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Effect of Micronutrients and Biofertilizer Treatments on Yield and it`s Attributes of Coriander (*Coriandrum sativum* L.) cv. RCR-41

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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

The current study, named "effect of micronutrients and biofertilizer on yield parameters of coriander *Coriandrum sativum* (L.) cv. RCR-41," is planned to be carried out in the Research Field, Department of Horticulture, College of Agriculture, Gwalior, M.P., during Rabi 2020-21 and 2021-

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22. The experiment was designed in a Completely Randomized Block Design (CRBD) with two factors concepts i.e., Micronutrients ($ZnSO_4$ (0.5%), $FeSo_4$ (0.5%), $CuSo_4$ (0.5%), Biofertilizers (Phosphorus Solubilizing Bacteria (PSB), *Azotobacter*, Potassium Solubilizing Bacteria (KSB) and replicated three times and included three replications. At the time of coriander seeding, treatments combinations including RDF doses of fertilisers and biofertilizers were used. The results showed that treatment M1 (ZnSO4 @ 0.5%) was the optimum micronutrient level treatment for coriander production. Treatment B2 (*Azotobacter*) was shown to be the optimal biofertilizer level for coriander production. The treatment combination M1B2 (ZnSO4 @ 0.5% x *Azotobacter*) was shown to be considerably better among all treatment combinations, yielding the highest coriander yield characteristics.

Keywords: Coriander; biofertilizers; micronutrients; fertilizers; yield attributes.

1. INTRODUCTION

Coriander (*Coriandrum sativum* L.), an annual herbaceous plant, holds historical significance as one of the earliest seed spices utilized by Homo sapiens. Belonging to the Apiaceae (Umbelliferae) family, coriander is cultivated year-round for its seeds, known as "Dhaniya" in Hindi, which are integral to the flavor of curry powder [1]. Rich in compounds such as a-pinene, a-terpinene, limonene, and nymene, along with various non-linalool alcohols and esters [2], coriander is widely used as a flavoring agent in Ayurvedic medicine due to its distinctive aroma and taste.

Coriander seeds and foliage offer significant nutritional value, being high in vitamin A and C content. Raw leaves consist of approximately 87.9% moisture, 3.3% protein, 6.5% carbohydrates, 1.7% total ash, and essential minerals, including calcium, phosphorus, and iron. Additionally, coriander seeds are rich in unrefined fiber, fat, protein, and carbohydrates [3].

In the cultivation of short-lived cereals, the use of inorganic fertilizers has been deemed crucial [4] Micronutrients play a vital role in plant development and yield, with deficiencies significantly impacting physiological and metabolic processes [5,6] The application of micronutrients is essential for superior crop quality and substantial yield [7,6], influencing various metabolic processes such as photosynthesis, N-fixation, and respiration [8].

Biofertilizers, viewed as more cost-effective, environmentally friendly, and sustainable, are expected to play a prominent role when used in conjunction with inorganic fertilizers [9,10] Despite their immense potential, the performance of biofertilizers, including *Azotobacter*, PSB, and KSB, can be inconsistent in practice [11] These biofertilizers contribute significantly to nitrogen (N) and phosphorus (P) availability, enhancing plant resistance to water stress [12]**.** Considering the above information, this field experiment aims to assess the impact of different micronutrients and biofertilizers on coriander yield parameters.

2. MATERIALS AND METHODS

The experiment was conducted at the Experimental Field, Department of Horticulture, College of Agriculture, Gwalior, M.P.

Treatments details: A completely Randomized Block Design (CRBD) with three replications was conducted included two factors concepts with combination of 60 treatments (5 Micronutrients × 4 Biofertilizers × 3 replicates). The first factor was induced by micronutrients treatments i.e., $ZnSo_4$ (0.5%), $FeSo_4$ (0.5%), $CuSo_4$ (0.5%), $MnSo_4$ (0.5%), along with untreated (plants) as a control treatment. The second factor was assigned to biofertilizer treatments *i.e*., Phosphorus Solubilizing Bacteria (PSB), *Azotobacter*, Potassium Solubilizing Bacteria (KSB), along with the untreated (Seeds) as a control treatment. 60:40:20 kg/ha NPK were applied in all treatments. Before sowing, the coriander seeds were split into two halves and treated with *Azotobacter*, KSB and PSB @ 2 g per kg of seed. The sowing was done in rows at 30 cm apart behind the plough with a seed rate of 12 kg/ha keeping 2-3 cm depth.

Variety RCr-41: It is a tall, straight type with round, small seeds that take longer to produce shoots after germination. The variety is highly immune to wilt and stem gall diseases when grown in the field. It takes 130–140 days to reach full maturity, producing an average of 920 kg of seeds per hectare.

Fertilizer application: Fertilizers were applied evenly with 60 kg of nitrogen, 40 kg of phosphorus, and 20 kg of urea, diammonium phosphate, and muriate of potash. An initial dose of 30 kg N/ha and full doses of phosphorus and potassium were hand-ploughed into the ground at a depth of 5 to 7 cm. The remaining nitrogen through urea was evenly spread over two sections and watered in.

Observations recorded:

Yield Characters: Number of Umbels per Plant: At harvest, the umbels of five tagged plants were counted in each plot, and the average number of umbels/plant was computed.

Number of Umbellate per Umbel: At harvest, twenty umbels were randomly chosen from the five tagged plants, and the total umbellets were tallied. The average umbellets/umbel were then calculated.

Number of Seeds per Umbel: At harvest, twenty umbels were randomly chosen from the five tagged plants, and the total quantity of seeds was tallied. The average number of seeds per umbel was calculated.

Weight of Seed per Umbel (g): Five plants were randomly chosen from each plot, permanently tagged, and used to calculate the weight of seed per umbel (g). A weighing machine was used for accurate measurements.

Test Weight (g): The seeds of all five randomly chosen plants were combined, and 1000 seeds were randomly picked and weighed from this lot.

Leaf Yield (g/plant): The weight of the fresh green leaf yield of five tagged plants was recorded, and the average was calculated to determine fresh green leaf yield/plant in grams and kilograms.

Seed Yield (g/plant): The product obtained from each plant was threshed to calculate seed yield. The seeds were washed, dried, and weighed in grams per plant.

3. RESULTS AND DISCUSSION

Number of Umbels per Plant: Table 1 presents the data regarding the quantity of umbels per plant. In the first year, second year, and overall, treatment M1 (ZnSO4 @ 0.5%) exhibited the highest number of umbels per plant (22.16, 22.20, and 22.18), whereas treatment M0 (Control) recorded the lowest number of umbels per plant (17.82, 17.83, and 17.82). Treatment B2 (*Azotobacter*), with the highest biofertilizer level, resulted in the highest number of umbels per plant (21.33, 21.38, and 21.36) in the first year, second year, and overall. Conversely, treatment B0 (Control), without biofertilizer, showed the lowest number of umbels per plant (18.51, 18.52, and 18.51). The treatment combination M1B2, consisting of ZnSO4 at a concentration of 0.5% and *Azotobacter*, significantly influenced the number of umbels per plant, producing the highest count (23.41, 23.47, and 23.44) in the first year, second year, and overall. In the first year, this was comparable to treatment combination M1B1 (ZnSO4 at a concentration of 0.5% combined with PSB). In the second year, it was equivalent to treatment combinations M1B1 (ZnSO4 at a concentration of 0.5% combined with PSB) and M2B2 (FeSO4 at a concentration of 0.5% combined with *Azotobacter*). These results were aggregated and analyzed for further insights.

Treatment B2 (*Azotobacter*) demonstrated the highest number of umbels per plant and umbellate per umbel, attributed to the conversion of phosphorus by phosphate-solubilizing bacteria. This aligns with [11]. Treatment M1 (ZnSO4 @ 0.5%) demonstrated superior micronutrient levels, resulting in the maximum number of umbels per plant and umbellate per umbel in both the first and second years. Zinc's role in enhancing photosynthesis and assimilate movement contributed to increased umbellate and umbels per plant. Zinc enhances the process of photosynthesis and facilitates the movement of assimilates to various parts of the plant, resulting in an increased number of umbellate and umbels per plant. The findings are consistent with the studies conducted by [6,13,7].

Number of Umbellate per Umbel: Table 2 presents the statistics on the number of umbellate per umbel. In the first year, second year, and overall, treatment M1 (ZnSO4 @ 0.5%) exhibited the highest number of umbellate per umbel (5.98, 6.00, and 5.99), while treatment M0 (Control) had the lowest number (5.24, 5.24, and 5.24) among the different micronutrient levels. Treatment B2 (*Azotobacter*) demonstrated the highest number of umbellate per umbel (5.88, 5.88, and 5.88) in the first year, second year, and when the data was pooled. Conversely, treatment B0 (Control) recorded the lowest number of umbellate per umbel (5.51, 5.54, and

5.53) among the different biofertilizer levels. The interaction effect of micronutrient and biofertilizer levels did not have a significant impact on the number of umbellate per umbel in coriander.

Number of Seeds per Umbel: Table 3 presents the statistics on the number of seeds per umbel. In the first year, second year, and pooled data, treatment M1 (ZnSO4 @ 0.5%) exhibited the highest number of seeds per umbel (25.92, 25.94, and 25.93), while treatment M0 (Control) recorded the lowest number (20.88, 20.93, and 20.91). Treatment B2 (*Azotobacter*) demonstrated the highest number of seeds per umbel (24.86, 24.91, and 24.88) in the first year, second year, and overall, whereas treatment B0 (Control) showed the lowest number of seeds per umbel (21.82, 21.83, and 21.82). The treatment combination M1B2, consisting of ZnSO4 at a concentration of 0.5% and *Azotobacter*, significantly influenced the number of seeds per umbel, resulting in the highest count (27.40, 27.45, and 27.43) in the first year, second year, and overall. However, the treatment combination M1B1 (ZnSO4 @ 0.5% x PSB) and M2B2 (FeSO4 @ 0.5% x *Azotobacter*) exhibited similar results to the control group in the first year, second year, and overall.

Table 1. Effect of Micronutrients and Bio-fertilizers on Number of Umbels per Plant of Coriander cv. RCR-41

Number of Umbels per Plant					
1st Year					
	B_0	**B_1**	**B_2**	**B_3**	**MEAN**
M_0	17.40	17.96	18.34	17.57	**17.82**
M_1	19.07	23.21	23.41	22.95	**22.16**
M_2	18.90	22.74	23.00	22.42	**21.77**
M_3	18.63	21.41	21.68	20.76	**20.62**
M_4	18.55	19.80	20.23	19.61	**19.55**
MEAN	**18.51**	**21.02**	**21.33**	**20.66**	
	M	**B**	**M*B**		
SE(m)	0.069	0.062	0.138		
CD(5%)	0.198	0.178	0.397		
2nd Year					
M_0	17.43	17.86	18.39	17.65	**17.83**
M_1	19.00	23.28	23.47	23.03	**22.20**
M_2	18.94	22.80	23.10	22.49	**21.83**
M_3	18.65	21.49	21.74	20.81	**20.67**
M_4	18.58	19.76	20.22	19.64	**19.55**
MEAN	**18.52**	**21.04**	**21.38**	**20.72**	
	M	**B**	**M*B**		
SE(m)	0.083	0.075	0.167		
CD(5%)	0.239	0.214	0.479		
Pooled					
M_0	17.42	17.91	18.36	17.61	**17.82**
M_1	19.04	23.25	23.44	22.99	**22.18**
M_2	18.92	22.77	23.05	22.45	**21.80**
M_3	18.64	21.45	21.71	20.79	**20.65**
M_4	18.57	19.78	20.22	19.62	**19.55**
MEAN	**18.52**	**21.03**	**21.36**	**20.69**	
	M	**B**	**M*B**		
SE(m)	0.077	0.069	0.153		
CD(5%)	0.220	0.197	0.440		

Table 2. Effect of micronutrients and bio-fertilizers on number of Umbellate per Umbel of Coriander cv. RCR-41

Number of Umbellate per Umbel					
1st Year					
	B_0	**B_1**	**B_2**	**B_3**	**MEAN**
M_0	5.10	5.26	5.43	5.14	**5.24**
M_1	5.69	6.09	6.10	6.04	**5.98**
M_2	5.64	6.00	6.07	5.97	**5.92**
M_3	5.61	5.91	5.94	5.88	**5.84**
M_4	5.53	5.76	5.84	5.74	**5.72**
MEAN	**5.51**	**5.81**	**5.88**	**5.76**	
	M	**B**	**M*B**		
SE(m)	0.065	0.058	0.130		
CD(5%)	0.186	0.167	NS		
2nd Year					
M_0	5.14	5.24	5.45	5.15	**5.24**
M_1	5.70	6.12	6.12	6.04	**6.00**
M_2	5.67	6.02	6.07	6.00	**5.94**
M_3	5.65	5.87	5.95	5.86	**5.83**
M_4	5.55	5.76	5.83	5.73	**5.72**
MEAN	**5.54**	**5.80**	**5.88**	**5.76**	
	M	**B**	**M*B**		
SE(m)	0.066	0.059	0.133		
CD(5%)	0.191	0.171	NS		
Pooled					
M_0	5.12	5.25	5.44	5.15	**5.24**
M_1	5.69	6.11	6.11	6.04	**5.99**
M_2	5.66	6.01	6.07	5.99	**5.93**
M_3	5.63	5.89	5.95	5.87	**5.84**
M_4	5.54	5.76	5.83	5.73	**5.72**
MEAN	**5.53**	**5.81**	**5.88**	**5.76**	
	M	**B**	**M*B**		
SE(m)	0.066	0.059	0.131		
CD(5%)	0.188	0.169	NS		

Table 3 Effect of micronutrients and bio-fertilizers on Number of Seeds per Umbel of Coriander cv. RCR-41

Number of Seeds per Umbel					
1st Year					
	B_0	**B_1**	**B_2**	**B_3**	**MEAN**
M_0	20.30	21.09	21.42	20.73	**20.88**
M_1	22.66	27.28	27.40	26.35	**25.92**
M_2	22.42	25.78	27.02	25.31	**25.13**
M_3	21.98	24.67	24.95	23.77	**23.84**
M_4	21.75	23.24	23.53	22.90	**22.86**
MEAN	**21.82**	**24.41**	**24.86**	**23.81**	
	M	**B**	**M*B**		
SE(m)	0.076	0.068	0.151		
CD(5%)	0.217	0.194	0.434		
2nd Year					
M_0	20.34	21.11	21.48	20.80	**20.93**
M_1	22.69	27.30	27.45	26.30	**25.94**
M_2	22.39	25.77	27.06	25.29	**25.13**
M_3	21.94	24.70	24.99	23.82	**23.86**

M_4	21.78	23.30	23.55	23.00	**22.91**
MEAN	**21.83**	**24.44**	**24.91**	**23.84**	
	M	**B**	**M*B**		
SE(m)	0.067	0.060	0.134		
CD(5%)	0.192	0.171	0.383		
Pooled					
M_0	20.32	21.10	21.45	20.76	**20.91**
M_1	22.68	27.29	27.43	26.33	**25.93**
M_2	22.41	25.78	27.04	25.30	**25.13**
M_3	21.96	24.69	24.97	23.80	**23.85**
M_4	21.76	23.27	23.54	22.95	**22.88**
MEAN	**21.82**	**24.43**	**24.88**	**23.83**	
	M	**B**	**M*B**		
SE(m)	0.071	0.064	0.143		
CD(5%)	0.205	0.183	0.410		

Weight of seed per umbel (g): The inquiry has determined that the weight of each seed cluster, known as an umbel, is shown in Table 4. In terms of micronutrient levels, the highest weight of seed per umbel (0.311, 0.312, and 0.312 g) was observed in the first year, second year, and overall in treatment M1 (ZnSo4 @ 0.5%). Conversely, the lowest weight of seed per umbel (0.215, 0.216, and 0.215 g) was recorded in the first year, second year, and overall in treatment M0 (Control).

The highest weight of seed per umbel (0.291, 0.293, and 0.292 g) was observed in treatment B2 (*Azotobacter*) in the first year, second year, and overall. Conversely, the lowest weight of seed per umbel (0.234, 0.234, and 0.234) was recorded in treatment B0 (Control) in the first year, second year, and overall.

The treatment combination M1B2, consisting of ZnSo4 at a concentration of 0.5% and *Azotobacter*, had a substantial effect on the weight of seeds per umbel. It resulted in the highest weight of seeds per umbel, measuring 0.340 g, 0.342 g, and 0.341 g in the first year, second year, and overall, respectively. The treatment combination M1B1 (ZnSo4 @ 0.5% x PSB) and M2B2 (FeSo4 @ 0.5% x *Azotobacter*) were equally effective in the first year and when the data was combined. In the second year, the treatment combination M1B1 (ZnSo4 @ 0.5% x PSB) was equally effective.

M1 (ZnSO4 @ 0.5%) also yielded the highest number and weight of seeds per umbel. The positive impact on seed weight can be attributed to improved mineral utilization, enhanced photosynthesis, and increased allocation of food material to seeds, consistent with [6,14,7].

B2 (*Azotobacter*) also led to the highest number and weight of seeds per umbel, attributed to enhanced nitrogen fixation and phosphorus solubilization. The treatment exhibited the highest test weight, likely due to *Azotobacter*'s provision of vital nutrients, consistent with [15, 16].

Test weight (g): Table 5 displays the statistics on the test weight, measured in grammes. Regarding micronutrient levels, the highest test weight (11.95, 12.01, and 11.98 g) was observed in the first year, second year, and overall, in treatment M1 (ZnSo4 @ 0.5%). Conversely, the lowest test weight (10.29, 10.31, and 10.30 g) was recorded in the first year, second year, and overall, in treatment M0 (Control).

The highest test weight (11.65, 11.69, and 11.67 g) was observed in treatment B2 (*Azotobacter*) in the first year, second year, and overall. Conversely, the lowest test weight (10.72, 10.73, and 10.72 g) was detected in treatment B0 (Control) in the first year, second year, and overall.

The treatment combination M1B2, consisting of ZnSo4 at a concentration of 0.5% and *Azotobacter*, had a substantial impact on the test weight. It resulted in the highest test weight of 12.40, 12.47, and 12.44 grammes in the first year, second year, and overall, respectively. The treatment combination M1B1 (ZnSo4 @ 0.5% x PSB) and M2B2 (FeSo4 @ 0.5% x *Azotobacter*) showed similar results to the treatment combination at the first year, second year, and when the data from both years was combined.

The enhanced number and weight of seeds per umbel can be attributed to the elevated concentration of humus-rich organic manures, which facilitate greater nitrogen fixation, phosphorus solubilization, and mobilisation by the microorganisms. As a result, the weight of the seeds has increased. In addition, biofertilizer enhances plant growth by synthesising phytohormones, fixing nitrogen, reducing root membrane potential, synthesising enzymes like ACC deaminase that regulate plant hormone levels, and solubilizing inorganic phosphates and mineralizing organic phosphates, thereby making phosphates accessible to plants. Findings are in accordance with those of [12].

Table 4. Effect of micronutrients and bio-fertilizers on Weight of Seeds per Umbel (g) of Coriander cv. RCR-41

Weight of Seeds per Umbel (g)					
1st Year					
	B_0	**B_1**	**B_2**	**B_3**	**MEAN**
M_0	0.205	0.218	0.226	0.211	**0.215**
M_1	0.249	0.336	0.340	0.318	**0.311**
M_2	0.245	0.308	0.330	0.300	**0.296**
M_3	0.238	0.285	0.292	0.274	**0.272**
M_4	0.232	0.262	0.267	0.256	**0.254**
MEAN	**0.234**	**0.282**	**0.291**	**0.272**	
	M	**B**	**M*B**		
SE(m)	0.002	0.002	0.005		
CD(5%)	0.007	0.006	0.014		
2nd Year					
M_0	0.206	0.218	0.227	0.212	**0.216**
M_1	0.251	0.338	0.342	0.319	**0.312**
M_2	0.245	0.309	0.332	0.301	**0.297**
M_3	0.239	0.287	0.294	0.275	**0.274**
M_4	0.232	0.263	0.268	0.256	**0.255**
MEAN	**0.234**	**0.283**	**0.293**	**0.273**	
	M	**B**	**M*B**		
SE(m)	0.002	0.001	0.003		
CD(5%)	0.005	0.004	0.009		
Pooled					
M_0	0.206	0.218	0.227	0.211	**0.215**
M_1	0.250	0.337	0.341	0.319	**0.312**
M_2	0.245	0.309	0.331	0.301	**0.296**
M_3	0.239	0.286	0.293	0.274	**0.273**
M_4	0.232	0.262	0.267	0.256	**0.254**
MEAN	**0.234**	**0.282**	**0.292**	**0.272**	
	M	**B**	**M*B**		
SE(m)	0.002	0.002	0.004		
CD(5%)	0.006	0.005	0.012		

Table 5. Effect of micronutrients and bio-fertilizers on Test Weight (g) of Coriander cv. RCR-41

Test Weight (g)					
1st Year					
	B_0	**B_1**	**B_2**	**B_3**	**MEAN**
M_0	10.11	10.34	10.56	10.17	**10.29**
M_1	11.00	12.33	12.40	12.07	**11.95**
M_2	10.95	11.96	12.23	11.87	**11.75**
M_3	10.85	11.55	11.72	11.51	**11.41**
M_4	10.68	11.26	11.34	11.18	**11.12**
MEAN	**10.72**	**11.49**	**11.65**	**11.36**	
	M	**B**	**M*B**		
SE(m)	0.071	0.064	0.143		

CD(5%)	0.204	0.183	0.409		
2nd Year					
M_0	10.13	10.33	10.57	10.19	**10.31**
M_1	11.04	12.37	12.47	12.14	**12.01**
M_2	10.93	11.99	12.28	11.91	**11.78**
M_3	10.90	11.60	11.78	11.55	**11.46**
M_4	10.65	11.29	11.36	11.14	**11.11**
MEAN	**10.73**	**11.51**	**11.69**	**11.39**	
	M	**B**	**M*B**		
SE(m)	0.060	0.054	0.121		
CD(5%)	0.173	0.155	0.346		
Pooled					
M_0	10.12	10.34	10.57	10.18	**10.30**
M_1	11.02	12.35	12.44	12.10	**11.98**
M_2	10.94	11.98	12.25	11.89	**11.76**
M_3	10.87	11.58	11.75	11.53	**11.43**
M_4	10.67	11.27	11.35	11.16	**11.11**
MEAN	**10.72**	**11.50**	**11.67**	**11.37**	
	M	**B**	**M*B**		
SE(m)	0.066	0.059	0.132		
CD(5%)	0.189	0.169	0.379		

The treatment further exhibited the highest test weight, and the increased seed weight may be linked to improved mineral utilization and enhanced photosynthesis. Similar findings were reported by [14,7].

Leaf Yield (g/plant): Table 6 provides data on leaf yield measured in grams per plant. In the first year, second year, and overall, treatment M1 (ZnSO4 @ 0.5%) demonstrated the highest leaf yield (11.42, 11.46, and 11.44 g/plant), while treatment M0 (Control) recorded the lowest leaf yield (8.23, 8.24, and 8.24 g/plant).

Among different biofertilizer levels, treatment B2 (*Azotobacter*) exhibited the highest leaf yield (10.85, 10.87, and 10.86 g/plant), while treatment B0 (Control) showed the lowest leaf yield (8.97, 9.00, and 8.99 g/plant).

The interaction effect of micronutrient and biofertilizer levels significantly impacted the leaf yield (g/plant). The treatment combination M1B2, comprising ZnSO4 at a concentration of 0.5% and *Azotobacter*, demonstrated superiority compared to all other treatment combinations. This combination resulted in the highest leaf yield of 12.29, 12.36, and 12.33 g/plant in the first year, second year, and overall, respectively. The treatment combinations M1B1 (ZnSO4 @ 0.5% x PSB) and M2B2 (FeSO4 @ 0.5% x *Azotobacter*) were equally effective in the first year and when the results were combined. In the second year, the treatment combination M1B1 (ZnSO4 @ 0.5% x PSB) was equally effective.

The rise in leaf weight may be attributed to the augmented and harmonised provision of all vital nutrients by *Azotobacter* and Phosphate solubilising bacteria. This might have led to a greater generation of photosynthate and its subsequent accumulation in the washbasin. The results are corroborated by the discoveries of [15, 16].

Seed Yield (g/plant): Table 7 presents the analysis of seed yield measured in grams per plant. In the first year, second year, and overall, treatment M1 (ZnSO4 @ 0.5%) exhibited the highest seed yield (6.95, 7.00, and 6.98 g/plant), while treatment M0 (Control) recorded the lowest seed yield (3.83, 3.85, and 3.84 g/plant).

Treatment B2 (*Azotobacter*) demonstrated the highest seed yield (6.29, 6.34, and 6.31 g/plant) in the first year, second year, and overall, whereas treatment B0 (Control) showed the lowest seed yield (4.34, 4.35, and 4.35 g/plant).

The seed yield (g/plant) was significantly influenced by the treatment combination M1B2 (ZnSO4 @ 0.5% x *Azotobacter*), resulting in the highest seed yield (7.95, 8.04, and 8.00 g/plant) in the first year, second year, and overall. The treatment combinations M1B1 (ZnSO4 @ 0.5% x PSB), M2B2 (FeSO4 @ 0.5% x *Azotobacter*), and M1B3 (ZnSO4 @ 0.5% x KSB) were equally effective in the first year. In the second year, the treatment combination M1B1 (ZnSO4 @ 0.5% x PSB) was equally effective, and the combination of M1B1 ($ZnSO_4$ @ 0.5% x PSB) and M2B2 ($FeSO_4$ @ 0.5% x *Azotobacter*) was also equally effective. These results remained consistent when the data from both years were combined.

Table 6. Effect of micronutrients and bio-fertilizers on Leaf Yield (g/plant) of Coriander cv. RCR-41

Leaf yield (g/plant)					
1st Year					
	B_0	**B_1**	**B_2**	**B_3**	**MEAN**
M_0	8.00	8.30	8.50	8.12	**8.23**
M_1	9.57	12.06	12.29	11.75	**11.42**
M_2	9.34	11.51	11.91	11.48	**11.06**
M_3	9.11	10.82	11.39	10.55	**10.47**
M_4	8.85	10.02	10.16	9.85	**9.72**
MEAN	**8.97**	**10.54**	**10.85**	**10.35**	
	M	**B**	**M*B**		
SE(m)	0.096	0.086	0.191		
CD(5%)	0.275	0.246	0.549		
2nd Year					
M_0	8.04	8.26	8.52	8.14	**8.24**
M_1	9.61	12.08	12.36	11.80	**11.46**
M_2	9.32	11.54	11.87	11.53	**11.06**
M_3	9.14	10.87	11.42	10.61	**10.51**
M_4	8.88	10.11	10.19	9.90	**9.77**
MEAN	**9.00**	**10.57**	**10.87**	**10.40**	
	M	**B**	**M*B**		
SE(m)	0.074	0.066	0.147		
CD(5%)	0.211	0.189	0.423		
Pooled					
M_0	8.02	8.28	8.51	8.13	**8.24**
M_1	9.59	12.07	12.33	11.78	**11.44**
M_2	9.33	11.52	11.89	11.51	**11.06**
M_3	9.13	10.85	11.41	10.58	**10.49**
M_4	8.86	10.06	10.18	9.88	**9.74**
MEAN	**8.99**	**10.56**	**10.86**	**10.37**	
	M	**B**	**M*B**		
SE(m)	0.085	0.076	0.171		
CD(5%)	0.245	0.219	0.490		

Table 7. Effect of micronutrients and bio-fertilizers on Seed Yield (g/plant) of Coriander cv. RCR-41

Seed Yield (g/plant)					
1st Year					
	B_0	**B_1**	**B_2**	**B_3**	**MEAN**
M_0	3.57	3.92	4.15	3.70	**3.83**
M_1	4.75	7.81	7.95	7.30	**6.95**
M_2	4.64	7.01	7.60	6.73	**6.50**
M_3	4.44	6.10	6.34	5.68	**5.64**
M_4	4.31	5.18	5.40	5.02	**4.98**
MEAN	**4.34**	**6.00**	**6.29**	**5.69**	
	M	**B**	**M*B**		
SE(m)	0.116	0.104	0.232		
CD(5%)	0.333	0.298	0.665		
2nd Year					
M_0	3.59	3.90	4.18	3.74	**3.85**

M_1	4.76	7.86	8.04	7.35	**7.00**
M_2	4.64	7.04	7.67	6.78	**6.53**
M_3	4.46	6.16	6.40	5.73	**5.69**
M_4	4.31	5.20	5.41	5.03	**4.99**
MEAN	**4.35**	**6.03**	**6.34**	**5.73**	
	M	**B**	**M*B**		
SE(m)	0.077	0.069	0.154		
CD(5%)	0.221	0.197	0.441		
Pooled					
M_0	3.58	3.91	4.16	3.72	**3.84**
M_1	4.76	7.84	8.00	7.33	**6.98**
M_2	4.64	7.03	7.64	6.76	**6.51**
M_3	4.45	6.13	6.37	5.70	**5.66**
M_4	4.31	5.19	5.40	5.03	**4.98**
MEAN	**4.35**	**6.02**	**6.31**	**5.71**	
	M	**B**	**M*B**		
SE(m)	0.098	0.088	0.197		
CD(5%)	0.282	0.252	0.564		

B2 (*Azotobacter*) resulted in the highest leaf yield, likely improving nitrogen and phosphate accessibility and promoting hormone synthesis. The treatment also led to the highest seed yield, indicating enhanced plant metabolic activity and the synthesis of growth hormones, consistent with [17, 5, 6].

Treatment M1 (ZnSO4 @ 0.5%) led to the highest leaf yield, attributed to zinc's positive effects on growth mechanisms. The treatment also resulted in the highest seed yield, enhancing yield-contributing factors and favorably influencing foliar application of micronutrients, in line with [18,6].

Interaction Effect of Micronutrients and Biofertilizers: The combination M1B2 (ZnSO4 @ 0.5% and *Azotobacter*) significantly impacted multiple yield metrics, including the number of umbels per plant, number of seeds per umbel, weight of seeds per umbel, test weight, leaf yield, and seed yield. However, the interaction did notsignificantly affect the number of umbellate per umbel. These results align with [7,19,6].

4. CONCLUSION

The results indicated that among the different levels of micronutrients, treatment M1 (ZnSo4 @ 0.5%) was determined to be the most effective treatment for enhancing the yield of coriander. Out of the several amounts of biofertilizers, treatment B2 (*Azotobacter*) was determined to be the most effective in enhancing the yield of coriander. The treatment combination M1B2, consisting of 0.5% ZnSo4 and *Azotobacter*, exhibited substantial superiority compared to other treatment combinations. It resulted in the highest yield metrics for coriander.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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