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Synergistic effect of micronutrients and biofertilizers on mustard (*Brassica juncea* L.)

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Abstract
A field experiment was conducted at Research farm, Department of Agronomy, Faculty of Agriculture and Veterinary Sciences, Mewar University Gangrar, Chittorgarh (Rajasthan) during Rabi season of 2024-25 to study evaluated the Synergistic Effect of Micronutrients and Biofertilizers of mustard "variety "NRCHB-506". The result revealed that the maximum plant height (27.76: 28.28, 76.52: 77.85 and 141.80: 143.13 cm at 30, 60, 90 DAS and harvest), number of branches per plant (3.15:3.26 17.63:18.76 and 21.87:22.36 at 60 DAS and harvest) and yield parameter such as number of siliquae per plant (165 and 175), number of seed per siliquae (8.75 and 9.15), grain yield (12.95 and 13.25 q/ha), straw yield (31.52 and 32.75 q/ha) with application of B_4-Azotobacter + VAM + M_4-$ZnSO_4$ @ 25 kg/ha + $FeSO_4$ @ 50 kg/ha. So, it was concluded that the treatment combination B_4-Azotobacter + VAM + M_4-$ZnSO_4$ @ 25 kg/ha + $FeSO_4$ @ 50 kg/ha are best treatment in compare to all the treatments because in this treatment recorded maximum growth and yield of mustard crop as compare to others treatments.

Keywords: Mustard, growth, siliquae, yield

1. Introduction
Rapeseed and mustard [*Brassica juncea* (L.) Czern] is one of the important edible oilseed crops of India next to groundnut and soybean. Indian mustard (*Brassica juncea*) is predominantly cultivated in the states of Rajasthan, Uttar Pradesh, Haryana, Madhya Pradesh, and West Bengal, out of which about 46.0% of total production contributed by Rajasthan state alone. produced globally (Ghildiyal, *et al.* 1981 [1]. The increased use of chemical fertilizers in agriculture has certainly enhanced the food production but it brought with it a host of problems related to micronutrient deficiency and environmental pollution. This alarming situation itself has emphasized the importance of organic manures in agriculture. A sudden reversion to organic farming cannot satisfy both the hungry soil and the ever-growing population. Haung advocated the use of organics plus limited input of chemical fertilizers and pesticides as the first stage of transition from conventional to organic farming. Integrated use of chemical fertilizers with organic manures could be quite promising in maintaining higher productivity and providing greater stability in crop production. Bio-fertilizer can play an important role in meeting the nutrient requirement of crops through biological nitrogen fixation (BNF), solubilization of insoluble phosphorus sources, stimulating plant growth and accelerating decomposition of plant residues. *Azotobacter* are important bioinoculants of rapeseed and mustard, which have non-symbiotic association to fix environmental nitrogen. *Azotobacter* inoculation to rapeseed and mustard can lead to a saving about 20 to 40 kg N/ha. In recent years micronutrients are considered as one of the constraints in the optimum production of crops. Singh (2008) [10] reported that 48, 12, 5, 4, 33, 13 and 41 soils of India are deficient in Zn, Fe, Mn, Cu, B, Mo and S, respectively. Soil and foliage tests indicate a wide spread deficiency of Zn particularly in the light textured soils, having low organic carbon and alkaline reaction. In many parts of country zinc is a plant nutrient now stands third in importance next to nitrogen and phosphorus (Takkar and Randhawa, 1978) [11]. Therefore, micronutrients are considered as one of the constraints in the optimum production of crops. It promotes synthesis of growth hormone, seed maturation, starch synthesis, chlorophyll synthesis and

regulates water absorption. It is an important element for the stability of cytoplasmic ribosomes, cell division, dehydrogenase, proteinase and peptidase enzymes and also help in the synthesis of protein and carotene. India has entered into the era of multi-nutrient deficiency, mainly of N, P, K, S, Fe and Zn and their use have become essential to obtain optimum crop yield.

2. Materials and Methods

A field experiment was conducted during Rabi season of 2024-25 at research farm, Department of Agronomy, Faculty of Agriculture and Veterinary Sciences, Mewar University Gangrar, Chittorgarh (Rajasthan). Soil of the experimental field was sandy loam in texture, saline in reaction with a pH value of 7.6, poor in organic carbon (0.32%), deficient in available zinc (0.48 ppm) and iron (1.2 ppm) low in available nitrogen (176 kg/ha) and phosphorus (20.2 kg/ha) but medium in available potassium (320 kg/ha). The experiment was laid out in factorial randomized block design with three replications and the treatments *viz.* main plot- Control, Azotobacter, VAM and Azotobacter + VAM and sub plot- Control, $ZnSO_4$ @ 25 kg/ha, $FeSO_4$ @ 50 kg/ha and $ZnSO_4$ @ 25 kg/ha + $FeSO_4$ @ 50 kg/ha. The required quantities of fertilizers as per treatments were applied.

3. Results and Discussion

3.1 Growth attributes

In case of biofertilizers the data was showed the significance impact on plant height at 30, 60 DAS and at harvest. The maximum plant height was found in treatment B_4-Azotobacter + VAM (27.76, 76.52 and 141.80 cm). The minimum plant height was found with B_1-Control (22.63, 56.32 and 121.60 cm), respectively. In case of micronutrients the data was showed the showed significance impact on plant height at 30, 60 DAS and at harvest. The maximum plant height was found in treatment M_4-$ZnSO_4$ @ 25 kg/ha + $FeSO_4$ @ 50 kg/ha (28.28, 77.85 and 143.13 cm). The minimum plant height was found with M_1-Control (22.75, 57.02 and 122.30 cm), respectively. In case of biofertilizers the data was showed the significance impact on number of branches per plant at 30, 60 DAS and at harvest. The maximum number of branches per plant was found in treatment B_4-Azotobacter + VAM (3.15, 17.63 and 21.87). The minimum number of branches per plant was found with B_1-Control (2.02, 11.96 and 16.45), respectively. In case of micronutrients the data was showed the significance impact on number of branches per plant at 30, 60 DAS and at harvest. The maximum number of branches per plant was found in treatment M_4-$ZnSO_4$ @ 25 kg/ha + $FeSO_4$ @ 50 kg/ha (3.26, 18.76 and 22.36). The minimum number of branches per plant was found with M_1-Control (2.05, 12.00 and 16.49), respectively. Similar findings also observed by Upadhyay (2012) [12], Pathak *et al.* (2016) [7], Gour *et al.* (2017) [2], Yadav *et al.* (2017) [15], Verma *et al.* (2017) [13], Kumar *et al.* (2019) [5], Gupta *et al.* (2023) [3] and Rahangdale *et al.* (2022) [8].

3.2 Yield attributes and Yield

In case of biofertilizers the data was showed significance impact on number of siliquae per plant. The maximum number of siliquae per plant was found in treatment B_4-Azotobacter + VAM (165). The minimum number of siliquae per plant was found with B_1-Control (140). In case of micronutrients the data was showed the significance impact on number of siliquae per plant. The maximum number of siliquae per plant was found in treatment M_4-$ZnSO_4$ @ 25 kg/ha + $FeSO_4$ @ 50 kg/ha (175). The minimum number of siliquae per plant was found with M_1-Control (140). In case of biofertilizers the data was showed significance impact on number of seed per siliquae. The maximum number of seed per siliquae was found in treatment B_4-Azotobacter + VAM (9.08). The minimum number of seed per siliquae was found with B_1-Control (7.40). In case of micronutrients the data was showed the significance impact on number of seed per siliquae. The maximum number of seed per siliquae was found in treatment M_4-$ZnSO_4$ @ 25 kg/ha + $FeSO_4$ @ 50 kg/ha (9.15). The minimum number of seed per siliquae was found with M_1-Control (7.40). In case of biofertilizers the data was showed significance impact on grain yield. The maximum grain yield was found in treatment B_4-Azotobacter + VAM (12.95 q/ha). In case of micronutrients the data was showed the significance impact on grain yield. The maximum grain yield was found in treatment M_4-$ZnSO_4$ @ 25 kg/ha + $FeSO_4$ @ 50 kg/ha (13.25 q/ha). The minimum grain yield was found with M_1-Control (9.25 q/ha). In case of biofertilizers the data was showed significance impact on straw yield. The maximum straw yield was found in treatment B_4-Azotobacter + VAM (31.52 q/ha). The minimum straw yield was found with B_1-Control (26.32 q/ha). In case of micronutrients the data was showed the significance impact on straw yield. The maximum straw yield was found in treatment M_4-$ZnSO_4$ @ 25 kg/ha + $FeSO_4$ @ 50 kg/ha (32.75 q/ha). The minimum straw yield was found with M_1-Control (25.85 q/ha). Similar result also reported by Sarkar *et al.* (2021) [9], Yadav *et al.* (2021) [16], Gupta *et al.* (2023) [3], Mishra *et al.* (2022) [6] and Vidmahe *et al.* (2022) [14].

4. Conclusion

On the basis of one-year experimentation it was concluded that the treatment combination B_4-Azotobacter + VAM + M_4-$ZnSO_4$ @ 25 kg/ha + $FeSO_4$ @ 50 kg/ha are best treatment in compare to all the treatments because in this treatment recorded maximum growth and yield of mustard crop as compare to others treatments.

Table 1: Effect of micronutrient and biofertilizers on plant height and number of branches per plant of mustard at 30, 60 DAS and at harvest

Treatments	Plant height (cm)			Number of branches per plant		
	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest
Main plot (Biofertilizers)						
B_1-Control	22.63	56.32	121.6	0.13	0.96	0.82
B_2-Azotobacter	26.85	75.41	140.69	0.41	2.90	2.48
B_3-VAM	25.45	73.65	138.93	0.13	0.96	0.82
B_4-Azotobacter + VAM	27.96	76.52	141.8	0.41	2.90	2.48
S. Em. ±	0.84	0.95	0.96	0.13	0.96	0.82
CD%	2.53	2.88	2.87	0.41	2.90	2.48
Sub plot (Micro nutrients)						
M_1-Control	22.75	57.02	122.3	2.05	12.00	16.49
M_2-$ZnSO_4$ @ 25 kg/ha	27.78	76.34	141.62	2.95	16.85	21.45
M_3-$FeSO_4$ @ 50 kg/ha	26.65	74.25	139.53	2.90	15.96	19.84
M_4-$ZnSO_4$ @ 25 kg/ha + $FeSO_4$ @ 50 kg/ha	28.28	77.85	143.13	3.26	18.78	22.36
S. Em. ±	0.55	0.85	0.93	0.12	0.35	0.84
CD%	1.65	1.20	1.19	0.37	0.94	2.53
CV%	7.42	7.85	7.68	7.85	7.98	7.65

Table 2: Effect of micronutrient and biofertilizers on yield attributes and yield of mustard

Treatments	Number of siliquae per plant	Number of seed per siliquae	Test weight (g)	Grain yield (q/ha)	Straw yield (q/ha)	Harvest index (%)
Main plot (Biofertilizers)						
B_1-Control	140	7.40	2.92	9.25	26.32	26.01
B_2-Azotobacter	158	8.75	2.98	12.04	30.21	28.50
B_3-VAM	152	8.65	2.95	11.85	28.02	29.72
B_4-Azotobacter + VAM	165	9.08	3.08	12.95	31.52	29.12
S. Em. ±	4.33	0.15	0.11	0.37	0.43	0.60
CD%	13.01	0.46	NS	1.13	1.31	NS
Sub plot (Micro nutrients)						
M_1-Control	140	7.40	2.92	9.25	25.85	26.35
M_2-$ZnSO_4$ @ 25 kg/ha	160	8.85	3.00	12.32	31.45	28.15
M_3-$FeSO_4$ @ 50 kg/ha	155	8.75	2.95	12.00	31.08	27.86
M_4-$ZnSO_4$ @ 25 kg/ha + $FeSO_4$ @ 50 kg/ha	175	9.15	3.04	13.25	32.75	28.80
S. Em. ±	4.99	0.10	0.05	0.30	0.44	0.65
CD%	14.98	0.30	NS	0.90	1.32	NS
CV%	8.32	8.65	7.22	7.45	7.18	6.78

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