Original Research Article

EFFECT OF SULPHUR LEVELS ON GROWTH AND YIELD OF INDIAN MUSTARD {(*Brassica juncea*(*L.*)*Czern.*}

Abstract

In the 2022 rabi season, a field experiment was conducted at the Agriculture Research Farm of Sage University, Bhopal (M.P.). The study employed a randomized block design with three replications and a factorial setup, examining the impact of varying Sulphur levels on crop growth and yield. Specifically, six treatments were implemented, encompassing four Sulphur dosage levels: 15, 30, 45, and 60 kg S/ha. The chosen crop variety for this experiment was Rani, aimed at determining the most suitable Sulphur dosage and variety combination for maximizing agricultural production.

The experiment commenced on December 8, 2023, in soil characterized as black soil with a pH of 6.5, organic carbon content of 0.32%, electrical conductivity (EC) measuring 0.33 ds/m, and nutrient levels of 180.4 kg/ha of available nitrogen, 18.4 kg/ha of available phosphorus, 290 kg/ha of available potassium, 7.3 ppm of available Sulphur, and 0.59 ppm of available Zinc.

Results from the study revealed that among the various Sulphur treatments, the application of 60 kg S/ha had a significant impact on various plant characteristics, including plant height, number of branches per plant, leaf area index, number of siliqua per plant, length of siliqua, number of seeds per siliqua, and dry matter accumulation per plant. Notably, this Sulphur dosage level outperformed the 15, 30, and 45 kg S/ha treatments and was superior to the rest of the Sulphur levels.

However, it's important to note that Sulphur dosage did not significantly affect certain parameters such as Harvest index, 1000-grain weight (g), nitrogen content, and protein content. Nevertheless, the application of Sulphur at a rate of 60 kg/ha led to significant increases in seed yield, stover yield, and Sulphur content in both the seed and stover, demonstrating its positive impact on overall crop production.

Keywords: Mustard, Sulphur, growth and yield.

Introduction:

Indian mustard,*Brassica juncea (L.)*Czernstands as a prominent winter oilseed crop, belonging to the Cruciferae family. This crop, along with rapeseed, holds significant importance in the realm of oilseed cultivation, ranking third globally, following soybean and palm oil production [1]. In the global production of rapeseed-mustard,*Brassica juncea (L.)*CzernIndia secures the third position, with Canada and China leading the way. Within India, key oilseed crops include soybean, groundnut, and rapeseed-mustard, collectively contributing to approximately 88% of the total oilseed production.

The seeds of Indian mustard contain a substantial oil content ranging from 37% to 49% [2]. These oil-rich seeds serve various purposes, such as condiments for pickles and flavorings for curries and vegetables. Mustard oil, a vital ingredient in Northern Indian cuisine, finds extensive use for cooking and frying, and it also holds significance in the formulation of hair oils and medicinal products. Additionally, the residual oil cake is utilized as cattle feed and fertilizer, boasting nutrient components of approximately 4.9% nitrogen, 2.5% phosphorus, and 1.5% potash [2].

In the agricultural landscape of India, oilseed crops, particularly those from the *Brassica* species, play a pivotal role. *Brassica juncea*, commonly known as Indian mustard, holds a substantial presence as a rabi crop in Eastern India, encompassing regions like Uttar Pradesh, Bihar, West Bengal, and Assam. India ranks third globally in rapeseed-mustard production, following China and Canada. In the 2009-10 period, India produced 7.8 million metric tonnes of rapeseed/mustard from an extensive cultivation area of 6.50 million hectares, boasting an average productivity of 1208 kg/ha. Notably, Uttar Pradesh, with a cultivation area of 6.39 lakh hectares, contributed significantly to this production, producing 7.9 lakh metric tonnes of mustard. The state's average productivity, standing at 1236 kg/ha, exceeded the national average [Anonymous, 2013].

However, the sustained extraction of nutrients from the soil, coupled with inadequate and imbalanced fertilizer application, has led to the emergence of multiple nutrient deficiencies. In Indian soils, deficiencies in at least six essential nutrients, namely nitrogen (N), phosphorus (P), potassium (K), sulphur (S), zinc (Zn), and boron (B), have been observed. Sulphur, in particular, plays a crucial role in various plant metabolic pathways, directly or indirectly influencing key processes. As the fourth major plant nutrient after nitrogen, phosphorus, and potassium, sulphur is indispensable for the synthesis of amino acids, proteins, oils, and even a component of vitamin A. Approximately 90% of sulphur is found in three critical amino acids: methionine (21% S), cysteine (26% S), and cystine (27% S), which serve as the fundamental building blocks of proteins. Furthermore, sulphur contributes to the formation of chlorophyll, glucosides, glycosylates (mustard oils), enzyme activation, and sulfhydryl (SH-) linkages, which impart pungency to oilseeds. Consequently, ensuring adequate sulphur levels is of utmost importance for the cultivation of oilseed crops. Recognizing this, there is a growing acknowledgment of the significance of sulphur fertilization in enhancing both the yield and quality of Indian mustard.

In light of the aforementioned considerations, this study proposes to conduct a field trial titled "Effect of Sulphur Levels on Growth and Yield of Indian Mustard" during the rabi season of 2022-2023 at the experimental farm of SAGE University, Bhopal.

Materials and Methods:

Experimental site

The research site was situated within the premises of the School of Agriculture at SAGE University in Bhopal, Madhya Pradesh.

Observations recorded

Pre harvest Observation

Plant height (cm)

The height was taken at 30, 45, 60, 90, Days after sowing and at harvest from point of root-shoot interaction to the top of main raceme with scale for five tagged plants and their average was worked out.

Number of primary branches (per plant)

The number of primary branches were counted separately from five selected plants drawn for biomass observation at 30, 45, 60, 90, Days after sowing and at harvest and their average was worked out.

Post -harvest observations

Yield attributing characters

We examined the yield attributes listed below using a sample of five previously tagged plants, which were collected at the time of harvest.

Number of siliquae (per plant)

We tallied the overall count of siliquae on five chosen plants and subsequently converted this count into the number of siliquae per individual plant.

Number of seeds (per siliqua)

Fifty siliquae were randomly selected from the five designated plants, then subjected to threshing and cleaning. Using a numerical seed counter, we meticulously counted the number of seeds contained within these siliquae. Following this, we computed the average number of seeds per siliqua.

1000-seed weight (g)

1000 seed (randomly drawn seed sample out of net plot produce) were counted on numeral seed counter and then weighed by electronic balance to record 1000-seed weight (test weight) in grams.

Seed yield (g) per plant

We processed the five specifically chosen plants through threshing and cleaning procedures, followed by weighing the seeds obtained. Subsequently, we transformed this weight measurement into seed yield, expressed as grams per individual plant.

Final yield

Seed yield (kg ha-1)

After allowing the crop to undergo sun drying for a period of 2-3 days, the harvest from a net plot area measuring 3 m x 2 m (equivalent to 6 m^2) was manually threshed. The resulting seed yield was subsequently converted into kilograms per hectare (kg ha^{-1}).

Moisture studies
Soil profile moisture content (%)

To determine the soil profile's moisture content, we employed the gravimetric method. Soil samples were collected on a plot-by-plot basis at specific depth intervals: 0 to 15 cm, 15-30 cm, 30-45 cm, 45-60 cm, and 60-90 cm soil layers. These samples were taken at various stages, including at sowing, before and after each irrigation, and at the time of harvest. A screw auger was used to extract these soil samples, and their fresh weight (W1) was recorded. Subsequently, the soil samples were subjected to oven drying at 90°C for a duration of 48 hours, resulting in the determination of their dry weight (W2). The moisture content of these soil samples was then calculated using the following formula:

$$\textbf{Soil moisture content (\%)} = \frac{W_1 - W_2}{W_1} \times 100$$

Were,
W_1=Fresh Weight of Soil (g)
W_2= Dry weight of Soil (g)

Water use efficiency (kg ha^{-1} mm)
To calculate the water use efficiency (expressed as kg ha^{-1} mm) for a specific treatment, we divided the seed yield (kg ha^{-1}) by the total consumptive water use (mm) during the crop period corresponding to that treatment. This calculation of water use efficiency was performed using the following formula:

$$\textbf{WUE} = \frac{\text{Seed yield (kg ha}^{-1}\text{)}}{\text{Consumptive water use (mm)}}$$

Table-1: Growth attributes of mustard as influenced by sulphur levels.

Treatments	Plant Height (cm)	No. of leaves/plant	Dry Matter Accumulation (g/plant)	No of branches/plant
	90 DAS	90 DAS	At harvest	60 DAS
Sulphur levels (kg/ha)				
Control	138.73	33.33	35.15	9.80
100% RDF	139.13	34.13	37.88	10.60
100% S + 100% RDF	149.46	37.66	41.39	12.26
75% S+ 100% RDF	146.66	37.53	41.00	11.80
50% S + 100% RDF	145.00	35.20	40.00	11.33
25% S + 100% RDF	144.40	34.93	39.83	11.20
SEM±	4.51	1.63	0.91	0.41
C.D.(P=0.05)	N/A	N/A	2.63	1.32

*Growth attributes of mustard as influenced by sulphur levels

Results & Discussion-

The growth-related attributes, including plant height, leaf area index, branches per plant, and dry matter accumulation per plant, exhibited significant responses to varying sulphur levels across all growth stages. Notably, as the sulphur levels increased, these growth characteristics displayed a successive and significant increase, with the most pronounced impact observed at the 60 kg/ha sulphur level. This maximum enhancement in growth attributes was consistently observed under the 60 kg S/ha treatment, which was on par with the 30 and 45 kg S/ha treatments, and notably superior to the 15 kg S/ha treatment and the control group across all stages of crop growth.

Additionally, it's worth noting that inherent genetic variability among the different varieties of the plant contributed to variations in these growth characteristics, including plant height and leaf area index.

Table-2: Yield attributes of mustard as influenced by sulphur levels and varieties.

Treatment	No. of siliquae/ plant	Length of siliqua (cm)	Seeds/ siliqua	Test weight (g)	Seed yield (q/ha)	Stover yield (q/ha)	Harvest index (%)
Sulphur levels (kg/ha)							
Control	76.93	5.00	16.00	3.78	1030	3239	22.06
100% RDF	87.46	5.20	16.06	4.12	1301	3485	22.39
100% S + 100% RDF	98.20	5.80	17.73	4.63	1479	3880	22.46
75% S + 100% RDF	97.90	5.63	16.80	4.57	1452	3848	22.45
50% S + 100% RDF	92.40	5.40	16.73	4.55	1439	3812	22.43
25% S + 100% RDF	89.40	5.23	16.26	4.51	1384	3762	22.40
SEM±	4.23	0.03	0.75	0.28	119	109	0.46
C.D. (P=0.04)	13.51	0.11	N/A	N/A	N/A	348	N/A

*Yield attributes of mustard as influenced by sulphur levels and varieties.

The Rani variety demonstrated a significant increase in growth attributes, including plant height, leaf area index, branches per plant, and dry matter accumulation per plant. This increase in plant height can be attributed to the ample availability of sulphur, which contributes to a more favorable nutritional environment for plant growth, particularly during active vegetative stages. This enhanced sulphur availability likely led to increased cell multiplication, elongation, and expansion within the plant, ultimately resulting in greater plant height. These findings align with previous research by Khanpara et al. (1993) and Singh and Saran (1993), which also highlighted the role of sulphur in cell multiplication and elongation.

Moreover, sulphur plays a direct role in cell multiplication, elongation, and cell expansion, leading to a higher number of branches per plant when adequate sulphur supply is provided, especially at higher sulphur doses compared to sulphur-deficient plants. These results are in line with studies conducted by Sharma et al. (1991) and Kumar et al. (2000), which further support the positive impact of sulphur on branching in plants. As a result, dry matter production steadily increased until maturity, thanks to the beneficial effects of sulphur on overall plant growth and development. This increase in the number of primary and secondary branches per plant, along with greater plant height and more leaves per plant, directly contributed to the enhanced accumulation of dry matter in plants at higher sulphur levels. Similar findings were also reported by Singh and Dhiman (2005), reinforcing the relationship between sulphur supply and these growth-related outcomes.

Conclusion: In the present experiment, a notable disparity emerged among the various sulphur sources tested in terms of their impact on mustard's growth, yield attributes, yield, nutrient content, and nutrient uptake. Specifically, the application of 60 kg S ha-1 (T3) exhibited a significant enhancement in these parameters in comparison to other sulphur levels. Notably, it was found to be on par with the performance of 45 kg S ha-1 (T4), signifying their similar effectiveness in promoting growth, yield attributes, yield, and nutrient-related aspects in mustard.

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