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Influence of foliar nutrition of boron, zinc and biofertilizer on economics of cowpea [*Vigna unguiculata* (L.) Walp] under agroclimatic conditions of Chhattisgarh plains

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Abstract
The present study, titled "Influence of foliar nutrition of Boron, Zinc and Biofertilizer on Economics of Cowpea [*Vigna unguiculata* (L.) Walp] under agroclimatic conditions of Chhattisgarh plains." was conducted during the rabi season of 2021-22. The experiment was carried out at the Krishi Vigyan Kendra farm in Raipur, which is situated in the central part of Chhattisgarh, an agro-climatic region known as the Chhattisgarh plains. Raipur lies at latitude 21.25° N and longitude 81.62° E, with an elevation of 289 meters above sea level. The study involved eight treatments: Rhizobium, Rhizobium + Boron at 0.2%, Rhizobium + Boron at 0.5%, Rhizobium + Zinc at 0.2%, Rhizobium + Zinc at 0.5%, Rhizobium + Boron + Zinc at 0.2%, Rhizobium + Boron + zinc at 0.5%, and a control treatment. The experiment was conducted using a Randomized Block Design with three replications. The highest total cost of cultivation (Rs118814/ha) was incurred under T_4 {Rhizobium + Boron @ 0.5%}, maximum gross income of Rs 249700/ha was obtained with the Rhizobium + Boron + Zinc @ 0.5% (T_8), maximum net return of Rs 131166/ha was obtained with treatment T_8 and maximum benefit: cost ratio obtained with T_8 (2.10).

Keywords: Cowpea, foliar nutrition, rhizobium, boron, zinc, economics

1. Introduction
Global warming and food security are urgent challenges facing agriculture both today and in the future. In this context, crops that are resilient to climate change and rich in nutrition are becoming more essential. Cowpea (*Vigna unguiculata*) is also called the poor man's meat because it is a rich source of protein, minerals, and vitamins (Tharanathan RN & Mahadevamma 2003) [17] for the rural poor with minimal access to animal-based protein sources like meat and fish", it is also known for its drought tolerance (Carvalho *et al.*, 2019; Fatokun *et al.*, 2018) [8, 11]. Originating from sub-Saharan Africa, where its greatest genetic diversity is found, cowpea is an important legume with significant economic value (Fatokun *et al.*, 2018; Saxena and Rukam 2020) [11, 16]. It also plays a key role in income generation for smallholder farmers in Asia and Africa (Boukar *et al.*, 2016; Vavilapalli *et al.*, 2013) [7, 20].
Cowpea is a highly nutritious food, rich in protein (24%), dietary fiber (11%), and potassium (1112 mg/100 g), while being low in lipids (<2%) and sodium (16 mg/100 g) (Affrifah *et al.*, 2022) [1]. Its high protein content makes it an excellent plant-based alternative to animal protein. Cowpea serves as both a vegetable and a grain, consumed by humans and animals alike (Avanza *et al.*, 2013) [4]. Its young leaves are often eaten like spinach, and dried leaves are stored as a meat substitute during off-seasons (Enyiukwu *et al.*, 2018). Moreover, cowpea contributes to sustainable agriculture by fixing atmospheric nitrogen, which boosts agroecosystem productivity (Namatsheve *et al.*, 2020) [12]. In intercropping systems, cowpea fixes 17.8-22.8 kg/ha of nitrogen, compared to 54.9-55.2 kg/ha in monocropping systems (Binacchi *et al.*, 2022) [5].
Globally, Niger leads in cowpea cultivation area (39%), followed by Nigeria (31%). However, Nigeria ranks first in production, contributing 42% of global output, while Niger is second with 29%, and Burkina Faso third with 8%. Among major producing countries, Ghana has the highest productivity (1662 kg/ha), followed by Nigeria (865 kg/ha) and

Cameroon (818 kg/ha). In India it is cultivated on 310.81 thousand ha area and its production 2897.51 thousand MT. In Chhattisgarh it is cultivated on 8.996 thousand ha and its production is 89.7 thousands MT.

2. Materials and Methods

The present study, titled "Influence of foliar nutrition of Boron, Zinc and Biofertilizer on Economics of Cowpea [*Vigna unguiculata* (L.) Walp] under agroclimatic conditions of Chhattisgarh plains." was conducted during the rabi season of 2021-22. The experiment was carried out at the Krishi Vigyan Kendra farm in Raipur, which is situated in the central part of Chhattisgarh, an agro-climatic region known as the Chhattisgarh plains. Raipur lies at latitude 21.25° N and longitude 81.62° E, with an elevation of 289 meters above sea level. The cowpea variety used in the study, Kashi Kanchan, is a dwarf, bush-type variety (height 50-60 cm) that is photo-insensitive, with early flowering (40-45 days after sowing) and early picking (50-55 days after sowing). It is well-suited for cultivation in both spring-summer and rainy seasons. The pods are 30-35 cm long, dark green, soft, fleshy, and free from parchment. This variety yields approximately 150-175 quintals per hectare of green pods and is resistant to golden mosaic virus and *Pseudocercospora cruenta*. Kashi Kanchan has been officially released and notified for cultivation in several states, including Uttar Pradesh, Punjab, Bihar, Chhattisgarh, Orissa, Andhra Pradesh, and Madhya Pradesh, during the XIII meeting of the Central Sub-Committee on Crop Standard Notification and Release of Varieties for Horticultural Crops. The study involved eight treatments: rhizobium, rhizobium + boron at 0.2%, rhizobium + boron at 0.5%, rhizobium + zinc at 0.2%, rhizobium + zinc at 0.5%, rhizobium + boron + zinc at 0.2%, rhizobium + boron + zinc at 0.5%, and a control treatment. The experiment was conducted using a Randomized Block Design with three replications. As per the treatment schedule, the required quantities of micronutrients were dissolved in appropriate amounts of water and applied as foliar sprays. The micronutrient solutions were freshly prepared just before spraying. For a 1-liter solution of 0.2% and 0.5% concentration, 2g and 5g of each micronutrient were weighed and carefully dissolved in 1 liter of water. The solutions were sprayed evenly onto both surfaces of the plant leaves using a knapsack or hand sprayer.

Table 1: Physico-chemical characters of soils

Particular's classification	Analytical Value
Physical Properties	
Sand (%)	24.32
Silt (%)	33.35 Clay (Vertisol)
Clay (%)	42.68
Chemical Properties	
Organic carbon (%)	0.63 (Low)
Available N (kg/ha)	185 (Low)
Available P (kg/ ha)	16.8 (High)
Available K (kg/ ha)	311.5 (Medium)
Soil Reaction pH	7.10 (Neutral)
Micronutrients	
Zinc (mg/kg)	0.5 (Medium)
Boron (mg/kg)	2 (Medium)

Table 2: Treatment details

S. No.	Treatment	Notation
1	Control (Water spray)	T_1
2	Rhizobium	T_2
3	Rhizobium + Boron @, 0.2%	T_3
4	Rhizobium + Boron @, 0.5%	T_4
5	Rhizobium + Zinc @ 0.2%	T_5
6	Rhizobium + Zinc @, 0.5%	T_6
7	Rhizobium + Boron + Zinc @ 0.2%	T_7
8	Rhizobium + Boron + Zinc @ 0.5%	T_8

3. Economics

3.1 Cost of Cultivation: The cost of cultivation (Rs. ha^{-1}) for each treatment was determined by factoring in the total input costs, cultivation practice expenses, labor charges, land costs, irrigation, fertilizers, and any other associated costs.

3.2 Gross Returns: Gross returns refer to the total monetary value of both the main produce and byproducts obtained from the crop under different treatments. This is calculated based on the local market prices or sale value.

3.3 Net Returns: Net returns (Rs. ha^{-1}) for each treatment were calculated by subtracting the average cultivation cost for each treatment from its respective gross returns. Net returns (Rs./ha) = Gross return-Cost of cultivation.

3.4 Benefit: Cost Ratio: The benefit-cost ratio for each treatment was calculated by dividing the gross monetary returns by the corresponding cultivation cost. This ratio serves as an estimate of the farmer's benefit relative to their expenditure. Benefit-cost ratio = Gross return (Rs./ha) / Cost of cultivation (Rs./ha)

4. Results and Discussion

Table 3: Economics of different treatment combination

Treatment	Pod Yield Q/ha	Treatment cost (Rs./ha)	Common Cost (Rs./ha)	Cost of cultivation (Rs./ha)	Gross income (Rs./ha)	Net income (Rs./ha)	Benefit cost ratio
T_1	100.28	0	118000	118000	200560.00	82560.00	1.69
T_2	104.25	14	118000	118014	208500.00	90486.00	1.76
T_3	108.14	334	118000	118334	216280.00	97946.00	1.82
T_4	114.26	814	118000	118814	228520.00	109706.00	1.92
T_5	110.35	110	118000	118110	220700.00	102590.00	1.86
T_6	118.20	254	118000	118254	236400.00	118146.00	1.99
T_7	122.35	222	118000	118222	244700.00	126478.00	2.06
T_8	124.85	534	118000	118534	249700.00	131166.00	2.10

4.1 Cost of Cultivation

The total cost of each treatment was divided into two categories: general costs and treatment-specific costs. The general costs included field preparation, seed, seed treatment, sowing, weeding, insecticide spraying, irrigation, harvesting, and other miscellaneous expenses, all of which were consistent across treatments. The cultivation cost of Rs. 118, 000 was the same for all treatments, but the costs associated with the application of rhizobium and micronutrients varied between treatments. The highest total cultivation cost (Rs. 118, 814/ha) was observed in T_4 (Rhizobium + Boron @ 0.5%), compared to the control treatment (T_1), which had a cost of Rs. 118, 000/ha.

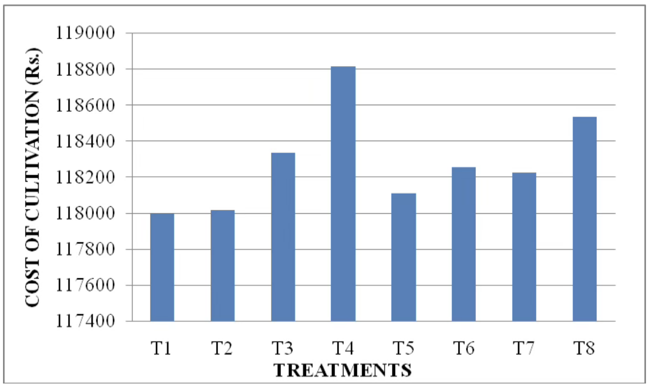

Fig 1: Cost of cultivation (Rs) as affected by the rhizobium and foliar spray of micronutrients on cowpea cv. Kashi Kanchan under agroclimatic condition of Chhattisgarh plains.

4.2 Gross income

The data presented in the table showed that the highest gross income of Rs. 249, 700/ha was achieved with the Rhizobium + Boron + Zinc @ 0.5% treatment (T_8). The other treatments ranked in the following order: T_7 (Rs. 244, 700), T_6 (Rs. 236, 400), T_4 (Rs. 228, 520), T_5 (Rs. 220, 700), T_3 (Rs. 216, 280), and T_2 (Rs. 208, 500), with the control treatment (T_1) yielding Rs. 200, 560.

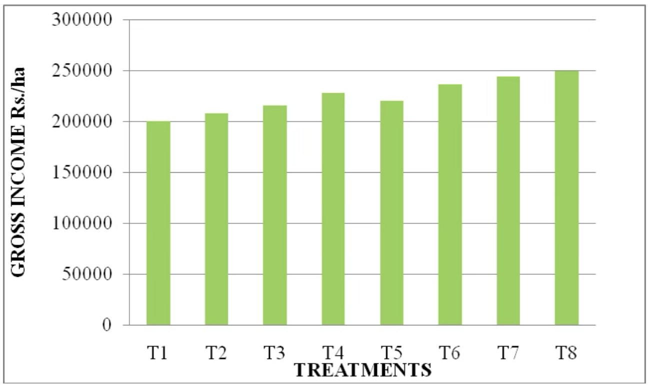

Fig 2: Gross income (Rs/ha) as effected by biofertilizer and foliar application of micro-nutrients on cowpea cv. Kashi Kanchan under agroclimatic condition of Chhattisgarh plains.

4.3 Net income

The net income from seed treatment with rhizobium and foliar application of micronutrient treatments on cowpea ranged from Rs. 82, 560 to Rs. 1, 31, 166 per hectare. The highest net return of Rs. 1, 31, 166/ha was achieved with treatment T_8, followed by T_7 (Rs. 1, 26, 478), T_6 (Rs. 1, 18, 146), T_4 (Rs. 1, 09, 706), T_5 (Rs. 1, 02, 590), T_3 (Rs. 97, 946), and T_2 (Rs. 90, 486), with the control treatment (T_1) yielding Rs. 82, 560. Similar results were reported by Sathishkumar *et al.*, (2020) [15], Ullah *et al.*, (2017) [18], and Blesseena *et al.*, (2019) [6].

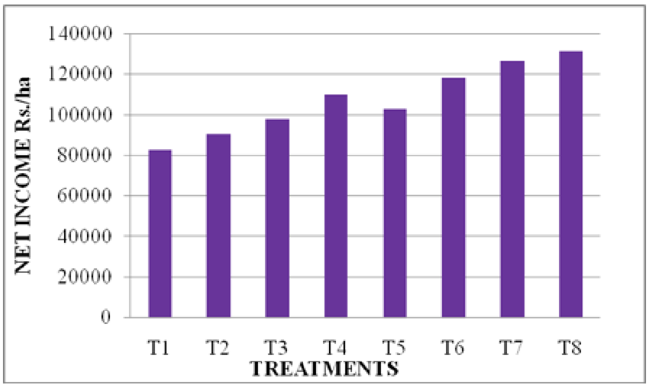

Fig 3: Net income (Rs) as effected by biofertilizer and foliar application of micro-nutrients on cowpea cv. Kashi Kanchan under agroclimatic condition of Chhattisgarh plains.

4.4 Benefit: Cost ratio
The B: C ratio for rhizobium and foliar application of micro-nutrients treatments was ranging from 1.69 to 2.10 while maximum benefit: cost ratio obtained with T_8 (2.10) followed by T_7 (2.06), T_6 (1.99), T_4 (1.92), T_5 (1.86), T_3 (1.82) and T_2 (1.76) respectively against T_1 (1.69) similarly result found by Patle *et al.*, (2021) [13], Dhaliwal *et al.*, (2021) [9], Vasava *et al.*, (2020) [19] and Rathore *et al.*, (2020) [14].

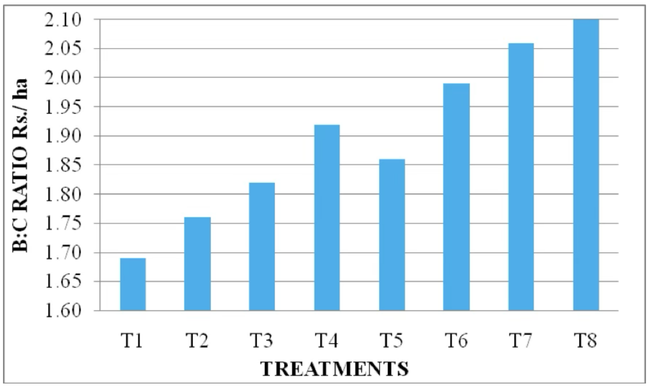

Fig 4: B:C ratio (Rs/ha) as effected by biofertilizer and foliar application of micro-nutrients on cowpea cv. Kashi Kanchan under agroclimatic condition of Chhattisgarh plains.

5. Conclusion
It can be concluded from the results that application of T_8 (Boric Acid @ 0.40%) was best among all other treatments. Total cost of cultivation was recorded maximum (Rs 118814/ha) under T_4 (Rhizobium + Boron @ 0.5%) and minimum (Rs 118000/ha) under T_1 Control (water spray). Maximum and minimum gross income was observed in T_8 (Rs 249700/ha) and T_1 (Rs 200560/ha) Control (water spray), respectively. Highest and lowest net income was recorded in T_8 (Rs 131166/ha) and T_1 (Rs 82560), respectively. Maximum B: C ratio was observed in T_8 (2.10) followed by T_7 (2.06) and minimum was recorded under T_1 (1.69).

6. Suggestions for Future Research Work
1. The experiment may be conducted with more combination of biofertilizers and micronutrients.
2. Studies need to be conducted on different agro climatic zone and different season along with biofertilizers and micronutrients.
3. Application of some other biofertilizers like Azotobactor, PSB culture and micronutrients such as Cu, Mo, Fe, Mn at different concentration to assess its effectiveness on growth and yield of cowpea.
4. For attaining any definite recommendations, the same experiment can be repeated for one or more season.

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