www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; SP-12(11): 1459-1462

www.thepharmajournal.com
Received: 18-09-2023
Accepted: 29-10-2023

Kratika
Department of Natural Resources Management, Faculty of Agriculture, Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya Chitrakoot, Satna, Madhya Pradesh, India

Opendra Kumar Singh
Department of Natural Resources Management, Faculty of Agriculture, Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya Chitrakoot, Satna, Madhya Pradesh, India

US Mishra
Department of Natural Resources Management, Faculty of Agriculture, Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya Chitrakoot, Satna, Madhya Pradesh, India

Pawan Sirothia
Department of Natural Resources Management, Faculty of Agriculture, Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya Chitrakoot, Satna, Madhya Pradesh, India

Ashutosh Mishra
Department of Natural Resources Management, Faculty of Agriculture, Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya Chitrakoot, Satna, Madhya Pradesh, India

Corresponding Author:
Ashutosh Mishra
Department of Natural Resources Management, Faculty of Agriculture, Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya Chitrakoot, Satna, Madhya Pradesh, India

Response of sulphur and zinc application on growth parameters, yield components and yield of mustard crop in Chitrakoot area

Kratika, Opendra Kumar Singh, US Mishra, Pawan Sirothia and Ashutosh Mishra

Abstract
A field trial took place during the Rabi season of 2022-2023 at Rajoula Agriculture Farm, affiliated with Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya in Chitrakoot, Satna (M.P.). The study involved 10 treatment combinations, each replicated three times in a randomized block design. The cultivation of the Mustard variety Pusa Mahak was carried out following the prescribed agronomic practices. Based on the findings of the current study, it can be concluded that the application of T_6 [100% NP + 15 kg Sulphur] demonstrated significantly increased growth parameters, including plant height (198.93 cm) and the number of branches per plant (6.13). Regarding yield-related characteristics, T_3 [100% NP + 2.5 kg Zinc] resulted in the highest number of siliqua per plant (300.10), T_9 [100% NP + 30 kg Sulphur + 2.5 kg Zinc] showed the maximum number of seeds per siliqua (15.20), and T_6 [100% NP + 15 kg Sulphur] exhibited the highest 1000 seed weight (5.28 g). The treatment T_{10} [100% NP + 30 kg Sulphur + 5.0 kg Zinc] produced the highest grain yield (1943.46 kg ha^{-1}), while T_8 [100% NP + 15 kg Sulphur + 5.0 kg Zinc] resulted in the highest straw yield (6203.17 kg ha^{-1}).

Keywords: Mustard, sulphur, yield and zinc

1. Introduction

Indian mustard is one of the most important edible oil-seed *rabi* crop of North India commonly known as *Sarson*, *Rai* or *Laha*. It belongs to the family *Brassicaceae* and genus *Brassica*. It comprises various traditionally grown indigenous species, namely, Toria (*Brassica campestris* L. var. toria), Brown sarson (*Brassica campestris* L. var. brown sarson), Yellow sarson (*Brassica campestris* L. var. yellow sarson), Black mustard (*Brassica nigra*) and Taramira (*Eruca sativa/vesicaria* Mill.) which are grown over different parts of the country (Mishra *et al*., 2022) [13].

Mustard stands as the primary oilseed crop for the Rabi season, covering over 74% of the area dedicated to oilseeds. Rajasthan, Uttar Pradesh, Madhya Pradesh, Haryana, and Gujarat are the leading states in terms of mustard cultivation, contributing to more than 70% of the total mustard acreage in the country. In India, mustard is planted across approximately 6.69 million hectares, yielding a production of about 10.11 million metric tons and a productivity of 1511 kg per hectare during the 2020-21 period, as per the Economic Survey of 2021-2022. However, in Madhya Pradesh, mustard is cultivated on approximately 7.7 lakh hectares, resulting in a production of about 13.1 lakh metric tons and a productivity of 1713 kg per hectare. (Economic Survey, 2021-2022) [5].

Sulphur is an essential secondary plant nutrient and fourth most important nutrient in crop production to increase quality and productivity of mustard next to N, P and K. It is an essential constituent of S-containing amino acids and helps in synthesis of cystine (27% S), cysteine (26% S) and methionine (21% S), as about 90% of sulphur is present in these amino acids (Havlin *et al*., 2013) [8]. Sulphur is an essential component in the formation of chlorophyll, a constituent of vitamins biotine and thiamine (B_1) and iron sulphur proteins called ferredoxins. It also plays a role in activation of various vitamins and enzymes, sulphydryl (SH) linkages, synthesis of oil and protein (Rathore *et al*., 2015) [19]. It is also a component of glucosinolate and glycosidase enzyme, which are the source of aroma and pungency in mustard oil. Compared to other crops mustard is more responsive to sulphur. Therefore, adequate sulphur availability is very crucial for its productivity. Studies have confirmed that sulphur fertilizer increases the growth, yield and quality of Indian mustard (Singh *et al*., 2015; Piri *et al*., 2011)

[24, 17]. Application of sulphur has a significant effect on oil, fatty acids and glucosinate content in mustard seeds (Falk *et al*., 2007) [6]. Sulphur application also has marked effect on soil properties and is used as soil amendment to improve the availability of other nutrients in soil.

More than 95% of the sulphur in soil is present in organic form as sulphate esters or carbon-bonded sulphur; the remaining 5% is inorganic sulphur, which is available to plants. The absorption of inorganic form *i.e*., sulphate, is what gives plants their nutrients (Kertesz and Mirleau, 2004) [11]. Sulphate is a highly mobile, negatively charged ion that is susceptible to leaching losses. Sulphur deficiency in Indian soils is on the rise as a result of intensifying agriculture with high yielding varieties and multiple cropping, along with the use of high analysis sulphate-free fertilisers and the limited or non-use of organic manures, which causes the soil's sulphate reserve to be depleted. Thus, adequate sulphur application and management becomes important to overcome problems like yield reduction due to sulphur deficiency in soil.

Zinc stands as a vital micronutrient crucial for various enzymatic and physiological processes within plants. In minute yet crucial concentrations, it facilitates the normal functioning of key physiological pathways in plants (Alloway, 2008; Mousavi *et al*., 2011) [1, 14]. Moreover, zinc is indispensable for processes like photosynthesis and nitrogen metabolism. It plays a crucial role in maintaining the stability of cytoplasmic ribosomes and supports cell division. Acting as a co-factor for enzymes like dehydrogenase, proteinase, and peptidase, zinc contributes to the synthesis of tryptophan a constituent of certain proteins and a compound essential for the production of growth hormones, including indole acetic acid (auxin) (Brown *et al*., 1993) [3]. In plant production, zinc stands out as a crucial element in carbohydrate metabolism. Many enzymes involved in carbohydrate metabolism rely on zinc activation. Specifically, zinc activates enzymes such as Carbonic anhydrase, Fructose-1,6-bisphosphate, and Aldolase. These enzymes play active roles in both chloroplasts and cytoplasm. Fructose-1,6-bisphosphate separates six-carbon sugar molecules between chloroplasts and cytoplasm, while Aldolase facilitates the transport of three-carbon sugar molecules from cytoplasm to chloroplasts during photosynthesis. In conditions of zinc deficiency, the activity of these enzymes decreases, leading to the accumulation of carbohydrates in plant leaves (Taheri *et al*., 2011) [27].

Keeping in view the significance of sulphur and zinc on growth parameter, yield components and yield of mustard present investigation was undertaken at Rajoula Agriculture Farm, of Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya Chitrakoot, Satna (M.P.)

2. Materials and Methods

2.1 Experimental Site

The study was conducted at Rajaula Agriculture Farm, affiliated with Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya in Chitrakoot, Satna (M.P.). This location is situated in the semi-arid and sub-tropical region of Madhya Pradesh, positioned between 25.148° North latitude and 80.855° East longitude. The town's altitude ranges from approximately 190 to 210 meters above mean sea level.

2.2 Edaphic condition

The experimental site featured well-drained soil with a consistent flat topography and adequate moisture. The soil in the experimental field originated from alluvial deposits, had a sandy loam texture, and exhibited a slightly alkaline pH of 7.3 (determined using the 1:2.5 soil: water suspension method according to Jackson, 1973) [9]. Organic carbon content was low, measuring 0.20% using Walkley and Black's rapid titration method (Walkley and Black, 1934) [29]. The soil showed low levels of available nitrogen at 94.68 kg ha^{-1} (determined by the Alkaline permanganate method by Subbiah and Asija, 1956) [26], medium levels of available phosphorus at 16.00 kg ha^{-1} (determined by Olsen's calorimetric method, Olsen *et al.*, 1954) [15], high levels of available potassium at 308.90 kg ha^{-1} (determined by the Flame photometer method by Hanwey and Heidel, 1952) [7], low levels of available sulfur at 26.41 ppm (determined by the Turbidometric method by Chesnin and Yein, 1951) [4], and low levels of available zinc at 0.542 ppm (determined by the DTPA extraction method by Lindsay and Norvell, 1978) [12].

2.3 Experimental Details

The experiment was laid out in randomized block design and replicated thrice comprising with 10 treatment combinations.

Table 1: Treatment details

Treatment	Combinations
T_1	Control (100%)
T_2	100% NP (RD)
T_3	100% NP + 2.5 kg Zinc
T_4	100% NP + 5.0 kg Zinc
T_5	100% NP + 30 kg Sulphur
T_6	100% NP + 15 kg Sulphur
T_7	100% NP + 15 kg Sulphur + 2.5 kg Zinc
T_8	100% NP + 15 kg Sulphur + 5.0 kg Zinc
T_9	100% NP + 30 kg Sulphur + 2.5 kg Zinc
T_{10}	100% NP + 30 kg Sulphur + 5.0 kg Zinc

Note: Recommended dose of fertilizer (60:40:40 kg ha^{-1}) was applied.

2.4 Fertilizer application

Farmyard manure (FYM) was administered at a rate of 10 quintals per hectare as the initial application. Following the layout of the experimental plots, fertilizers were measured and distributed across the plots, ensuring thorough mixing with the soil. The assigned plots received the recommended doses of nitrogen, phosphorus, and potassium. This involved the application of the prescribed quantities of nitrogen, phosphorus, and potassium through urea, DAP, and MOP, respectively, at a ratio of 60:40:40 kg per hectare. Additionally, sulfur and zinc were applied using a wettable powder, with rates set at 15 and 30 kg per hectare for sulfur and 2.5 and 5.0 ppm per hectare for zinc, in accordance with the specific treatment.

2.5 Seed and sowing

The seed sowing was done on 19th Oct. 2022. The seed was sown in line after making a narrow furrow with the help of pointed wooden stick at different row spacing. The seeds were dropped in the furrow after mixture with fine dust of soil and then after seeds were covered with thin soil layer. The total quantity of seed was required @ 6 kg/ha. The Mustard variety was “Pusa Mahak”.

2.5.1 Harvesting

The harvest of the crop took place on February 14, 2023, coinciding with its physiological maturity. This stage was identified by the yellowing of leaves and the full maturation of over 70% of the capsules, a precautionary measure taken to prevent crop shattering.

2.6 Observations recorded
2.6.1 Grain yield (q ha^{-1})
The electronic balance was utilized to measure the total weight of clean and dried grains from each plot, expressed in kilograms per hectare.

2.6.1 Straw yield (q ha^{-1})
The straw yield for each plot can be calculated by subtracting the grain yield from the corresponding biological yield and then expressing it in kilograms per hectare.

2.7 Statistical analysis
The information related to the various characteristics observed throughout the investigation was subjected to statistical analysis using a randomized block design. In cases where there were significant differences among treatments (determined by the "F" test), critical differences were calculated at a five percent probability level. The statistical analysis of the data collected during the study followed the procedures recommended by Gomez and Gomez in 1984.

3. Results and Discussion
3.1 Growth Parameters
Data pertaining to growth parameters mainly plant height (cm), and number of branches $plant^{-1}$ are presented in table no. 2 clearly revealed that application of sulphur and zinc significantly increased growth parameters. The results revealed that plant height of mustard varied in between 184.06 to 198.93 cm. The treatment combination T_6 [100% NP + 15 kg Sulphur] gave the maximum plant height (198.93 cm) followed by the treatment T_7 [100% NP + 15 kg Sulphur + 2.5 kg Zinc] with the value 198.86 cm. Number of branches of mustard varied in between 4.93 to 6.13. The treatment combination T_6 [100% NP + 15 kg Sulphur] gave the maximum number of branches (6.13) followed by the treatment T_9 [100% NP + 30 kg Sulphur + 2.5 kg Zinc] with the value 6.10. These findings are further supported by Rakesh and Banik (2016) [18], Singh *et al.*, (2021) [23], Waghmare *et al.* (2022) [28] and Pandey *et al.* (2022) [16].

Table 2: Effect of different treatment combination on growth parameters of mustard

Treatment	Plant height (cm)	No. of branches $plant^{-1}$
T_1	184.06	4.93
T_2	189.93	5.80
T_3	189.33	5.40
T_4	187.20	5.60
T_5	196.66	6.00
T_6	198.93	6.13
T_7	198.86	5.60
T_8	196.13	5.80
T_9	192.40	6.10
T_{10}	198.46	5.66
S.Em±	1.25	0.13
C.D. (P= 0.05)	3.75	0.40

3.2 Yield components
Data pertaining to yield attributing parameters mainly no. of siliqua $plant^{-1}$, no. of seed $siliqua^{-1}$ and 1000 seed weight (g) are presented in table no. 3 clearly revealed that application Sulphur and zinc increased yield attributes significantly over control except 1000 seed weight (g). The results revealed that the treatment combination T_3 [100% NP + 2.5 kg Zinc] gave the maximum no. of siliqua $plant^{-1}$ (300.10) followed by the treatment T_6 [100% NP + 15 kg Sulphur] with the value 291.80. The treatment combination T_9 [100% NP + 30 kg Sulphur + 2.5 kg Zinc] gave the maximum no. of seed $siliqua^{-1}$ (15.20) followed by the treatment T_7 [100% NP + 15 kg Sulphur + 2.5 kg Zinc] with the value 14.93. The treatment combination T_6 [100% NP + 15 kg Sulphur] gave the maximum 1000 seed weight (5.28 g) followed by the treatment T_{10} [100% NP + 30 kg Sulphur + 5.0 kg Zinc] with the value 5.08 g. These findings are further supported by Yadav *et al.* (2010) [30], Jaiswal *et al.*, (2015) [10] and Sinha *et al.* (2022) [25].

Table 3: Effect of different treatment combination on yield attributes of mustard

Treatment	No. of siliqua $plant^{-1}$	No. of Seed $siliqua^{-1}$	1000 seed weight (g)
T_1	241.50	13.00	5.12
T_2	272.00	14.20	5.22
T_3	300.10	14.20	4.77
T_4	289.06	14.20	4.91
T_5	269.13	13.60	4.73
T_6	291.80	13.00	5.28
T_7	281.73	14.93	4.09
T_8	289.46	13.06	4.45
T_9	284.93	15.20	5.06
T_{10}	266.06	13.53	5.08
S.Em±	6.19	0.16	0.07
C.D. (P= 0.05)	18.58	0.49	NS

3.3 Productivity parameters
It was observed that application of Sulphur and zinc enhanced the grain yield and straw yield of mustard significantly and present in table no. 4. The results revealed that the seed yield (kg ha^{-1}) of mustard varied in between 1466.87 to 1943.46 kg ha^{-1}. The treatment combination T_{10} [100% NP + 30 kg Sulphur + 5.0 kg Zinc] gave the maximum seed yield (1943.46 kg ha^{-1}) followed by the treatment T_4 [100% NP + 5.0 kg Zinc] with the value 1852.27 kg ha^{-1}. Total stover yield (kg ha^{-1}) of mustard varied in between 3796.82 to 6203.17 kg ha^{-1}. The treatment combination T_8 [100% NP + 15 kg Sulphur + 5.0 kg Zinc] gave the maximum total stover yield (6203.17 kg ha^{-1}) followed by the treatment T_5 [100% NP + 30 kg Sulphur] with the value 6139.68 kg ha^{-1}. These findings are further supported by the findings of Bhadre *et al.* (2019) [2], Sachan *et al.*, (2019) [20], Sharma *et al.*, (2020) [22] and Sachan *et al.*, (2022) [21].

Table 3: Effect of different treatment combination on yields of mustard

Treatment	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})
T_1	1466.87	3796.82
T_2	1499.04	3980.95
T_3	1572.48	4552.38
T_4	1852.27	4749.20
T_5	1703.48	6139.68
T_6	1653.96	5517.45
T_7	1672.37	4907.93
T_8	1583.69	6203.17
T_9	1823.27	4869.84
T_{10}	1943.46	4971.42
S.Em±	31.20	23.14
C.D. (P= 0.05)	93.61	69.43

4. Conclusion
The experimental results indicated that superiority in regard to growth parameters, yield components and productivity parameters *viz,* grain yield (kg ha^{-1}), stover yield (kg ha^{-1}), with the use of treatment combination T_{10} [100% NP + 30 kg Sulphur + 5.0 kg Zinc] gave in soil ensure highest growth parameters, yield components and productivity, of mustard crop as comparison to all the treatments.

5. References

1. Alloway BJ. Zinc in soil and crop nutrition. IZA and IFA press, France; c2008.
2. Bhadre CK, Narkhede WN, Gokhale DN. Growth, yield and economics of soybean- safflower cropping sequence as influenced by different land configuration and nutrient management. J. of P.P. 2019;8(1):169-173.
3. Brown PH, Cakmak I, Zhang Q. Form and function of zinc plants. Zinc in soils and plants. Robson A.D. (Eds). Developments in Plant and Soil Sciences, 1993, 55.
4. Chesnin L, Yien CH. Turbidimetric determination of available sulfates. Soil Science Society of America Journal. 1951;15(C):149-151.
5. Economic Survey (2021-22). Statistical Tables, Ministry of Finance, Government of India; c2021.
6. Falk KL, Tokuhisa JG, Gershenzon J. Effect of sulphur nutrition on plant glucosinolate content: Physiology and molecular mechanisms. Plant Biology. 2007;9:573-581.
7. Hanway JJ, Heidel H. Soil analysis methods as used in Iowa State College, Soil Testing Laboratory. Iowa Agriculture. 1952;54:1-31.
8. Havlin JL, Tisdale SL, Nelson WL, Beaton JD. Soil Fertility and Fertilizers: An Introduction to Nutrient Management (Eighth Edition). Pearson India Education Services Pvt. Ltd.; c2013.
9. Jackson ML. Soil chemical analysis. Prentice Hall of India Pvt. Ltd, New Delhi; c1973.
10. Jaiswal AD, Singh SK, Singh YK, Singh S, Yadav SN. Effect of sulphur and boron on yield and quality of mustard (*Brassica juncea* L.) grown on Vindhyan red soil. Journal of the Indian Society of Soil Science. 2015;63(3):362-364.
11. Kertesz MA, Mirleau P. The role of soil microbes in plant sulphur nutrition. Journal of Experimental Botany. 2004;55:1939-1945
12. Lindsay WL, Norvell W. Development of a DTPA soil test for zinc, iron, manganese, and copper. Soil science society of America Journal. 1978;42(3):421-428.
13. Mishra A, Singh V, Sachan R. Evaluation of growth characters, agro physiological performance and quality trait of different mustard hybrid (*Brassica juncea* L.) under agro-climatic condition of Prayagraj. The Pharma Innovation Journal. 2022;11(1):1242-1244.
14. Mousavi SR. Zinc in crop production and interaction with phosphorus. Australian Journal of Basic and Applied Sciences. 2011;5:1503-1509.
15. Olsen SR, Cole CV, Watanable FS, Dean LA. Estimation of available phosphorous in soil by extraction with sodium bicarbonate. USDA, Cric. 1954;930:19-23.
16. Pandey SB, Sachan R, Patel V, Bhawan R. Effect of Sulphur, Potassium and PSB on Growth Parameters, Root Architecture and Quality of Mustard (*Brassica juncea* L.). International Journal of Plant & Soil Science. 2022l34(24):122-127.
17. Piri I, Nik MM, Tavassoli A, Rastegaripour F, Babaeian M. Effect of irrigation frequency and application levels of sulphur fertilizer on water use efficiency and yield of Indian mustard (*Brassica juncea*). African Journal of Biotechnology. 2011;10(55):11459-11467.
18. Rakesh S, Banik GC. Effect of sulphur levels and sources on growth, yield and quality of mustard in terai region of West Bengal. Annals of Plant and Soil Research. 2016;18(2):152-155.
19. Rathore SS, Shekhawat K, Kandpal BK, Premi OP, Singh SP, Singh GC, *et al*. Sulphur management for increased productivity of Indian mustard: A review. Annals of Plant and Soil Research. 2015;17(1):1-12.
20. Sachan R, Thomas T, Rao PS. Soil test based fertilizer recommendation for mustard (*Brassica juncea* L.) in eastern plain zone of Uttar Pradesh, India. IJCS. 2019;7(3):2716-2719.
21. Sachan R, Thomas T, Pandey HP, Tiwari A, Kumar A, Yadav P, *et al*. Effect of STCR-IPNS based nutrient application on soil health, yield, nutrient content and uptake of mustard (*Brassica juncea* L.) in eastern plain zone of Uttar Pradesh, India. International Journal of Plant & Soil Science. 2022;34(20):248-258.
22. Sharma S, Chaudhray S, Singh R. Effect of boron and sulphur on growth, yield and nutrient uptake of mustard (*Brassica juncea* L.). International Journal of Chemical Studies. 2020;8(4):998-2001.
23. Singh PD, Pathak A, Singh A, Kumar P. Effect of different levels and sources of sulphur on growth, yield attributes and nutrient removal by mustard (*Brassica juncea* L.). The Pharma Innovation Journal. 2021;10(4):521-524.
24. Singh U, Tomar SS, Rameshwar, Choudhary S. Yield, nutrient uptake and economics of Indian mustard as influenced by varieties, sources and levels of sulphur. Annals of Plant and Soil Research. 2015;17(3):266-268.
25. Sinha T, Mishra A, Mishra US, Sachan R, Singh D. Interaction effect of sulphur and boron on growth characteristics, yield components and productivity parameters of mustard (*Brassica juncea* L.) under rainfed condition of Chitrakoot Region. International Journal of Plant & Soil Science; c2022. p. 1329-1336.
26. Subbiah BV, Asija CL. A rapid procedure for the estimation of available N in Soil. Curr. Sci. 1956;25:259-260.
27. Taheri N, Heidari H, Yousefi K, Mousavi SR. Effect of organic manure with phosphorus and zinc on yield of seed potato. Australian Journal of Basic and Applied Sciences. 2011;5(8):775-780.
28. Waghmare PS, Suryavanshi VP, Gawande RS, Sawant DS, Kokate AP. Effect of zinc sulphate and ferrous sulphate on growth and yield of sunflower. The Pharma Innovation Journal. 2022;11(1):1334-1336.
29. Walkley A, Black CSA. Old piper, S.S. soil and plant analysis. Soil Sci. 1934;37:29-38.
30. Yadav HK, Thomas T, Khajuria V. Effect of different levels of sulphur and biofertilizer on the yield of Indian mustard (*Brassica juncea* L.) and soil properties. J of Agril. Physics. 2010;10:61-65.