

EFFECT OF MICRONUTRIENTS AND BIO - CAPSULE ON ECONOMICS OF CAPSICUM (*CAPSICUM ANNUUM* L.) UNDER PROTECTED CONDITIONS

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ABSTRACT

An Research was showed over two consecutive rabi seasons (2022–23 and 2023–24) at Horticulture Research Field, SHUATS, Naini, Prayagraj, U.P, to assess the effect of micronutrients and bio-capsules on the economics of capsicum cultivation in protected conditions implemented a Completely Randomized Design with 15 treatments and 3 replications. The results indicated that the treatment T₁₄, which involved the application of a mixture of all micronutrients with bio-capsules, significantly influenced the economic aspects of capsicum cultivation, showing the highest net return of ₹1,620,397.95 per hectare, followed by T₇ with ₹1,540,868.59 per hectare. In contrast, the control group (T₀) had the lowest net return of ₹811,556.18 per hectare. The analysis of benefit-cost ratio (B:C) across treatments revealed that T₁₄ had the highest ratio of 4.47, followed by T₇ (4.25) and T₈ (4.03), while the control (T₀) had the lowest B:C ratio of 2.28. These findings suggest that utilizing a combination of micronutrients and bio-capsules in protected conditions can significantly enhance the profitability of capsicum cultivation, providing valuable insights for farmers aiming to maximize their returns.

KEYWORDS: Effect, bio- capsule, micronutrients, net return, B:C Ratio.

INTRODUCTION

Sweet pepper, scientifically known as *capsicum annuum* L. var. *Grossum* Sendt, is a highly profitable yearly herbaceous vegetable crop popularly sophisticated in protected environments. Belonging to the Solanaceae family, it is frequently referred to as bell pepper, sweet pepper, or by additional terms like Shimla Mirch, pepper, and red capsicum. Unlike chili peppers, sweet peppers are distinct and favored for their mild flavor. Cultivated extensively worldwide, particularly in hot regions of Central and South America, European countries, and tropical/subtropical areas of Asia, notably India and China. In India, major cultivation areas include Andhra Pradesh, Karnataka, Maharashtra, Tamil Nadu, Himachal Pradesh, and hilly regions of U.P. Green capsicum, the primary product, is valued for its mature fruits used in various culinary applications such as stuffing, baking, salads, noodles, and soups. Renowned for its rich vitamin content, notably vitamins A and C, with every 100 grams providing 24 kcal of energy, protein, 4.3 grams of carbohydrates, and 0.3 grams of fat.

India ranks second in vegetable production globally, accounting for 15.38% of the world's total vegetable output, just behind China. In 2009-2010, India produced 107.8 million tons of vegetables from 7.79 million hectares of land, with a productivity rate of 16.60 tons per hectare. Micronutrients have been found to significantly enhance pepper yields, as demonstrated by studies such as Navrot and Levin (1976) and Muthukrishnan et al. (1993), which showed increased yields with micronutrient sprays applied at regular intervals. Protected cultivation, particularly in greenhouses, has become crucial for maintaining high productivity, quality, and profitability in agriculture, especially given challenges such as shrinking land availability and climate change. The concept of greenhouse technology traces back to Italy in the thirteenth century, but modern implementation in India began around 1980, initially for research purposes. The NCPA in 1982 indorsed trials of greenhouse technology across India. The first polyhouse in India was established in Leh, Jammu & Kashmir, in 1985, marking the country's entry into this technology.

Modern agriculture has shifted its focus from simply producing crops to responding to market demands. Horticulture growers are adapting by adding vegetables like capsicum, broccoli, off-season leafy vegetables, and cut flowers to their crop rotations to meet consumer needs. Green capsicum cultivation, also known as sweet pepper or bell pepper, shows prodigious ability for farmers in India. India produces an average of 327 thousand tons of capsicum annually from 4600 thousand hectares, with a productivity of 7108.7 kg ha⁻¹. Precision Agriculture, particularly the use of polyhouses, offers a smart technology for Indian agriculture, providing controlled environments that enhance plant growth and yield compared to open field conditions. The size and weight of capsicum fruits are crucial factors that influence market prices and consumer preferences. To ensure

successful pepper cultivation and consumer acceptance, it's important to test different production systems to enhance fruit quality and appeal.

MATERIAL AND METHODS

An experiment was conducted over two consecutive winter (rabi season) periods, 2022-23 and 2023-24, at the HRF of SHUATS, located in Naini, Prayagraj, Uttar Pradesh. The study encompassed 15 treatment combinations, each replicated thrice. Each treatment involved a unique combination of micronutrients and a bio-capsule containing Plant Growth Promoting Rhizobacteria (PGPR). The treatments were designated as follows: T₀ served as the control, while T₁ to T₆ included individual applications of boric acid, zinc sulphate, ammonium molybdate, copper sulphate, ferrous sulphate, and manganese sulphate, respectively, at specified concentrations. T₇ comprised a mixture of all micronutrients. Additionally, treatments T₈ to T₁₃ mirrored T₁ to T₆, respectively, but included the application of bio-capsules alongside micronutrient treatments. T₁₄ consisted of a mixture of all micronutrients along with bio-capsules. The experimental layout followed a completely randomized design.

The experiment sought to examine the effect of various micronutrient treatments and bio-capsules on the growing and development of NVPH (need species) plants. Researchers employed different combinations of micronutrients, both with and without bio-capsules, to examine potential synergies and assess the efficacy of bio-capsules in enhancing plant growth. The study's design facilitated robust statistical analysis, yielding insights into optimal treatment strategies for maximizing NVPH productivity during winter seasons. Seedlings weighing 10 grams each were utilized for the experiment, with transplantation occurring in November when the seedlings were 25-30 days old and at the 3-4 leaf stage. Transplantation was conducted at a spacing of 60 cm x 45 cm, with a total of 360 seedlings planted in raised beds prepared after achieving fine soil tilth. The entire crop cycle spanned from 90 to 150 days in protected conditions, with the experimental net cultivated area covering 56.7 cm² and the gross cultivated area totalling 76.95 cm². Harvesting took place in the third week of March for both years of experimentation, namely 2022-23 and 2023-24. This comprehensive approach allowed for a thorough evaluation of the effects of micronutrients and bio-capsules on NVPH plant growth and development, providing valuable insights for optimizing agricultural practices in winter conditions.

The responses of capsicum to various treatments were measured in terms of Economics *i.e.*, Total cost of cultivation (₹/ha), Gross return (₹/ha), Net return (Rs/ha), B:C Ratio.

The data was analyzed using a Completely Randomized Design (CRD) methodology in both R-Software (v4.3.0) and SPSS 20. Statistical analysis aimed to discern differences among means through critical difference tests (CD). The results were then depicted graphically. The adoption of CRD in statistical analysis ensures randomness in assigning treatments to experimental units, thus minimizing bias. R-Software and SPSS 20 are well-established tools for data analysis, providing robust statistical functions for researchers. Critical difference tests are utilized to determine the significance of mean differences, aiding in the interpretation of experimental results. Graphical representation of findings enhances comprehension and facilitates comparison among treatments. This approach synthesizes complex statistical information into accessible visual formats, aiding in data interpretation for both researchers and stakeholders. By employing both software tools, researchers could benefit from their complementary features, potentially enhancing the depth and reliability of the analysis. Overall, the utilization of CRD, critical difference tests, and graphical representation underscores a rigorous approach to data analysis, ensuring robust conclusions and facilitating effective communication of findings.

RESULTS & DISCUSSION

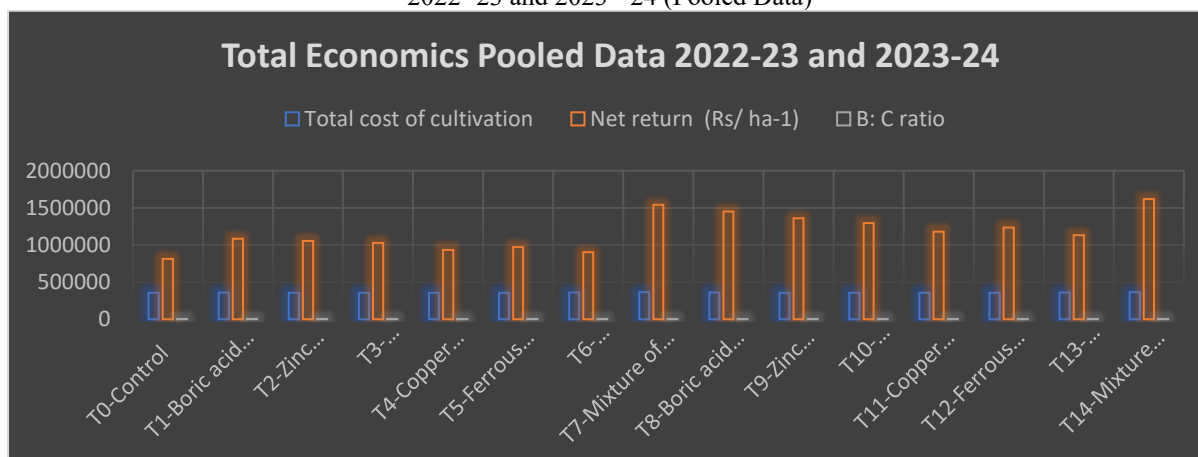
The economic viability of cultivating capsicum under protected conditions, influenced significantly by the application of micronutrients and bio-capsules, is manifest from the data presented in Table 1 and Figure 1. Analysis of pooled data reveals that the highest net return of ₹1,620,397.95 per hectare was achieved in treatment T₁₄, followed by T₇ with ₹1,540,868.59 per hectare. Conversely, the lowest net return of ₹811,556.18 per hectare was observed in the control group (T₀) during the years 2022-23 and 2023-24, respectively. The superiority of polyhouses in providing a protective environment against abiotic stresses and excessive precipitation positively impacts the economics of capsicum cultivation, as highlighted by Singh *et al.* (2003, 2010). Additionally, Singh *et al.* (2004) emphasizes the profitability of net house cultivation for small landholding farmers, attributing it to the structure's ability to create favourable atmospheric conditions conducive to successful capsicum cultivation. Overall, these findings underscore the importance of protected cultivation methods and supplementary interventions like micronutrient application and bio-capsules in maximizing the economic returns of capsicum farming, particularly for small-scale farmers.

The significant effect of micronutrients and bio-capsules on the B: C ratio was consistent over the years 2022-23 and 2023-24. Pooled data analysis revealed that Treatment T₁₄ exhibited the highest B: C ratio (4.47), followed by Treatments T₇ (4.25) and T₈ (4.03), while the control group (T₀) had the lowest ratio (2.28). The impact of these interventions on net returns and the benefit-cost ratio is crucial, showcasing their positive influence on numerous profitable parameters such as fruit number, weight, diameter, and setting, alongside a reduction in fruit drop. These enhancements not only increase overall production but also yield substantial economic benefits. Furthermore, the interventions improve product quality, highlighting a holistic approach to crop management that considers both quantity and intrinsic attributes affecting market value and consumer satisfaction. The findings align with previous studies on cauliflower by Tekasangla *et al.* (2015) and Batabyal *et al.* (2016). Overall, the study underscores the importance of micronutrients and bio-capsules in optimizing crop productivity and economic returns while enhancing produce quality, in line with existing research.

Table. 1 Effect of micronutrients and bio - capsule on economics capsicum under Protected Conditions during rabi 2022 -23 and 2023 - 24 (Pooled Data)

Treatment	Total cost of cultivation (Rs/ ha ⁻¹)	Net return (Rs/ ha ⁻¹)	B: C ratio
T ₀ -Control	356237	811556.18	2.28
T ₁ -Boric acid 100 ppm (0.571 g/l)	359987	1082523.48	3.01
T ₂ -Zinc sulphate 100 ppm (0.246g/l)	356239	1055995.6	2.96
T ₃ -Ammonium Molybdate 50 ppm (0.644g/l)	356265	1029006.04	2.89
T ₄ -Copper sulphate 100 ppm (0.52 g/l)	356245	934393.69	2.62
T ₅ -Ferrous sulphate 100 ppm (0.515 g/l)	356259	973706.32	2.73
T ₆ -Manganese sulphate 100 ppm (0.32 g /l)	358737	901526.11	2.51
T ₇ -Mixture of all	362547	1540868.59	4.25
T ₈ -Boric acid 100 ppm (0.571 g/l) with bio- capsule	360107	1450934.11	4.03
T ₉ -Zinc sulphate 100 ppm (0.246g/l) with bio- capsule	356359	1358509.98	3.81
T ₁₀ -Ammonium Molybdate 50 ppm (0.644g/l) with bio- capsule	356385	1294699.53	3.63
T ₁₁ -Copper sulphate 100 ppm (0.52 g/l) with bio- capsule	356365	1180351.59	3.31
T ₁₂ -Ferrous sulphate 100 ppm (0.515 g/l) with bio- capsule	356379	1234568.12	3.46
T ₁₃ -Manganese sulphate 100 ppm (0.32 g /l) with bio- capsule	358857	1131373.25	3.15
T ₁₄ -Mixture of all with bio- capsule	362667	1620397.95	4.47

Fig.1 Effect of micronutrients and bio - capsule on economics capsicum under Protected Conditions during rabi 2022 -23 and 2023 - 24 (Pooled Data)



CONCLUSION

The study unequivocally illustrated the remarkable synergistic impact of utilizing a combination of micronutrients with bio-capsules on the economic aspects of capsicum cultivation in protected environments. It was evident that this approach outperformed others in terms of economic parameters. Therefore, it is recommended that farmers engaged in protected cultivation opt for the application of micronutrients along with bio-capsules to enhance their production yields and ultimately achieve greater profitability.

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