

Effect of foliar spray of zinc and iron on the productivity of spring cowpea

J Sharma¹, H Gupta² and U Patle^{3#}

Summary

Micronutrients such as iron (Fe) and zinc (Zn) play an important role in different metabolic process in cowpea and deficiency of these nutrients is a major constraint for sustainable productivity of cowpea for both human and animal consumption. To increase sustainable productivity of cowpea, a field study was conducted in an agricultural farm at college of Agriculture, AICRP on Pulses (Arid Legumes), RVSKVV, Gwalior (M.P.) during summer season of 2023 to find out the effect of soil and foliar application of zinc and iron at different growth stages for enhancing the productivity of summer cowpea and evaluate the economics of applied treatments. The experiment was conducted in randomised block design (RBD), with three replications and 9 treatments. It is found that T₇ (combine application of 0.5% ZnSO₄ + 0.5% FeSO₄ spray at flower initiation and pod initiation) recorded significantly the highest growth attributes viz. plant height (60.33 cm), No. of branches/plant (5.40 branches/plant), yield attributes viz. No. of pods/plant (25.67 pods/plant), Pod length (10.60 cm), No. of seeds/ pod (11.20 seeds/ pod) and 100 seed weight (11.70 g), seed yield (1345 kg/ha), stover yield (2593 kg/ha), cost of cultivation (₹23,645/ha), gross return (₹83,231/ha) and net return (₹59,586/ha). However, the benefit-cost (B:C) ratio (3.55) was higher under (25 kg ZnSO₄ ha⁻¹ soil application) over control T₁ Control (100% RDF 20: 40: 20 NPK kg/ha). These results highlight the importance of improving cowpea growth, productivity and profitability.

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Introduction

Indian farmers heavily depend on high-analysis fertilizers viz. Urea, DAP and MOP for an intensive cropping system that induced the deficiencies of micronutrients. Using the same kind of synthetic fertilizers over the years led the emergence of micronutrient deficiencies in many parts of the country (Anitha *et al.* 2005). Zinc and iron are considered two important essential micronutrients (Dhaliwal *et al.* 2022) and their deficiencies in plant associated with human health (Acik & Oncan 2023). Iron is involved in important metabolic processes in plants such as chlorophyll biosynthesis, enzyme activation, DNA synthesis and respiration, and it is a key structural component for various enzymes (Briat 2011). Similarly, zinc as a trace element involved in crucial metabolic activities such as structural stability of chloroplasts (Debasma & Parijat 2024), in antioxidant defence mechanism during pathogen attack (Gupta *et al.* 2016) and as Zn-finger protein, it mediates various protein-protein interactions (Cabot *et al.* 2019). Although iron and zinc abundant in earth's crust but poor bioavailability and their binding with soil matrix form insoluble complexes in aerobic conditions (Gómez-Galera *et al.* 2010). As a lucrative summer crop, cowpea is intensively grown as important pulse crop in tropical and subtropical

regions for rich protein (23-25%), minerals and carbohydrates (50-60%) (Manzeke *et al.* 2017). Moreover, it is used in sustainable cropping systems due to its ability of fix atmospheric nitrogen (Dhanasekar *et al.* 2021). Due to traditional cultivation and following of inadequate cropping management practices by farmers, the productivity of pulses is comparatively low. It is important to adopt balanced fertilization with foliar application of micronutrients to maximize the productivity of pulses (Savithri *et al.* 2001). In order to sustain cowpea productivity, foliar application and biofortification of micronutrients has led to a growing interest in sustainable agriculture systems. Keeping these facts in view, the present investigation was conducted at the Regional Agricultural Research Station, under the AICRP on Pulses (Arid Legumes) project under the College of Agriculture, Rajmata Vijayaraje Scindia Krishi Vishwavidyalaya, Gwalior (M.P.), during the summer season of 2023.

Materials and Methods

Field investigation was conducted in summer 2023 at the Regional Agricultural Research Station, under AICRP on Pulses (Arid Legumes) project under College of Agriculture, Rajmata Vijayaraje Scindia Krishi Vishwavidyalaya, Gwalior (M.P.), which lies between 26° 21' North latitude and 78° 18' East longitude with an altitude of 207 m from mean sea level. The experiment was laid out in a simple randomized block design (RBD) with three replications. The climatic condition is extremely hot during summer and very cold during winter. Weekly meteorological data showed that the maximum temperature ranged from 30.6°C to 43.5°C. Whereas the minimum temperature ranged from 13.9°C

¹Scientist, Agronomy, College of Agriculture, Rajmata Vijayaraje Scindia Krishi Vishwavidyalaya, Gwalior, Madhya Pradesh, India

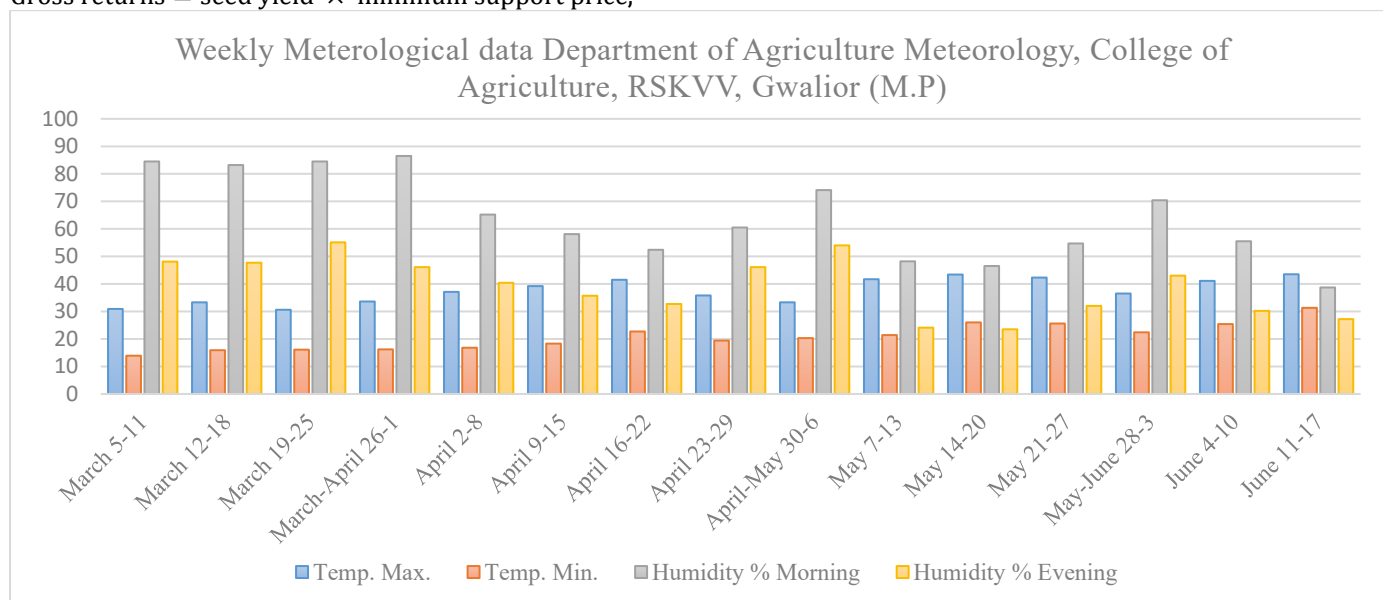
²Phd Scholar (Soil Science), College of Agricultural Sciences, Nagaland University, Medziphema Campus, Nagaland, India.

³Phd Scholar (Agronomy), College of Agriculture, Rajmata Vijayaraje Scindia Krishi Vishwavidyalaya, Gwalior, Madhya Pradesh, India

[#]Corresponding author: Patle U E-mail: umesh18patle@gmail.com

to 31.3°C. Morning relative humidity ranged from 38.7% to 86.5%. Evening relative humidity varied from 23.5% to 55.1%. The soil of the experimental area was Sandy clay loam, with 7.3 pH, 210 kg ha⁻¹ available N, 14.6 kg ha⁻¹ available P and 230 kg ha⁻¹ available K. 20 kg ha⁻¹ seeds were sown manually in line, having row spacing of 45 cm×10cm at 15 March 2023. 20 kg ha⁻¹ nitrogen, 20 kg ha⁻¹ phosphorus and 20 kg ha⁻¹ potash were applied as basal dose. Gross return was obtained by the formula, Gross returns = seed yield × minimum support price,

while stover returns were calculated using the sold price at local market. Net returns were obtained by formula Net returns = Gross return – total cost of cultivation. The BCR was calculated by formula $BCR = \frac{\text{Gross return}}{\text{Cost of cultivation}}$. Statistical analysis was done with the help of window-based SPSS based on ANOVA (F-test) as per the method suggested by Gomez & Gomez (1984) and critical difference (CD) was work out at 0.05 level of significance for comparison.



Treatment details

Treatments	
T ₁	Control (100% RDF 20: 40: 20 NPK kg/ha)
T ₂	0.5% ZnSO ₄ spray at flower initiation
T ₃	0.5% ZnSO ₄ spray at flower initiation and pod initiation
T ₄	0.5% FeSO ₄ spray at flower initiation
T ₅	0.5% FeSO ₄ spray at flower initiation and pod initiation
T ₆	0.5% ZnSO ₄ + 0.5% FeSO ₄ spray at flower initiation
T ₇	0.5% ZnSO ₄ + 0.5% FeSO ₄ spray at flower initiation and pod initiation
T ₈	25 kg ZnSO ₄ ha ⁻¹ soil application
T ₉	10 kg FeSO ₄ ha ⁻¹ soil application

Result and Discussion

Growth parameters

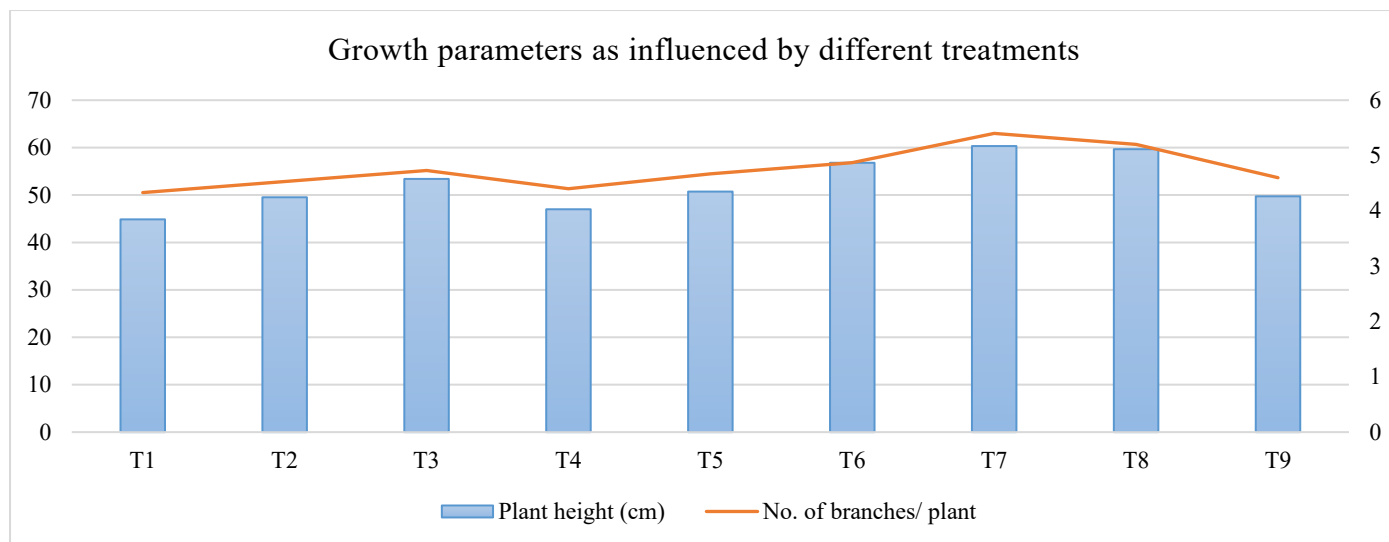
The result revealed that the foliar application of zinc and iron at different growth phases has a significant effect on growth parameters viz. plant height (cm) and no. of

branches/plant. The highest plant height was reported in T₇ (0.5% ZnSO₄ + 0.5% FeSO₄ spray at flower initiation and pod initiation) followed by T₈ (25 kg ZnSO₄ ha⁻¹ soil application) and the lowest plant height was reported in T₁ (Control), i.e., 60.33, 59.67 and 44.87 (cm), respectively. The highest no. of branches/plant was reported in T₇ (0.5% ZnSO₄ + 0.5% FeSO₄ spray at flower initiation and pod initiation) followed by T₈ (25 kg ZnSO₄ ha⁻¹ soil application), and the lowest no. of branches/plant was reported in T₁ (Control), i.e., 5.40, 5.20 and 4.33 (branches/plant), respectively. These trends may be attributed to combining the application of zinc and iron at critical growth stages, and adequate supply of these micronutrients may increase photosynthesis efficiency, enhance carbohydrate synthesis and the translocation of these assimilates may result in vigorous growth. Similar findings reported by Patel *et al.* (2016), Sah *et al.* (2018) and Anitha *et al.* (2005).

Table 1. Growth and Yield attributes as influenced by different treatments

Treatments		Plant height (cm)	No. of branches/plant	No. of pods/plant	Pod length (cm)	No. of seeds/pod	100 seed weight (g)
T ₁	Control (100% RDF 20: 40: 20 NPK kg/ha)	44.87	4.33	16.33	9.03	10.27	10.00
T ₂	0.5% ZnSO ₄ spray at flower initiation	49.53	4.53	18.07	9.73	10.47	11.13
T ₃	0.5% ZnSO ₄ spray at flower initiation and pod initiation	53.40	4.73	19.73	9.93	10.67	11.13
T ₄	0.5% FeSO ₄ spray at flower initiation	47.00	4.40	17.67	9.60	10.40	11.07

T ₅	0.5% FeSO ₄ spray at flower initiation and pod initiation	50.73	4.67	19.07	9.93	10.67	11.13
T ₆	0.5% ZnSO ₄ + 0.5% FeSO ₄ spray at flower initiation	56.80	4.87	19.87	10.00	10.73	11.13
T ₇	0.5% ZnSO ₄ + 0.5% FeSO ₄ spray at flower initiation and pod initiation	60.33	5.40	25.67	10.60	11.20	11.70
T ₈	25 kg ZnSO ₄ ha ⁻¹ soil application	59.67	5.20	23.00	10.25	11.00	11.70
T ₉	10 kg FeSO ₄ ha ⁻¹ soil application	49.73	4.60	18.40	9.73	10.53	11.13
	S.E.m. ±	2.44	0.25	1.11	0.26	0.37	0.21
	C.D. at 5 %	7.32	0.75	3.32	0.78	1.11	0.62
	CV %	8.06	9.14	9.72	4.57	6.03	3.21



Yield attributes

The result revealed that the foliar application of zinc and iron at different growth phase has a significant effect on yield attributes viz. no. of pods/plant, pod length (cm) no. of seeds/pod and 100 seed weight (g). The highest no. of pods/plant was reported in T₇ (0.5% ZnSO₄ + 0.5% FeSO₄ spray at flower initiation and pod initiation) followed by T₈ (25 kg ZnSO₄ ha⁻¹ soil application) and the lowest no. of pods/plant was reported in T₁ (Control) i.e., 25.67, 23.00 and 16.33 (pods/plant) respectively. The highest pod length was reported T₇ (0.5% ZnSO₄ + 0.5% FeSO₄ spray at flower initiation and pod initiation) followed by T₈ (25 kg ZnSO₄ ha⁻¹ soil application) and lowest pod length was reported in T₁ (Control) i.e., 10.60, 10.25 and 9.03 (cm), respectively. The highest No. of seeds/pod was reported in T₇ (0.5% ZnSO₄ + 0.5% FeSO₄ spray at flower initiation and pod initiation) followed by T₈ (25 kg ZnSO₄ ha⁻¹ soil application) and the lowest no. of seeds/pod was reported in T₁ (Control) i.e., 11.20, 11.00 and 10.27 (seeds/pod), respectively. The highest 100 seed weight was reported in T₇ (0.5% ZnSO₄ + 0.5% FeSO₄ spray at flower initiation and pod initiation), followed by T₈ (25 kg ZnSO₄ ha⁻¹ soil application) and the lowest 100 seed weight was reported in T₁ (Control) i.e., 11.70, 11.70 and 10.00 (g), respectively. The synergistic effect of zinc and iron may contribute to better reproductive development and seed formation. The foliar application of these micronutrients at critical growth stages may result in better flower initiation and pollen viability, ultimately resulting in higher pod length and pod

setting plant⁻¹. Improved nutrient availability during the seed-filling stage promotes increased seed weight. Similar findings were reported by Patel et al. (2016), Pandey et al. (2013), Debnath et al. (2018) and Acik & Oncan (2023).

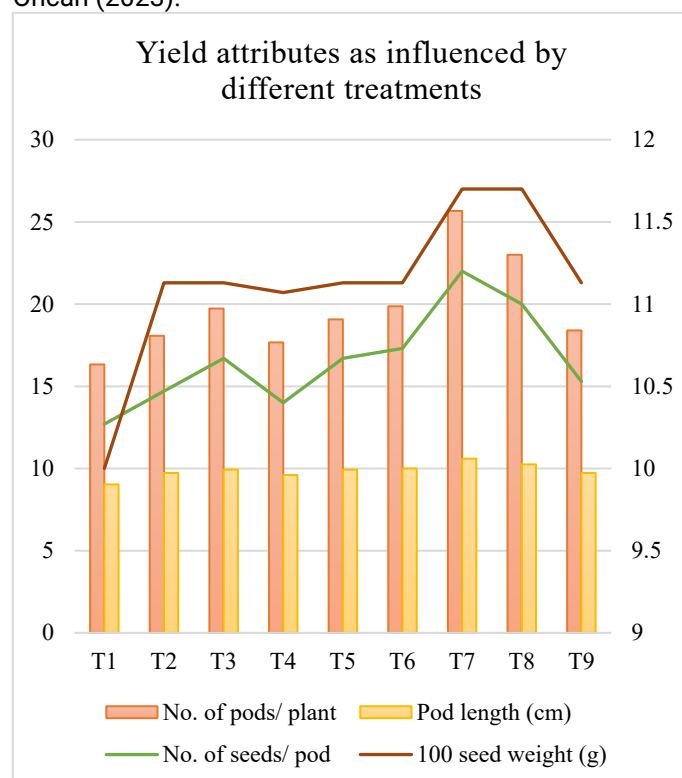


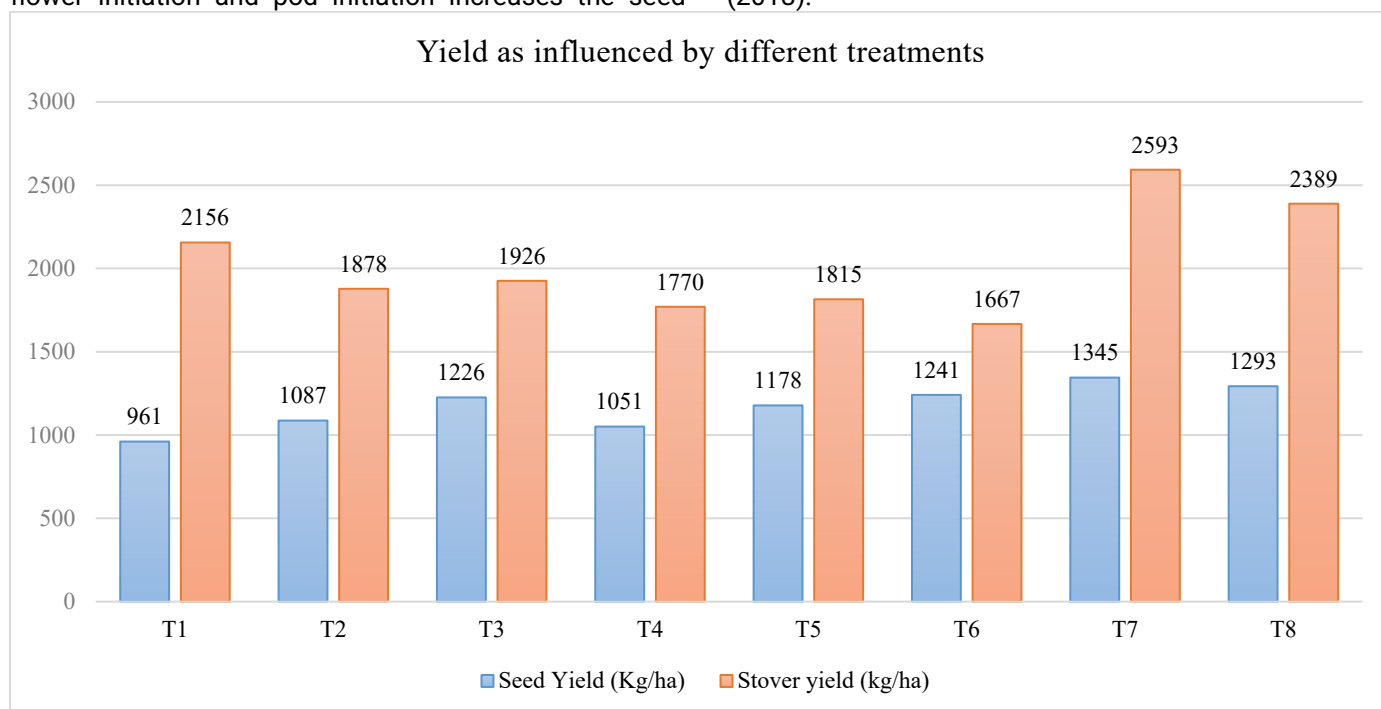
Table 2. Yield and Economics as influenced by different treatments

	Treatments	Seed Yield (Kg/ha)	Yield % increase over control	Stover yield (kg/ha)	Cost of Cultivation (₹/ha)	Gross Return (₹/ha)	Net Income (₹/ha)	BCR
T ₁	Control (100% RDF 20: 40: 20 NPK kg/ha)	961	-	2156	20,703	59,832	39129	2.89
T ₂	0.5% ZnSO ₄ spray at flower initiation	1087	13.11	1878	21,458	67,164	45706	3.13
T ₃	0.5% ZnSO ₄ spray at flower initiation and pod initiation	1226	27.57	1926	22,145	75,514	53369	3.41
T ₄	0.5% FeSO ₄ spray at flower initiation	1051	9.3	1770	22,220	64,883	42663	2.92
T ₅	0.5% FeSO ₄ spray at flower initiation and pod initiation	1178	22.58	1815	23,693	72,501	48808	3.06
T ₆	0.5% ZnSO ₄ + 0.5% FeSO ₄ spray at flower initiation	1241	29.13	1667	22,322	76,117	53795	3.41
T ₇	0.5% ZnSO ₄ + 0.5% FeSO ₄ spray at flower initiation and pod initiation	1345	39.95	2593	23,645	83,231	59586	3.52
T ₈	25 kg ZnSO ₄ ha ⁻¹ soil application	1293	34.54	2389	22,515	79,927	57412	3.55
T ₉	10 kg FeSO ₄ ha ⁻¹ soil application	1152	19.87	2082	24,742	71,257	46515	2.88
	S.Em. ±	34.86	-	77.68	-	-	-	-
	C.D. at 5 %	104.51	-	232.89	-	-	-	-
	CV %	5.16	-	6.63	-	-	-	-

Yield

The result revealed that the foliar application of zinc and iron at different growth phases has a significant effect on yield viz., seed yield (kg/ha) and stover yield (kg/ha). The highest seed yield was reported in T₇ (0.5% ZnSO₄ + 0.5% FeSO₄ spray at flower initiation and pod initiation) followed by T₈ (25 kg ZnSO₄ ha⁻¹ soil application) and the lowest seed yield was reported in T₁ (Control) i.e., 1345, 1293 and 961 (kg/ha), respectively. It is also found that combine application of 0.5% ZnSO₄ + 0.5% FeSO₄ spray at flower initiation and pod initiation increases the seed

yield by 39.95% when compared to the control. Whereas the highest stover yield was reported in T₇ (0.5% ZnSO₄ + 0.5% FeSO₄ spray at flower initiation and pod initiation) followed by T₈ (25 kg ZnSO₄ ha⁻¹ soil application), and the lowest stover yield was reported in T₁ (Control) i.e., 2593, 2389 and 2156 (kg/ha), respectively. The improvement in seed yield and stover yield due to a higher number of pods plant⁻¹, seed weight and vigorous plant growth in these treatments. Similar findings were reported by Patel et al. (2016), Anitha et al. (2005) and Debnath et al. (2018).

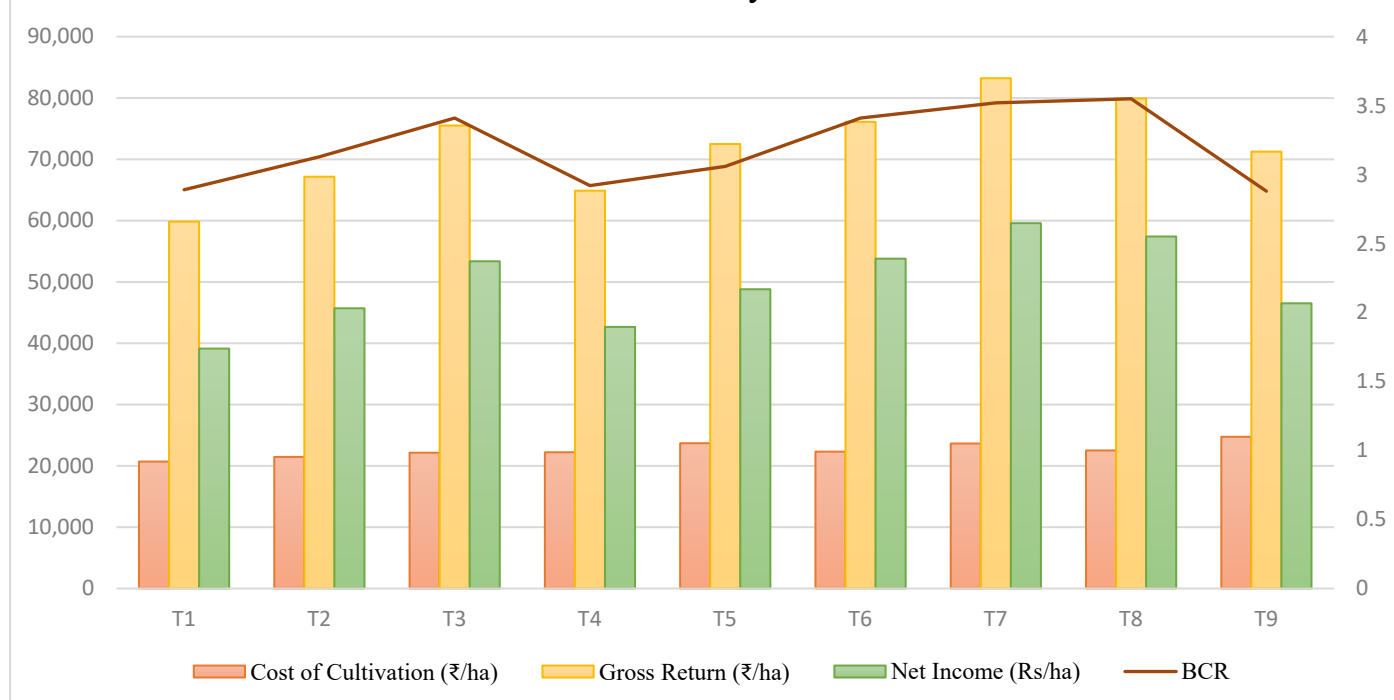


Economics

The result revealed that T₇ (0.5% ZnSO₄ + 0.5% FeSO₄ spray at flower initiation and pod initiation) produced the highest cost of cultivation (₹23,645/ha), gross return (₹83,231/ha) and net return (₹59,586/ha). However, the benefit-cost (B:C) ratio (3.55) was higher under (25 kg ZnSO₄ ha⁻¹ soil application). Whereas T₁ (Control) produced the lowest cost of cultivation (₹20,703/ha),

gross return (₹59,832/ha) and net return (₹59,586/ha) and BC ratio (2.89). These trends may be due to a substantial increase of growth and yield achieved by combining foliar application of zinc and iron. Whereas deficiencies of these micronutrients restricted the economic yield in control. Similar supporting findings were reported by Dass et al. (2022), Anitha et al. (2005) and Patel et al. (2016)

Economics as influenced by different treatments



Conclusion

It can be concluded that the combined foliar application of 0.5% ZnSO₄ + 0.5% FeSO₄ at flower initiation and pod initiation (T₇) proved most effective in enhancing the growth, yield attributes, and economic returns of summer cowpea. This treatment recorded the highest seed yield (1345 kg/ha), stover yield (2593 kg/ha), and net return (₹59,586/ha), showing a 39.95% increase in seed yield over the control (T₁). The results clearly demonstrate that balanced micronutrient management through foliar supplementation of zinc and iron at critical growth stages is a sustainable strategy to improve productivity and profitability of cowpea cultivation.

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Conflict of interest

All the author declares that there is no conflict of interest related to this article.

Data sharing

All relevant data are within the manuscript.

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