Interaction effect of sulphur and NPK on growth parameters and yield of mustard

Abstract

The field experiment conducted at Rajaula Agriculture Farm of Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya Chitrakoot, Satna (M.P.) during the Rabi season of 2021-22 aimed to study the effect of sulphur (S) and NPK (nitrogen, phosphorus, and potassium) on the growth parameters, yield components, and yield of chickpea. The experiment consisted of 12 treatment combinations arranged in a randomized block design with three replications. The mustard variety Pitambari was grown using recommended agronomic practices. Based on the results obtained from the investigation, it was observed that the application of S at a rate of 40 kg ha^{-1} in combination with 125% of the recommended dose of fertilizers (RDF) had a significant impact on various growth parameters. The treatment with S at 40 kg ha^{-1} + 125% RDF resulted in the highest values for plant height (198.4 cm), number of leaves (36.9), and number of branches (13.2) at 90 days. Furthermore, this treatment also showed the highest values for yield attributing characters, including the number of siliqua per plant (327.7), number of seeds per siliqua (12.1), and seed index (6.9 gm). The maximum seed yield of 11.53 quintals per hectare (q ha-1) was also obtained with the application of S at 40 kg ha^{-1} + 125% RDF

Key Words: Mustard (*Brassica juncea* L.), growth, RDF, sulphur and yield.

1. Introduction

India is one of the important among the 3rd leading oilseed producing countries of the world after Canada and China. In world, during 2020-21, Rapeseed-mustard occupied almost 37.08 million ha area with total production was 71.62 million tonnes and 1920 kg ha^{-1} productivity **(Anonymous, 2018)**.

Mustard is cultivated in several states in India, including Rajasthan, Uttar Pradesh, Haryana, Madhya Pradesh, and Gujarat. The total area occupied by mustard cultivation in India is approximately 6.23 million hectares. The country's mustard production amounts to around 9.34 million tonnes, with an average productivity of 1499 kg per hectare. In UP Mathura district have the highest area, production and productivity which is 0.053 mha, 0.077 mt and 1453 kg ha^{-1}**(INDIASTAT, 2019-20).**

UNDER PEER REVIEW

The oil is utilized for human consumption, preparation of hair oils, medicines, soap making. Mustard seed contains 30-33% oil, 17-25% proteins, 8-10% fibres, 10-12% extractable substances **(Mishra *et al*., 2019).**The cake obtained after extraction of oil is used as cattle feed and manure. The composition of mustard oil cake can vary, but generally, it contains approximately 25-30% crude protein. In addition to protein, mustard oil cake typically contains around 5% nitrogen, which is an essential nutrient for plant growth. The phosphorus content in mustard oil cake ranges from 1.8% to 2.0%, while the potassium content ranges from 1.0% to 1.2%.**(Mutha *et al*., 2021).**

Oilseed crops, including mustard, are often cultivated under rainfed conditions with low inputs and poor management practices, resulting in lower productivity levels. Imbalanced nutrition is indeed a significant constraint to achieving higher mustard productivity, oil content, and quality parameters**(Lal *et al*., 2015).**In recent agricultural practices, there has been an increasing reliance on chemical fertilizers to enhance crop production. However, it is important to consider the drawbacks associated with this approach. The cost of chemical fertilizers has been steadily increasing, adding financial burden to farmers. Moreover, the indiscriminate use of inorganic fertilizers can have detrimental effects on soil health and productivity**(Eyhorn *et al*., 2007).**

The importance of nutrient management in crop yield, and the continuous and imbalanced use of fertilizers can have detrimental effects on soil health and the cost of production. Nitrogen (N) fertilization plays a significant role, and it has been observed that mustard crops often exhibit a strong response to N application, with yield increases of 30% or more being common. The recommended rates of N for mustard cultivation typically range from 50 to 80 lbs/acre of actual N, especially in soils where N deficiency is observed. It is important to note that increasing N levels above the soil test recommendation does not always result in further yield increases. The highest response to added N typically occurs when moisture is not a limiting factor. In dry years, when moisture availability is limited, N rates closer to the lower end of the recommendation can still be adequate since the target yields will be adjusted accordingly based on the moisture availability.**(Kumar *et al*., 2017)**

Phosphorus plays a crucial role in the development of a healthy and vigorous root system. Deficiency of phosphorus, it can have noticeable effects on their growth and development. Initially, the deficiency may result in dwarfed plants with stunted root growth. As the deficiency becomes more severe, the plants may appear spindly and exhibit reduced overall growth.

UNDER PEER REVIEW

Potassium is considered a major plant nutrient due to the significant quantity in which it is absorbed by plants. In fact, the amount of K absorbed by plant roots is second only to nitrogen (N) for most cultivated crops. Low soil potassium status can be a significant limiting factor that affects crop yields. Insufficient potassium availability in the soil can lead to poor yields in various crops, including mustard. Therefore, it is crucial to evaluate the response of mustard crops to potassium nutrition to enhance productivity. t is worth noting that there has been relatively limited research conducted on assessing the response of mustard to potassium fertilization. To address this research gap and gain a better understanding of the effect of potassium on mustard yield and quality, studies have been undertaken to evaluate the impact of potassium application on mustard crops.**(Sharma *et al.*, 2020)**

2. Material and Methods

2.1 Experimental Site

The experiment you mentioned was conducted at Rajaula Agriculture Farm, which is located in Mahatma Gandhi Chitrakoot Gramoday Vishwavidyalaya Chitrakoot, Satna (M.P.). This region is situated in Madhya Pradesh, India. It falls within the semi-arid and sub-tropical climatic zone. The geographical coordinates of Rajaula Agriculture Farm are approximately 25°148' North latitude and 80°855' East longitude. The town's altitude is approximately 190-210 meters above mean sea level.

2.2 EdaphicCondition

The soil was moist, well drained with uniform plane topography. The soil of the experimental field was sandy loam in texture and slightly alkaline in reaction having pH 7.28 (1:2.5 soil: water suspension method given by **Jackson, 1973**), Organic carbon percentage in soil is 0.24 per cent (Wet oxidation method given by **Walkley and Black, 1934**), with available nitrogen 98 kg ha^{-1} (Alkaline permanganate method given by **Subbiah and Asija, 1956**), available phosphorus as sodium bicarbonate-extractable P was 17.32 kg ha^{-1} (Olsen's calorimetrically method**, Olsen *et al.*, 1954**), available potassium was 305.99 kg ha^{-1}(Flame photometer method given by **Hanwey and Heidel, 1952**) and available sulphur was 15.51 kg ha^{-1} (Turbidometric method, **BardsleyandLancaster,1960)**

2.3 Detail of treatments and design

The 12 treatments combination of nutrient management practices having four each RDF levels (0, 75, 100 and 125 % andvermicompost 3 levels (20, 30 and 40 kg ha^{-1}). Experiment was laid out in Factorial Randomized Block Design with three replications.

UNDER PEER REVIEW

Table -1: Detail of the treatment combinations:

Symbol	Treatment Combinations	Details of Treatment
T_1	RDF_0S_1	0 % RDF + 20 kg S ha^{-1}
T_2	RDF_0S_2	75 % RDF + 20 kg S ha^{-1}
T_3	RDF_0S_3	100 % RDF + 20 kg S ha^{-1}
T_4	RDF_1S_1	125 % RDF + 20 kg S ha^{-1}
T_5	RDF_1S_2	0 % RDF + 30 kg S ha^{-1}
T_6	RDF_1S_3	75 % RDF + 30 kg S ha^{-1}
T_7	RDF_2S_1	100 % RDF + 30 kg S ha^{-1}
T_8	RDF_2S_2	125 % RDF + 30 kg S ha^{-1}
T_9	RDF_2S_3	0 % RDF + 40 kg S ha^{-1}
T_{10}	RDF_3S_1	75 % RDF + 40 kg S ha^{-1}
T_{11}	RDF_3S_2	100 % RDF + 40 kg S ha^{-1}
T_{12}	RDF_3S_3	125 % RDF + 40 kg S ha^{-1}

Note:Recommended doseof fertilizer(80:40:40kgha^{-1})wasapplied.

2.4 Preparation of experimental field

The field was initially ploughed using a tractor-drawn disc plough. Ploughing helps to loosen the soil, break up any compacted layers, and facilitate better root penetration and water infiltration. After ploughing, the field was subjected to cross harrowing. Following cross harrowing, the field was planked. Planking involves using a plank or roller to compact the soil, smoothen the surface, and create a firm seedbed. Once the field was prepared, it was laid out according to the planned experimental design manually.

2.5 Application of manures and fertilizers

In the experiment, sulphur (S) was applied as a basal dose at different rates. The application rates of sulphur were 20 kg/ha, 30 kg/ha, and 40 kg/ha. After laying out the experimental plots, the fertilizers, including nitrogen (N), phosphorus (P), potassium (K), and sulphur (S), were weighed and applied to the respective plots. The fertilizers were thoroughly mixed with the soil to ensure uniform distribution. The recommended doses of nitrogen, phosphorus, and potassium were applied to all the plots. Specifically, the recommended doses for nitrogen, phosphorus, and potassium were applied through Urea, DAP (Di-Ammonium Phosphate),

UNDER PEER REVIEW

and MOP (Muriate of Potash) at rates of 80:40:40 kg/ha, respectively. For sulphur application, gypsum (calcium sulfate) was used. The rates of gypsum applied were 20 kg/ha, 30 kg/ha, and 40 kg/ha, corresponding to the different treatment combinations.

2.6 Harvesting and Threshing

The crop was harvested on 25th February 2022 when it reached physiological maturity. At this stage, the leaves of the mustard crop had turned yellow, and more than 70% of the capsules were fully matured. Harvesting at this stage is important to prevent shattering or loss of seeds. After harvesting, the crop was threshed on 28th February 2022. The threshing was done manually. The plot-wise produce, including the seeds and straw, was recorded separately. The seed weight was determined after sun drying the seeds for three days, which helps in removing any excess moisture from the seeds. The weight of the seeds was recorded in the chosen unit of measurement (e.g., kilograms). Similarly, the weight of the straw was determined by subtracting the seed weight from the total weight of the harvested crop bundle. The seed and straw weights obtained were then converted into quintals per hectare based on the net plot size.

2.7 Statistical analysis:

In the mentioned experiment, the growth parameters and yields of the mustard crop were recorded and analyzed according to the statistical method outlined by Gomez and Gomez (1984). To interpret the results, a significance level of 5% was used.

3. Results and Discussion

3.1 Growth Parameters

The data presented in Table-2 clearly demonstrates that the application of different levels of sulphur and NPK significantly influenced the growth parameters of mustard, including plant height, number of leaves, and number of branches at 90 days after sowing (DAS). The interaction between sulphur and NPK also had a significant impact on these growth parameters. The plant height at 90 days ranged from 175.6 to 198.4 cm, the number of leaves at 90 days ranged from 30.5 to 36.9, and the number of branches at 90 days varied from 10.7 to 13.2. The maximum values for these growth parameters, including the highest plant height (198.4 cm) at 90 days, number of leaves (36.9), and number of branches (13.2), were observed under treatment T_{12}, which involved the application of sulphur at a rate of 40 kg/ha and 125% RDF. On the other hand, the minimum values for these growth parameters, including the lowest plant height (175.6 cm) at 90 days, number of leaves (30.5), and number of branches (10.7), were recorded under treatment T_1, which received sulphur at a rate of 20 kg/ha and no RDF. Similar findings were reported by **Upadhyay*et al.* (2017), Singh *et al.* (2016), and Tripathi*et al.* (2011)**

3.2 Yield attributes

The data presented in Table-3 clearly indicates that the application of different levels of sulphur and RDF significantly influenced the yield components of mustard, including the number of siliqua per plant, number of seeds per siliqua, and seed index. The interaction between sulphur and RDF also had a significant impact on these yield attributing parameters. The number of siliqua per plant ranged from 301.4 to 327.7, the number of seeds per siliqua ranged from 9.7 to 12.1, and the seed index varied from 5.2 to 6.9 grams. The maximum values for these yield components, including the highest number of siliqua per plant (327.7), number of seeds per siliqua (12.1), and seed index (6.9 grams), were observed under treatment T_{12}, which involved the application of sulphur at a rate of 40 kg/ha and 125% RDF. On the other hand, the minimum values for these yield components, including the lowest number of siliqua per plant (301.4), number of seeds per siliqua (9.7), and seed index (5.2 grams), were recorded under treatment T_1, which received sulphur at a rate of 20 kg/ha and no RDF. The consequences of the current investigation are additionally in concurrence with the investigation of**Singh *et al.* (2004), Sahu *et al.* (2017) and Reddy *et al.* (2009)**

3.3 Seed Yield

The data presented in Table-4 clearly demonstrates the significant impact of different levels of sulphur and RDF on the seed yield of mustard crops. The increased seed yield observed under adequate nutrient supply can be attributed to various factors, including an increase in the number of siliqua per plant, number of seeds per siliqua, and higher seed index. The application of sulphur and RDF levels resulted in improved translocation of photosynthates from the source (leaves) to the sink (seeds). This improved translocation likely contributed to the higher yield of seeds. The collective effect of increased yield attributes, such as a greater number of siliqua per plant, more seeds per siliqua, and higher seed index, ultimately led to an increase in seed yield. Among the treatment combinations, the maximum seed yield of 11.53 quintals per hectare was recorded under treatment T12, which involved the application of sulphur at a rate of 40 kg/ha and 125% RDF. On the other hand, the minimum seed yield of 9.64 quintals per hectare was observed under treatment T1, which received sulphur at a

UNDER PEER REVIEW

rate of 20 kg/ha and no RDF. These results also confirms the findings of**Singh *et al.* (2017), Sahoo *et al.* (2017) and Rathore *et al.* (2015)**

Table-2: Effect of different treatment combinations of growth parameters of mustard.

Treatments	Combinations	Plant Height(cm) 90 DAS	Number of Leaves 90 DAS	Number of Branches 90 DAS
T_1	RDF_0S_1	175.6	30.5	10.7
T_2	RDF_0S_2	177.4	31.2	11.0
T_3	RDF_0S_3	179.8	31.6	11.3
T_4	RDF_1S_1	182.4	32.2	11.5
T_5	RDF_1S_2	184.9	32.9	11.7
T_6	RDF_1S_3	186.2	33.4	11.9
T_7	RDF_2S_1	190.8	34.0	12.0
T_8	RDF_2S_2	192.7	34.4	12.2
T_9	RDF_2S_3	193.4	35.0	12.4
T_{10}	RDF_3S_1	194.6	35.5	12.6
T_{11}	RDF_3S_2	196.3	36.1	12.9
T_{12}	RDF_3S_3	198.4	36.9	13.2
C.D. at 5%	**RDF**	**4.71**	**0.83**	**0.33**
	S	**4.13**	**0.72**	**0.30**
	RDF×S	**8.27**	**1.47**	**0.61**
S.E(m)±	**RDF**	**1.59**	**0.28**	**0.11**
	S	**1.38**	**0.24**	**0.10**
	RDF×S	**2.76**	**0.49**	**0.20**

Table-3 Effect of different treatment combinations on yield components of mustard.

Treatments	Combinations	No. of Siliqua $Plant^{-1}$	No. of Seed $Siliqua^{-1}$	Seed Index (g)
T_1	RDF_0S_1	301.4	9.7	5.2
T_2	RDF_0S_2	302.8	10.0	5.3
T_3	RDF_0S_3	303.7	10.3	5.4
T_4	RDF_1S_1	306.7	10.5	5.6
T_5	RDF_1S_2	309.5	10.7	5.7
T_6	RDF_1S_3	312.7	10.8	5.8
T_7	RDF_2S_1	315.4	10.9	5.9
T_8	RDF_2S_2	318.7	11.2	6.0
T_9	RDF_2S_3	321.5	11.3	6.2
T_{10}	RDF_3S_1	323.2	11.5	6.4
T_{11}	RDF_3S_2	325.5	11.8	6.7
T_{12}	RDF_3S_3	327.7	12.1	6.9
C.D. at 5%	**RDF**	**6.93**	**0.37**	**0.12**
	S	**6.01**	**0.30**	**0.10**
	RDF×S	**12.1**	**0.64**	**0.22**

UNDER PEER REVIEW

S.E(m)±	**RDF**	**2.31**	**0.12**	**0.04**
	S	**2.00**	**0.10**	**0.03**
	RDF×S		**0.21**	**0.07**

Table-4: Effect of different treatment combinations on seed yield (q ha^{-1}) of mustard.

Treatments	**Combinations**	**Seed Yield (q ha^{-1})**
T_1	RDF_0S_1	9.64
T_2	RDF_0S_2	9.92
T_3	RDF_0S_3	10.16
T_4	RDF_1S_1	10.30
T_5	RDF_1S_2	10.46
T_6	RDF_1S_3	10.59
T_7	RDF_2S_1	10.75
T_8	RDF_2S_2	10.88
T_9	RDF_2S_3	11.02
T_{10}	RDF_3S_1	11.17
T_{11}	RDF_3S_2	11.35
T_{12}	RDF_3S_3	11.53
C.D. at 5%	**RDF**	**0.25**
	S	**0.22**
	RDF×S	**0.43**
S.E(m)±	**RDF**	**0.08**
	S	**0.07**
	RDF×S	**0.14**

4. Conclusion

The study conducted on the effect of sulphur and NPK fertilizers on mustard crops showed that the application of sulphur in combination with the recommended dose of fertilizers (125% RDF) resulted in significant improvements in growth parameters, yield components, and seed yield of mustard. These findings have important implications for farmers and can contribute to the upliftment of their socioeconomic status. The results suggest that the addition of sulphur, along with the optimal dose of NPK fertilizers, can enhance the growth and productivity of mustard crops.

References

Anonymous. (2018). Agricultural Statistics at a Glance 2018. Directorate of Economics & Statistics, Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Govt. of India, New Delhi, p. 63.

UNDER PEER REVIEW

Kumar A., Mahapatra B.S., Singh V.P., Shukla A., Negi M.S., Yadav A. S., Singh P., Gaurendra G. and Singh M. (2017). Effect of nutrient levels on yield, nutrient uptake and economics of Indian mustard (Brassica juncea) in tarai region of Uttarakhand. *Indian Journal of Agronomy* 62 **(3**): 378-381.

Lal, G., Mehta, R. S., Chand, P., Godara, A. S., & Cheriyan, H. (2015). Performance of improved varieties and technological interventions at farmers' fields for cumin cultivation.

Mishra, J., Singh, R. K., Deshraj Yadav, S. S., & Mishra, A. P. (2019). Quality of Indian mustard [Brassica juncea (L.) Czernj and Cosson] as influenced by tillage and irrigation frequency. *Journal of Pharmacognosy and Phytochemistry*, *8*(1), 2280-2283.

Mutha Sravya, V. S., & George, S. G. (2021). Effect of nitrogen and zinc levels on growth, yield and economics of safflower (*Carthamus tinctorius* L.).

Rathore, S.S., Shekhawat, K., Kandpal, B. K., Premi, O.P., Singh, S.P., Singh, G.C. And Singh, D. (2015) Sulphur Management for Increased Productivity of Indian mustard: A Review. *Annals of Plant and Soil Research* 17 (1): 1-12 (2015)

Reddy, R.U., Reddy, S.N. and Reddy, M.S. (2009). Yield, yield attributes and oil content of soybean as influenced by integrated nutrient management in soybean-maize cropping system. International of Journal of Agricultural Sciences, **5**: 15-17.

Sahoo, G.C., Biswas, P.K. and Santra, G.H. (2017) Effect of Different Sources of Sulphur on Growth, Productivity and Oil Content of Brassica campestris var. toria in the Red Soil of Odisha. *IJAEB*: 10(6): 689-694

Sahu, D.K., Swaroop, N., Thomas, T., David A.A., and Rao, S. P.(2017). Effect of Different Doses of Sulphur and Zinc with NPK on Physico-Chemical Properties of Soil and Yield Attribute of Yellow Mustard (*Brassica compestris* L.) Cv. Sunanda. *Int.J.Curr.Microbiol.App.Sci.* 6(6): 1897-1902.

Singh, Amar and Meena N.L. (2004). Effect of nitrogen and sulphur on growth, attributes and seed yield of mustard (*Brassica juncea*) in eastern plain of Rajasthan. Indian Journal of Agronomy, 49: 186-188.

Sharma, M., & Kumar, P. (2020). Biochemical alteration of mustard grown under tin contaminated soil. *Plant Archives*, *20*(2), 3487-3492.

UNDER PEER REVIEW

Singh, V., Singh, A.K., Raghuvanshi, N. and Singh, R.A. (2016) Effect of Sulphur Levels on Growth and Yield of Mustard (*Brassica Juncea* L. Czern and Coss) Varieties. Progressive Research, *an International Journal.* Volume 11 (Special-II): 845-848

Singh, R.; Singh, Y., and Singh, S. (2017). Yield, quality and nutrient uptake of Indian mustard (*Brassica juncea*) under sulphur and boron nutrition. *Annals of Plant and Soil Research*, 19(2), 227-231.

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. J. Crop and Weed, 7(2): 104-107.

Upadhyay, Y., Swaroop, N., Dhruw, S.S., Mashih, A. and Verma, P.D. (2017). Interaction Effects of different doses of Sulphur and Zinc with NPK on Growth of Yellow Mustard (*Brassica compestris* L.). *Journal of Pharmacognosy and Phytochemistry*, 7(1): 1260-1263

UNDER PEER REVIEW