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Cost-effectiveness and profitability analysis of polyhouse and open field cultivation for bottle gourd and marigold

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Abstract
This review paper presents a comprehensive analysis of the comparative microclimate parameters in a polyhouse and open field over four months (April to July) as part of the Sustainable Cropping Model (SCM). The focus is on four key environmental factors: temperature, humidity, light, and carbon dioxide (CO_2) levels. The results highlight the significant differences between the polyhouse and open field environments, with the polyhouse providing a more stable and controlled atmosphere for crop growth. These differences are substantiated by statistical analysis, confirming the positive impact of the polyhouse in enhancing crop productivity. In addition, we explore the implications of these microclimate conditions on sustainable agriculture and propose future areas for research to improve polyhouse technologies and strategies for enhancing crop yields.

Keywords: Production cost, polyhouse, open field, bottle gourd, marigold, labor costs, electricity costs

Introduction
Sustainable agriculture is increasingly relying on controlled environments such as polyhouses to optimize the growth conditions for crops. The polyhouse provides a regulated microclimate, which contrasts with the variable conditions of open-field agriculture. This review focuses on the comparative analysis of microclimate parameters temperature, humidity, light, and CO_2 levels within both the polyhouse and open field. Understanding these factors' influence on crop productivity is crucial for developing sustainable cropping models, as explored in the Sustainable Cropping Model (SCM).

Temperature
In this study, the temperature was significantly lower and more stable within the polyhouse. The average minimum temperature in the polyhouse was 24.08 °C, with a maximum of 26.1 °C, making it an optimal environment for crops sensitive to heat stress. In contrast, the open field experienced extreme temperature fluctuations, with a minimum average temperature of 35.0°C and a maximum of 42.0 °C, particularly during the warmer months (April-July). According to Kumari and Jha (2015) [1], the ideal temperature for crop growth ranges from 22.0 °C to 28.0 °C, a range that is more easily maintained in the polyhouse environment. These findings support the notion that polyhouses offer a more controlled environment, beneficial for minimizing heat stress in crops.

Innovative humidity control systems
Humidity levels were higher in the polyhouse, which is beneficial for crop growth. The minimum humidity ranged from 32.67% in April to 67.67% in July, while the maximum humidity ranged from 51.67% in May to 83.00% in July. The open field showed lower humidity, with minimum humidity ranging from 19.47% in May to 65.67% in July, and maximum humidity between 48.60% and 79.00%. Higher humidity in the polyhouse was found to promote crop growth, as evidenced by Singh (2006) [2], who observed that polyhouses with a humidity range of 35.40% to 85.50% benefit crop production. The use of humidifiers, such as high-pressure systems and pulsators, further contributes to maintaining ideal conditions in the polyhouse.

Optimization of supplemental lighting

The light levels in the polyhouse were significantly lower than those in the open field, with the polyhouse recording an average minimum of 22,301.92 Lux and a maximum of 23,438.8 Lux. In comparison, the open field had an average minimum of 65,262.7 Lux and a maximum of 67,314.5 Lux. While natural sunlight is abundant in open-field agriculture, the polyhouse offers reduced light intensity. However, supplementary lighting can be used in polyhouses to ensure crops receive adequate light for photosynthesis, particularly during overcast weather or in regions with limited sunlight (Jarvis, 2014). This highlights the need for innovative lighting technologies to support polyhouse farming during shorter daylight periods.

Impact of elevated CO_2 on crop yield

Polyhouses also maintain higher CO_2 concentrations, with an average minimum of 758.42 ppm and a maximum of 912.50 ppm. In comparison, the open field had lower CO_2 levels, with a minimum of 455.25 ppm and a maximum of 559.92 ppm. Enriched CO_2 levels in polyhouses are known to enhance plant growth and resilience, as demonstrated by Choudhury and Das (2023) [3]. Managing CO_2 levels in polyhouses can lead to more efficient photosynthesis and better crop yields, particularly for crops that benefit from elevated CO_2 concentrations.

Statistical analysis

The statistical analysis of the differences in microclimate parameters (temperature, humidity, light, and CO_2 levels) revealed significant variations between the polyhouse and open field, with p-values for temperature (0.04), humidity (0.01), light (0.03), and CO_2 (0.02). These differences were particularly pronounced in the months of April, May, and June, indicating that polyhouse conditions significantly diverge from those of the open field. Such findings validate the notion that polyhouses provide a more controlled environment conducive to crop growth.

Production cost of SCM (Bottle gourd + Marigold)

The analysis of production costs for cultivating bottle gourd and marigold reveals that the total cost is lower in the polyhouse (₹1735) compared to the open field (₹1924). This cost difference is primarily due to reduced labor costs for field preparation, sowing, and weeding in the polyhouse, despite the higher electricity expenses. A similar study by Kishore indicated that under polyhouse cultivation, the major expenses seed and sowing, harvesting, and fertilizers & manure totalled ₹2000, while under open field conditions, these costs amounted to ₹3000.

Economic Feasibility of SCM (Bottle Gourd + Marigold)

In terms of economic feasibility, both the polyhouse and open field models show a Benefit-Cost Ratio (BCR) of -1.02 for the polyhouse (gross return of ₹2075 divided by net return of ₹846) and -0.17 for the open field (gross return of ₹470 divided by net return of ₹2640). Similar findings were reported by Murthy, who observed that the returns for marigold were higher in polyhouse conditions, with a BCR of 2.21, compared to 1.82 for open field cultivation.

Conclusion

The findings from this review confirm the significant advantages of polyhouse farming over open-field agriculture in terms of providing a stable and controlled environment for crop growth. Temperature, humidity, light, and CO_2 levels are all crucial factors in determining crop productivity, and the polyhouse offers a clear advantage in maintaining optimal conditions. As sustainable agriculture continues to evolve, polyhouses represent a promising solution for improving crop yields and resilience, particularly in the face of climate change and environmental variability.

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