



Economics of Hybrid Mustard (*Brassica juncea* L.) Cultivation Following Foliar Application of Micronutrients and Sulphur at Various Stages of Growth

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Mustard (*Brassica juncea* L.) is an important oilseed crop in India, particularly during the Rabi season, contributing significantly to the agricultural economy. However, its productivity is often limited by imbalanced nutrient management, especially in soils with low fertility such as sandy loam. An experiment was carried out for two consecutive years during the Rabi season of 2022-23 and 2023-24 at the Crop Research Farm of the Samhigginbottom University of Agriculture, Technology and Science, Prayagraj, Uttar Pradesh to evaluate the economic impact of foliar application of micronutrients and Sulphur at different concentrations on mustard (Pioneer hybrid

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45S46). The study aimed to determine the most cost-effective nutrient management practices through analysis of gross return, net return, and benefit-cost ratio. The experiment consisted of 16 treatments with three replications in Randomized Block Design (RBD). Foliar application of micronutrients and Sulphur at various concentrations were carried out at 45 and 65 days after sowing (DAS) with the objective to assess their impact on overall economics of mustard (Pioneer hybrid 45S46) cultivation in sandy loam soil of Prayagraj, Uttar Pradesh. Crop economics was calculated on the basis of inputs incurred during 2022-23 and 2024 for agricultural operations, followed by gross return, net return and benefit-cost ratio (B:C). The two-year study concluded that gross return (Rs ha⁻¹), net return (Rs ha⁻¹) and benefit-cost ratio of different treatments were based on input output analysis. The data on gross return in different treatment varied significantly. The highest gross return was obtained in the treatment T₁₁ (RDF + S 1.0%) during both years and pooled data (124112, 136255 and 130183Rs. ha⁻¹, respectively) which was significantly higher than RDF. The data on net return revealed the highest net return (91937, 100180 and 96058 Rs. ha⁻¹, respectively) was also obtained from the treatment T₁₁: RDF + S 1.0% during both the years and pooled data. The benefit-cost ratio was significant among treatments. Maximum benefit-cost ratio was noted in treatment T₁₁: S 1.0% during both the years and pooled data (2.86, 2.78 and 2.82) which was significantly higher than RDF.

Keywords: Foliar spray; net return; pioneer hybrid (45S46); benefit-cost ratio; sandy loam soil.

1. INTRODUCTION

Vegetable oil has one of the highest shares (40%) of the production of all agricultural commodities globally. Among the seven edible oil seed cultivated in India, rapeseed mustard is the second-most important oilseed crop in India, next only to soybean, with almost one-fourth share in both area and production (Jat *et al.*, 2019). It was grown on 6.86 million ha in India (2019), with a production of 9.12 million tons (2019-20) and a productivity of about 1329 kg ha⁻¹ (Agriculture Cooperation & Farmers Welfare, Government of India, 2021). Adoption of improved varieties and their timely sowing are important factors for improving their productivity. Different cultivars may respond differently to sowing times (Sharma & Kumar, 2023). Mustard is the most responsive crop to weather and has different results at different sowing times. Sowing at times plays a prime role in providing growing conditions i.e. temperature, humidity, rain, and light intensity. The development period of mustard should synchronize with ideal conditions for better articulation of growth and yield. Rapeseed and mustard are usually sown from late September to mid-October in North India when grown as a sole crop or on dates of the main crop when sown as mixed or intercrop. However, with the development of new varieties of crops and the adoption of multiple cropping systems under irrigated conditions, it has become essential to extend their sowing from October to mid-November or even later. In the present study, we have reported application of various combinations of micronutrients and Sulphur (S)

at two growth stages of hybrid mustard crop, as reported; S fertilization enhances mustard seed quality resulting in test weight. Studies suggest that S applications can improve mustard seed test weight by enhancing nutrient availability and protein content. This work has been designed to evaluate different combinations of foliar spray of micronutrients and S in hybrid mustard crop in sandy loam soil of Prayagraj. The study has resulted in valuable insights for improving mustard productivity and impacting crop's economic viability.

2. MATERIALS AND METHODS

The study was conducted at Crop Research Farm, Samhigginbottom University of Agriculture, Technology and Science, Prayagraj, Uttar Pradesh during *Rabi* season, 2022-23 and 2023-24. The soil was sandy loam in texture, low in organic carbon and potassium and medium in available nitrogen and phosphorus. Hybrid variety; Pioneer hybrid 45S46 was sown with spacing of 45 cm × 20 cm, plot size of 4m×3m=12 m²; gross experimental area of 586.5 m² (72.5×18m=length x width including 0.5 m bunds and 1.5 m channels); net experimental area of 432 m². Micronutrients were sprayed at 45 and 65 days after sowing (DAS), spray volume was 1000 l ha⁻¹.

The experiment was conducted using a Randomized Block Design (RBD) with 16 treatments, repeated thrice at 20, 40, 60, 80, 100 days after sowing and at harvest from each plot. The treatments were as follows:

- **T1:** Recommended Dose of Fertilizer (RDF) – 80:40:40 kg N:P₂O₅:K₂O ha⁻¹
- **T2:** RDF + Zinc sulfate (ZnSO₄·7H₂O) at 0.25%
- **T3:** RDF + Zinc sulfate (ZnSO₄·7H₂O) at 0.5%
- **T4:** RDF + Molybdenum (Mo) at 0.05%
- **T5:** RDF + Molybdenum (Mo) at 0.1%
- **T6:** RDF + Boron (B) at 0.05%
- **T7:** RDF + Boron (B) at 0.1%
- **T8:** RDF + Ferrous sulfate (FeSO₄·5H₂O) at 0.2%
- **T9:** RDF + Ferrous sulfate (FeSO₄·5H₂O) at 0.4%
- **T10:** RDF + Sulphur (S) at 0.5%
- **T11:** RDF + Sulphur (S) at 1.0%
- **T12:** RDF + Manganese sulfate (MnSO₄) at 0.2%
- **T13:** RDF + Manganese sulfate (MnSO₄) at 0.4%
- **T14:** RDF + Copper sulfate (CuSO₄·5H₂O) at 0.2%
- **T15:** RDF + Copper sulfate (CuSO₄·5H₂O) at 0.4%
- **T16:** Control (no fertilizer or micronutrient application)

The data generated following 2 years of experimentation was analyzed using ANOVA for interpretation.

3. RESULTS AND DISCUSSION:

Results obtained following 2 years of experimentation are presented in Tables 1 and 2.

3.1 Gross Return, Net Return and B:C Ratio

The data on gross return in different treatment varied significantly. The highest gross return was obtained in the treatment T₁₁ (RDF + S at 1.0%) during both years and pooled data (Rs.124112, 136255 and 130183 ha⁻¹, respectively) which was significantly higher than RDF. Significant differences were observed for net return. The data on net return revealed that the highest net return (Rs.91937, 100180 and 96058 ha⁻¹, respectively) was obtained from the treatment T₁₁: RDF + S at 1.0% during both the years and pooled data. This treatment was significantly superior to RDF. The B:C ratio was significant among treatments. Maximum B:C ratio was noted in treatment T₁₁: S at 1.0% during both the years and pooled data (2.86, 2.78 and 2.82) which was significantly higher than RDF. Kumar

and Tiwari (2024) reported a gross return ranging from Rs- 1,16,993.30 to Rs- 1,23,533.30 ha⁻¹, Rs- 1,16,811.70 to Rs- 1,23,170.00 ha⁻¹, and Rs- 1,01,006.70 to Rs- 1,24,623.30 ha⁻¹ for the RH-404, DRMR, and NRCM varieties, respectively. The corresponding net returns were Rs- 66,374.50 to Rs- 72,914.50 ha⁻¹ for RH-404, Rs- 66,192.90 to Rs- 72,551.20 ha⁻¹ for DRMR, and Rs- 50,387.90 to Rs- 74,004.50 ha⁻¹ for NRCM. The benefit-cost (B:C) ratio ranged from 1.32 to 1.45 for RH-404, 1.33 to 1.44 for DRMR, and 1.01 to 1.35 for NRCM, respectively. Yadav and Debberma (2024) reported maximum gross return (1,10,546.40 INR ha⁻¹), net return (75,546.40 INR ha⁻¹) and B:C ratio (2.16) in treatment 8 of their experiment when applied 30 kg S ha⁻¹ +20 kg Zinc ha⁻¹. Similarly, Halim et al. (2023) reported that field application of zinc and boron significantly improved seed yield and oil content in mustard, highlighting the beneficial effect of micronutrient supplementation in enhancing economic returns. Patil et al. (2024) also noted Rs- 1,30,905, Rs- 81,592 and 1.97, gross return, net return and B:C ratio, respectively in mustard hybrid (M-400) which is at par with our findings. Further, Chand et al. (2024) have also found similar economic return following integrated nutrient management on yield and economic returns in mustard (*Brassica juncea* L). They also revealed Rs- 1,05,798; 1,16,624 gross return; Rs- 71,988; 82,814 net return ha⁻¹ and 2.13, 2.44 B:C ratio in 2022 and 2023, respectively which are again in align with our findings. Mukhi et al. (2024) also emphasized that integrated nutrient management practices led to improvement in growth, yield, and overall economic viability of Indian mustard. Bharose et al. (2025) also reported Rs- 1,01,972 gross return and Rs- 65,277 ha⁻¹ net return with B:C ratio of 1.77 following use of RDF with boron in mustard crop which are close to our findings. Kumar et al. (2025) have studied the cost of cultivation, net return and B:C ratio of mustard cultivation in various size of the farm and found that per hectare input cost was Rs- 42,135.45 on marginal farms, Rs- 44164.74 in small farms and Rs- 51,411.71 on large farms. The net return was highest i.e. Rs- 89,610.89 followed by small farms and marginal farms i.e. Rs- 75,747.40 and Rs- 71,546.55, respectively with B:C ratio of 2.7. However, Deewan et al. (2024) reported lesser gross return (Rs- 46,763 ha⁻¹), net return (Rs- 39,663 ha⁻¹) but higher B:C ratio (5.59) under semi-arid condition of Rajasthan in timely sown Pusa Jai Kisan variety of mustard.

Table 1. Effect of foliar spray of micronutrients and Sulphur on cost of cultivation and gross return of mustard

Sr. No.	Treatments	Economics					
		Cost of cultivation (Rs- ha ⁻¹)			Gross return (Rs- ha ⁻¹)		
		2022	2023	Pooled	2022	2023	Pooled
1	RDF (80:40:40)	30375	34075	32225	103772	112257	108014
2	RDF + ZnSO ₄ 0.25%	31931	35831	33881	115637	126338	120988
3	RDF + ZnSO ₄ 0.5%	32285	36185	34235	122228	135858	129043
4	RDF + Mo 0.05%	33075	36975	35025	115072	125942	120507
5	RDF + Mo 0.10%	34575	38475	36525	116578	128123	122351
6	RDF + B0.05%	31855	35755	33805	120722	134470	127596
7	RDF + B0.1%	32135	36035	34085	122982	136652	129817
8	RDF + FeSO ₄ 0.2%	33687	37587	35637	115825	124355	120090
9	RDF + FeSO ₄ 0.4%	35799	39699	37749	120722	134668	127695
10	RDF + S 0.5%	31875	35775	33825	116202	125347	120774
11	RDF + S 1.0%	32175	36075	34125	124112	136255	130183
12	RDF + MnSO ₄ 0.2%	34575	38475	36525	113000	122967	117983
13	RDF + MnSO ₄ 0.4%	37575	41475	39525	114130	124553	119342
14	RDF + CuSO ₄ 0.2%	36375	40275	38325	119403	135065	127234
15	RDF + CuSO ₄ 0.4%	41175	45075	43125	121287	136057	128672
16	Control	25435	28935	27185	54617	62277	58447
	F-test				S	S	
	S Em (±)				4949	7531	
	CD (p=0.05)				14363	21857	

Table 2. Effect of foliar spray of micronutrients and sulphur on net return and benefit cost ratio of mustard

Sr. No	Treatments	Economics					
		Net return (Rs- ha ⁻¹)			B:C ratio		
		2022	2023	Pooled	2022	2023	Pooled
1	RDF (80:40:40)	73397	78182	75789	2.42	2.29	2.36
2	RDF + ZnSO ₄ 0.25%	83706	90507	87107	2.62	2.53	2.57
3	RDF + ZnSO ₄ 0.5%	89943	99673	94808	2.79	2.75	2.77
4	RDF + Mo0.05%	81997	88967	85482	2.48	2.41	2.44
5	RDF + Mo 0.10%	82003	89648	85826	2.37	2.33	2.35
6	RDF + B 0.05%	88867	98715	93791	2.79	2.76	2.78
7	RDF + B0.1%	90847	100617	95732	2.83	2.79	2.81
8	RDF + FeSO ₄ 0.2%	82138	86768	84453	2.44	2.31	2.37
9	RDF + FeSO ₄ 0.4%	84923	94969	89946	2.37	2.39	2.38
10	RDF + S 0.5%	84327	89572	86949	2.65	2.50	2.57
11	RDF + S 1.0%	91937	100180	96058	2.86	2.78	2.82
12	RDF + MnSO ₄ 0.2%	78425	84492	81458	2.27	2.20	2.23
13	RDF + MnSO ₄ 0.4%	76555	83078	79817	2.04	2.00	2.02
14	RDF + CuSO ₄ 0.2%	83028	94790	88909	2.28	2.35	2.32
15	RDF + CuSO ₄ 0.4%	80112	90982	85547	1.95	2.02	1.98
16	Control	29182	33342	31262	1.15	1.15	1.15
	F-test	S	S	S	S	S	S
	SEm (±)	4949	7531		0.15	0.20	
	CD (p=0.05)	14363	21857		0.44	0.59	

The study suggests that Sulphur plays a crucial role in improving nutrient uptake, seed filling, and oil quality, leading to increased market value and better returns. The supplementation with Zinc

sulfate (T2, T3) and Boron (T6, T7) treatments also showed positive results but their economic returns were slightly lower than Sulphur. Treatments with Manganese and Copper had

comparatively lower B:C ratios, indicating limited economic benefits in this type of sandy loam soil and crop condition. The B:C ratio in this study was comparatively higher than that reported by Kumar and Tiwari (2024), due to significant differences in mustard varieties and spacing pattern, but lower than Deewan et al. (2024) which may be attributed to differences in geographical location, temperature and time of sowing, as their findings were based on the arid zone from the Rajasthan, having very significant impact on yield, B:C ratio .

These findings are similar with previous studies conducted by Kumar and Tiwari (2024) and Yadav & Debberma (2024), confirming that the strategic foliar application of key micronutrients and Sulphur is an effective and more economically practical method for mustard cultivators. This approach ensures more efficient nutrient utilization compared to soil application, particularly in nutrient deficient soils that are prone to leaching due to their light texture.

4. CONCLUSION

This two year field study (2022–23 and 2023–24) on *Brassica juncea* L. (hybrid mustard cultivar Pioneer 45S46) clearly establishes that the foliar application of Sulphur (S) at 1.0% concentration along with the Recommended Dose of Fertilizers (RDF) significantly enhances the economic returns of mustard cultivation on sandy loam soils of Prayagraj, Uttar Pradesh.

Among all 16 treatment combinations, the Treatment T11 group with RDF + Sulphur 1.0% recorded maximum yield with significantly highest gross return (Rs- 1,24,112 ha⁻¹ in 2022; Rs- 1,36,255 ha⁻¹ in 2023 and Rs- 1,30,183 ha⁻¹ in pooled); highest net return (Rs- 91,937 ha⁻¹ in 2022; Rs- 1,00,180 ha⁻¹ in 2023 and Rs- 96,058 ha⁻¹ in pooled) and maximum benefit- cost (B:C) ratio (2.86 in 2022, 2.78 in 2023 and pooled 2.82) . These values were significantly higher when compared to both the RDF-alone treatment (T1) and the control (T16). This confirms that Sulphur at 1.0% foliar spray is not only agronomically effective but also economically practical method for enhancing mustard productivity under the given conditions.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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