2 (107.5 cm), T1 (99.5 cm), and T4 (93.5 cm). Our results suggested that the application of sulphur positively affected the growth of Brassica juncea plants, leading to increased plant height. Previous studies conducted by (Tripathi et al., 2011; Verma et al., 2012; and Dubey et al., 2013) also yielded similar findings. Sulphur plays a vital role in the process of photosynthesis by influencing the formation of chlorophyll. The provision of essential nutrients is critical for the growth and development of crops, as it promotes carbohydrate formation and pod formation, as highlighted in the work of Tisdale et al. (1984). Our investigation revealed a non-significant interaction effect of sulphur and boron, consistent with Ranjan et al.'s (2018) findings. Additionally, Krishna (1995) conducted a study that exam the influence of sulphur application on the pod count per mung bean plant. The results of the study indicated a significant effect of sulfur on the number of pods per plant. Our study has yielded similar results to those reported by Krishna (1995). Our study also found that the application of sulphur had a significant impact on the yield of Brassica juncea, as evident from the mean results of table. Treatment T3 produced the highest yield of 1.6 kg/Marla, followed by T2 with 1.4 kg/Marla, T1 with 1.1 kg/Marla, and T4 with 0.9 kg/Marla. These results indicated that the application of sulphur had a positive effect on the yield of Brassica juncea, resulting in a higher yield. Sulphur plays a pivotal role in the synthesis of protein and vitamin, which contributes to the increase in grain yield of particular crop. Several studies have reported similar findings, including

those conducted by Patel et al., 2010; Shekhawat et al., 2012; Verma et al., 2012; Dubey et al., 2013; Singh et al., 2007; Trivedi and Kumar (2011) and Singh et al., 2012).

5. CONCLUSION

In summary, the results obtained from this investigation indicate that the utilization of sulfur had a favorable impact on both the development and productivity of *Brassica juncea*. The plant's height, number of pods, and overall yield increased significantly with the application of sulfur. The germination percentage, on the other hand, was not significantly affected by sulfur application. Treatment T3 was found to be the most effective, followed by T2, T1, and T4. The estimated yield data in terms of kg/ha further supported these findings. These results have practical implications for farmers and researchers looking to improve the yield of *Brassica juncea*. It is recommended that farmers consider using sulfur as a fertilizer to enhance the growth and productivity of *Brassica juncea*. Future studies could explore the optimum dose and time of sulfur.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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