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Yash Ratilal Gawali
Master of Science in Agriculture, Department of Agronomy, VGU, Jaipur Vivekananda Global University, Jaipur, Rajasthan, India

Dr. Prajapat AL
Assistant Professor, Department of Agriculture, VGU, Jaipur Vivekananda Global University, Jaipur, Rajasthan, India

Corresponding Author:
Yash Ratilal Gawali
Master of Science in Agriculture, Department of Agronomy, VGU, Jaipur Vivekananda Global University, Jaipur, Rajasthan, India

Effect of *Mycorriza* and sulphur on nutrient uptake and yield of mustard (*Brassica juncea* L.)

Yash Ratilal Gawali and Prajapat AL

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Abstract
A field experiment entitled "Effect of *Mycorrhiza* and sulphur on growth and yield of mustard (*Brassica juncea* L.)" was conducted during Rabi 2024 at the research farm of Vivekananda Global University, Jaipur, using a Factorial Randomized Block Design with 15 treatment combinations and three replications. The study revealed that the application of 8.0 kg ha^{-1} *Mycorrhiza* significantly enhanced growth and yield attributes such as plant height, dry matter accumulation, branches per plant, siliquae per plant, seeds per siliqua, test weight, seed yield (1967 kg ha^{-1}), stover yield (5032 kg ha^{-1}), and nutrient uptake, and also recorded the highest net return (Rs. 63,073) and B:C ratio (2.60), found at par with 6.0 kg ha^{-1} *Mycorrhiza*. Similarly, 40 kg ha^{-1} Sulphur application resulted in significantly better performance across the same parameters, with seed yield (1966 kg ha^{-1}), stover yield (4947 kg ha^{-1}), highest net return (Rs. 61,741), and B:C ratio (2.52), indicating the beneficial role of both *Mycorrhiza* and Sulphur in improving mustard productivity and profitability.

Keywords: *Brassica juncea*, *Mycorrhiza*, sulphur, productivity, profitability

Introduction
India is the third largest producer of rapeseed-mustard, yet its average yield remains low due to sub-optimal nutrient management and cultivation on marginal, rainfed lands. Mustard is a key oilseed crop, especially in Rajasthan, which contributes nearly half of the national production. Despite its significance in edible oil supply and protein meal, the productivity gap highlights the need for improved nutrient strategies. Biofertilizers like *Mycorrhiza* and sulphur play a crucial role in enhancing soil fertility, nutrient uptake, crop growth, yield, and oil quality. Sulphur is particularly vital for mustard due to its role in oil synthesis and metabolic functions. Recognizing this, the present study entitled "Effect of *Mycorriza* and Sulphur on Growth and Yield of Mustard (*Brassica juncea* L.)" was conducted during Rabi 2024-25 to evaluate the effects of *Mycorrhiza* and sulphur on the growth, yield, and quality of mustard, as well as to assess the economic viability of various treatment combinations.

Materials and Methods
A field experiment titled *"Effect of Mycorriza and Sulphur on Growth and Yield of Mustard (Brassica juncea* L.)" was conducted during Rabi season 2024-25 at the Research Farm, Vivekananda Global University and Jaipur, situated in Agro-climatic Zone IIIa of Rajasthan. The experiment was laid out in a Factorial Randomized Block Design with 15 treatment combinations of five *Mycorriza* levels (0 to 8.0 kg/ha) and three Sulphur levels (0, 20, and 40 kg/ha), replicated thrice. The soil of the experimental field was loamy sand, low in organic carbon and nitrogen, medium in phosphorus and potassium, and alkaline in reaction. The mustard variety 'Bio-902' was used, sown at 45 cm row spacing with a seed rate of 4 kg/ha. All standard agronomic practices, including two irrigations, were followed. Weather during the season was semi-arid with a total rainfall of 25.6 mm. The experiment aimed to study the individual and combined effects of *Mycorriza* and Sulphur onthe growth, yield, and qualityof mustard, along with economic viability.

Results and Discussion

Table 1: Effect of *Mycorriza* and sulphur on nutrient uptake in mustard

Treatments	N uptake (%)			P uptake (%)		
Mycorriza application (Kg ha^{-1})	**Seed**	**Stover**	**Seed**	**Stover**	**Seed**	**Stover**
Control	44.69	13.24	7.57	9.39	12.90	7.55
2.0	48.11	13.70	8.04	10.49	14.96	8.03
4.0	50.22	15.24	8.69	11.65	17.32	8.81
6.0	52.62	16.22	9.25	12.25	20.74	9.46
8.0	55.52	17.34	9.95	12.96	22.48	9.94
SEM±	2.34	0.40	0.26	0.36	1.44	0.26
C.D (P=0.05)	6.78	1.16	0.76	1.05	4.17	0.76
Sulphur application (Kg ha^{-1})						
0	44.99	13.86	7.77	10.19	13.29	7.76
20	49.85	14.96	8.57	11.18	17.81	8.76
40	55.86	16.62	9.77	12.67	21.93	9.75
SEM±	1.81	0.31	0.20	0.28	1.11	0.20
C.D (P=0.05)	5.25	0.90	0.59	0.81	3.23	0.59

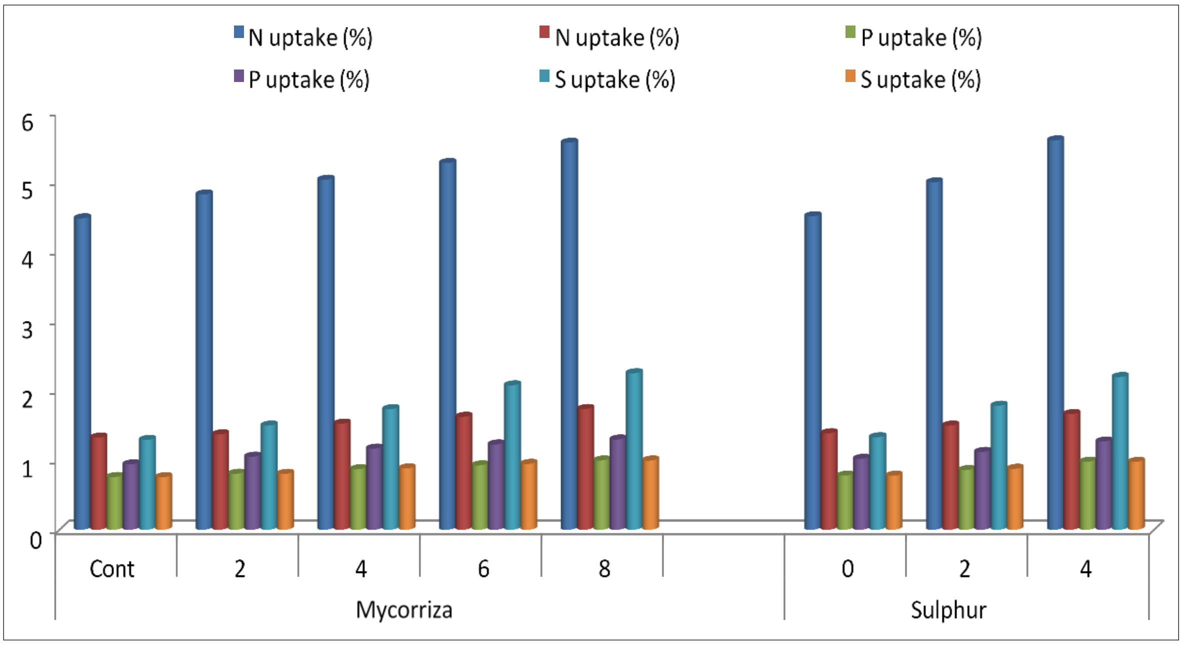

Fig 1: Effect of *Mycorriza* and sulphur on nutrient uptake in seed and Stover of mustard

The study revealed that both *Mycorrhiza* and sulphur applications had a significant positive impact on nitrogen, phosphorus, and sulphur uptake in mustard seed and stover. Among the *Mycorrhiza* treatments, the application of 8.0 kg ha⁻¹ resulted in the highest nutrient uptake, showing marked improvements over the control. Specifically, nitrogen uptake in the seed and stover increased by 24.23% and 30.96%, respectively, with values of 55.52 kg ha⁻¹ and 17.34 kg ha⁻¹. This dose was statistically at par with 6.0 and 4.0 kg ha⁻¹ *Mycorrhiza*. Similarly, phosphorus uptake in seed and stover reached 9.95 kg ha⁻¹ and 12.96 kg ha⁻¹, representing a 31.43% and 38.01% increase over the control. Sulphur uptake also followed this trend, with 8.0 kg ha⁻¹ *Mycorrhiza* leading to the highest uptake in seed (22.48 kg ha⁻¹) and stover (9.94 kg ha⁻¹), translating to increases of 74.26% and 31.65%, respectively. In terms of sulphur application, the highest level tested, 40 kg ha⁻¹, produced the most significant increases in nutrient uptake across all three elements. Nitrogen uptake reached 55.86 kg ha⁻¹ in seed and 16.62 kg ha⁻¹ in stover; phosphorus uptake was 9.77 kg ha⁻¹ in seed and 12.67 kg ha⁻¹ in stover and sulphur uptake peaked at 21.93 kg ha⁻¹ in seed and 9.75 kg ha⁻¹ in stover. These findings clearly demonstrate that combined application of 8.0 kg ha⁻¹ *Mycorrhiza* and 40 kg ha⁻¹ sulphur is highly effective in maximizing nutrient uptake in mustard cultivation. Among all *Mycorrhiza* treatments, the application of 8.0 kg ha⁻¹ resulted in the highest nutrient uptake in mustard seed and stover N (55.52 and 17.34 kg ha⁻¹), P (9.95 and 12.96 kg ha⁻¹), and S (22.48 and 9.94 kg ha⁻¹). The lowest uptake was observed under the control (no inoculation). *Mycorrhiza* also improved seed oil content from 37.13% (control) to 39.60%, with a 6.65% increase in oil yield. These improvements are attributed to enhanced nutrient availability, particularly phosphorus, which promotes better root growth and uptake of N and S key elements in protein and oil synthesis. Similar findings were reported by Chandan *et al.* (2018) [1] and Solanki *et al.* (2017) [5].

The study demonstrated that the application of *Mycorrhiza* and sulphur significantly influenced the yield attributes and yield of mustard. The number of siliquae per plant was markedly improved with the application of 8.0 kg ha⁻¹ *Mycorrhiza*, which recorded the highest number (205.11), representing a 33.09% increase over control, and was statistically similar to 6.0 kg ha⁻¹ (197.44). Similarly, sulphur application at 40 kg ha⁻¹ resulted in the maximum number of siliquae per plant (201.27), with a 25.53% increase over the no-sulphur control.

Table 2: Effect of *Mycorriza* and sulphur on yield and hand harvest index of mustard Treatments yields

Mycorriza application (Kg ha^{-1})	Seed yield (Kg ha^{-1})	Stover Yield (Kg ha^{-1})	Harvest Index
Control	1672	4528	26.96
2.0	1752	4582	27.66
4.0	1815	4785	27.49
6.0	1881	4904	27.65
8.0	1967	5032	27.99
SEM±	42	52	0.38
C.D (P=0.05)	121	150	NS
Sulphur application (Kg ha^{-1})			
0	1684	4604	26.76
20	1803	4748	27.52
40	1966	4947	28.37
SEM±	32	40	0.29
C.D (P=0.05)	93	116	0.84

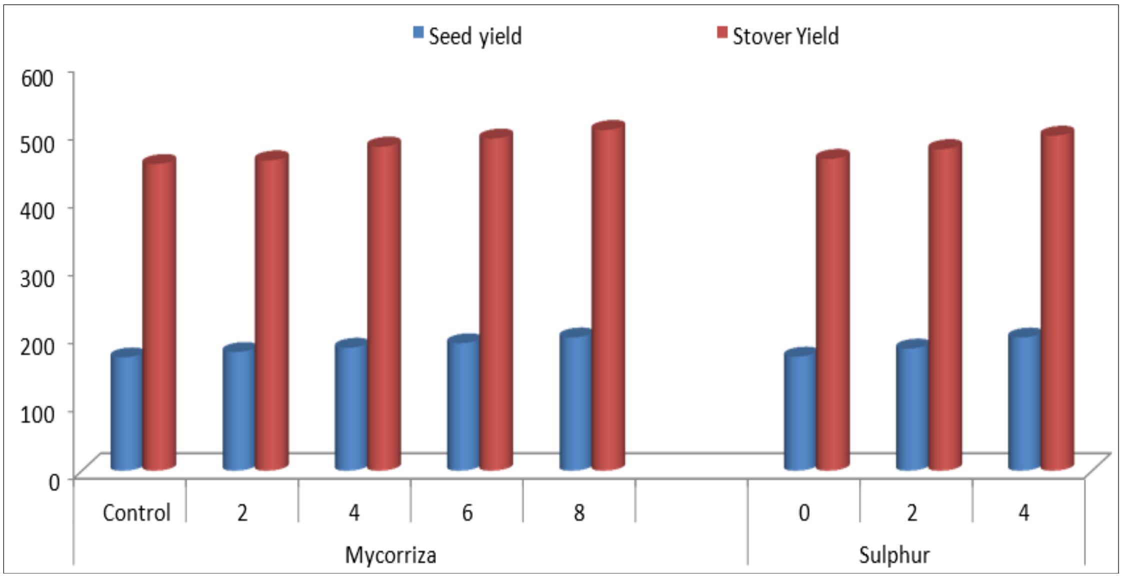

Fig 2: Effect of *Mycorriza* and sulphur on seed and stover yield of mustard

The number of seeds per siliquae also improved significantly with *Mycorrhiza*, where 8.0 kg ha^{-1} recorded the highest value (11.79), followed closely by 6.0 and 4.0 kg ha^{-1}. Sulphur at 40 kg ha^{-1} yielded the highest number of seeds per siliquae (11.52), statistically on par with 20 kg ha^{-1}. Test weight of mustard seeds showed similar trends, with the highest test weight recorded at 8.0 kg ha^{-1} *Mycorrhiza* (4.43 g) and 40 kg ha^{-1} sulphur (4.34 g), both significantly superior to their respective controls. Seed yield was notably enhanced by both treatments, with 8.0 kg ha^{-1} *Mycorrhiza* and 40 kg ha^{-1} sulphur producing nearly identical highest yields (1967 and 1966 kg/ha respectively), each significantly higher than their controls. Stover yield also followed this pattern, with the highest yield from 8.0 kg ha^{-1} *Mycorrhiza* (5032 kg/ha) and 40 kg ha^{-1} sulphur (4947 kg/ha), showing 11.13% and substantial increases over control, respectively. Interestingly, while *Mycorrhiza* did not significantly influence the harvest index, sulphur application did; the highest harvest index (28.37) was recorded with 40 kg ha^{-1} sulphur. Overall, the findings underscore the effectiveness of applying 8.0 kg ha^{-1} *Mycorrhiza* and 40 kg ha^{-1} sulphur to enhance the yield attributes and productivity of mustard. The data from Table 2 demonstrated a progressive increase in the number of siliquae per plant with advancing *Mycorrhiza* application, reaching a significantly higher value of 205.11 siliquae per plant with 8.0 kg ha^{-1} *Mycorrhiza*, which was statistically at par with 6.0 kg ha^{-1}. This increase is attributed to improved availability of phosphorus and micronutrients such as zinc, facilitated by *Mycorrhiza* inoculation, which promotes siliquae primordial formation. Similar findings were reported by Hadiyal *et al.* (2017) [2]. The number of seeds per siliquae also showed a significant increase with 8.0 kg ha^{-1} *Mycorrhiza* (11.79), again at par with 6.0 kg ha^{-1}. This improvement results from *Mycorrhiza*'s ability to mobilize sparingly soluble nutrients, particularly phosphorus, enhancing root growth, nutrient uptake, and photosynthetic activity. This, in turn, supports better partitioning of photosynthates, improving both vegetative and reproductive growth. Consequently, the highest seed and stover yields were also observed with 8.0 kg ha^{-1} *Mycorrhiza*, showing increases of 17.64% and 11.13% over control, respectively. These results align with the findings of Shubhangi and Kachhave (2010) [3], Sharma *et al.* (2016) [4], Verma *et al.* (2017) [6], Yadav *et al.* (2010) [7], highlighting the effectiveness of *Mycorrhiza* in improving nutrient availability by reducing phosphorus fixation and transforming unavailable forms into plant-accessible nutrients, thereby enhancing mustard yield attributes and productivity.

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Conclusion
Based on the results of one year experimentation, it can be concluded that application of *Mycorriza* 8.0 Kg ha^{-1} recorded significantly higher growth and yield attributes, yields, net returns of mustard over control but remain at par with the application of 6.0 kg ha^{-1} *Mycorriza*. Further, results revealed that the application of 40 kg sulphur obtained the similar trend regarding to growth, yield and net returns. So application of 6.0 kg ha^{-1} *Mycorriza* culture and 40 kg sulphur may be proved productive, profitable and economically viable to the farmers.

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