

# Unlocking the profit potential of intercropping of vegetables in farming systems

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*Intercropping with vegetables is an agricultural practice that involves growing multiple crop species together in the same field, promoting biodiversity and optimizing resource use. This practice offers a variety of economic, environmental, and agronomic benefits, particularly in smallholder farming systems. By intercropping vegetables with staple crops or fruit orchards, farmers can enhance soil fertility, improve pest and disease control, increase overall crop yields, and diversify farm income. The integration of vegetables, with their shorter growth cycles and higher market demand, provides additional income streams for farmers, especially during the early stages of crop growth. Moreover, intercropping enhances the efficiency of water and nutrient usage, reduces soil erosion, and promotes better soil microbial ecosystem, leading to improved long-term soil health. Intercropping plays a vital role in improving food security, economic stability, and sustainability in farming, particularly in regions facing resource limitations and climate change challenges. The adoption of intercropping with vegetables can be a sustainable farming strategy, contributing to enhanced productivity, resilience and profitability.*

**Keywords:** Farming, Intercrops, Profit, Vegetables

**I**N India, where resources such as land, water, and labour are often limited, intercropping stands out as a strategic approach to boost productivity and economic returns. With the growing pressure to feed an ever-increasing population, the need for optimal resource utilization has never been more critical. Intercropping provides a solution by enhancing land use, improving water efficiency, and maximizing labour utilization. The country faces the dual challenges of ensuring food security while promoting crop diversification to increase farm incomes. However, the growth of the horticultural sector is constrained by the perishable nature of its products and their short shelf-life. Additionally, challenges such as low crop productivity, limited irrigation facilities, and inadequate infrastructural difficulties faced by Indian farmers further aggravate the jeopardy. Intercropping could play a pivotal role in enhancing the commercial viability of Indian agriculture, opening new dimensions for growth and sustainability.

As a sustainable farming practice, intercropping addresses key concerns like pollution impacts, resource optimization, and low crop productivity. By growing two or more crops together, farmers can maximize yields, enrich soil nutrients, and boost ecological diversity,

making every inch of farmland more productive.

Intercropping is a sustainable farming strategy rooted in agroecology, system biology, and sustainable intensification, offering numerous benefits of productivity, ecological balance, and resilience. It enhances resource-use efficiency by optimizing light, water, and nutrient utilization through spatial and temporal niche differentiation. The practice enriches soil health via biological nitrogen fixation, nutrient cycling, and microbial activity while suppressing pests and diseases through biodiversity and allelopathy. Intercropping increases crop yields and stability, as reflected in higher Land Equivalent Ratios (LER), and supports ecosystem services like biodiversity conservation, carbon sequestration, and improved water management. By diversifying crops, it bolsters resilience against climate variability and reduces greenhouse gas emissions, aligning with eco-intensification goals. This approach ensures economic viability, minimizes ecological footprints, and promotes regenerative agriculture, making it a cornerstone of sustainable farming systems.

Considering the importance of horticultural crops in farming systems, a horticulture-based farming system

model of 1.5 hectare has been developed at ICAR-IIFSR, Modipuram (Siwaya Farm), Meerut, U.P., to benefit small farmers of Western Uttar Pradesh. This on-station horticulture-based farming system model incorporates four distinct modules: *Module 1 - Fruit Orchards* (integrated with vegetable intercropping), *Module 2 - Vegetables*, *Module 3 - Field Crops*, and *Module 4 - Pond Dyke System* (integrated with poultry birds). This model aims to improve profitability, enhance productivity, and ensure nutritional security for small farmers of western plain zone of Uttar Pradesh. The details of the crops cultivated within these modules are presented in Table 1.

The developed model has shown that intercropping vegetables in fruit orchards, viz. Module-1 can significantly increase profitability (as shown in Table 1). The income generated from the intercrops not only offsets the maintenance cost of the orchard but also provides financial stability to small and marginal farmers during the gestation period of the fruit trees.

By integrating vegetables into the orchards (Module-1), farmers can make the most of available resources, ensuring sustainability and economic resilience in their farming systems. An economic analysis of the model revealed that the total gross returns of ₹407,776, with net returns of ₹181,815 and a cost of cultivation (COC) of ₹225,961, resulting in a benefit-to-cost (B: C) ratio of 1.8 can be obtained from the model. When comparing the various modules, Module 1 where intercropping with vegetables was advocated, generated the highest gross returns (₹172,460), followed by Module 2 (₹100,875) and Module 3 (₹99,422), while Module 4 recorded the lowest gross returns (₹10,705).

In terms of cost of cultivation (COC), Module 1 had the highest at ₹72,450, followed by Module 2 with ₹48,432 and Module 3 at ₹46,712. Module 4 incurred the lowest COC at ₹14,147. When it comes to net returns,

Module 1 recorded the highest at ₹100,010, followed by Module 2 with ₹52,443, while Module 4 had the lowest net returns of ₹5,710. Overall, this analysis indicates that a higher cost of cultivation does not necessarily equate to lower profitability, as seen in Module 1, where greater input results in higher returns. The choice of crops and farming practices plays a crucial role in determining economic success.

When evaluating the economic efficiency across the modules, Module 1 exhibited the highest efficiency at ₹685.00 per hectare per day, followed by Module 3 (₹361.03), Module 2 (₹287.36), and Module 4 (₹278.55). The evaluation of economic efficiency across the modules provide significant insights into the impact of integrating vegetables into farming systems. Module 1, which incorporates fruit orchards with vegetable intercropping, demonstrated the highest economic efficiency at ₹685.00 per ha per day. This is a clear indication that the inclusion of vegetables within the system offers substantial financial returns on a daily basis, making it a highly profitable practice for farmers.

The integration of vegetables into orchard systems, as seen in Module 1, creates a highly efficient farming model that maximizes land use, optimizes resource utilization, and provides consistent income streams. This approach leads to higher returns per hectare per day, making it an economically viable and sustainable practice for farmers. The comparative analysis highlights the substantial financial potential of intercropping vegetables in orchards, particularly in regions where land and resource optimization are crucial for enhancing farm productivity and profitability.

The analysis of energy dynamics in the studied modules reveals valuable insights into the energy use efficiency (EUE) of different cropping systems, highlighting the benefits of intercropping and its superior efficiency in comparison to monoculture

**Table 1.** Economics of 1.5 ha horticulture-based farming system model

Enterprise	Component	Area (ha)	Details	GR	COC	NR
Horticulture (Module 1)	Orchards (With Inter crops)	0.4	Mango (Amrapalli) + intercrops (Onion-Okra-Pea) Mango( Dashehri) + intercrops (turmeric) Guava + intercrop (Turmeric) Kinnow + intercrops (Pea- Beans- Radish-Cauliflower)	1,72,460	72,450	1,00,010
	Vegetables	0.5	Brinjal-Potato-Beans Onion-Bottlegourd-Cauliflower Okra-Potato-Brinjal Radish-Beans-Pumpkin-Fenugreek Coriander-Bottlegourd-Lobia-Carrot	1,00,875	48,432	52,443
Secondary (Module 2)	Field crops	0.4	Rice-Wheat Sugarcane-S. Ratoon-Wheat	99,422	46,712	52,710
Complimentary (Module 3)	Fish pond dyke-vegetable system	0.1	Fish (Rohu/Catla/Mrigal/Grass carp) + Dyke (Radish-Bottlegourd-Broccoli+Spinach)	24,314	14,147	10,167
Supplementary (Module 4)	Poultry (20 birds)		Layers (Eggs+ Meat)	10,705	2,560	8,145
		1.5	Grand total	4,07,776	225,961	1,81,815
			B:C ratio	1.80		

practices. The energy dynamics of the modules upon study showed that the module M3 has the highest energy-use efficiency (2.81) followed by Module 1 (1.42). Vegetables when grown as intercrop (Module-1) have higher energy-use efficiency (1.42) than the vegetables taken as sole crops (Module 2) having energy use efficiency of 1.37. The energy-use efficiency of the modules underscores the advantages of incorporating vegetables as intercrops, especially in systems like Module 1, which combine perennial fruit orchards with short-duration vegetable crops. The ability to generate more yield per unit of energy input, as demonstrated by the higher EUE in intercropping systems, not only enhances the economic viability of farming but also contributes to the sustainability of agricultural

practices. Intercropping helps reduce external input requirements, optimizes resource use, and improves overall productivity, making it a more energy-efficient and sustainable approach compared to sole cropping systems.

**Table 2.** Energy dynamics of the modules under study

Module	Energy input (MJ)	Energy output (MJ)	Net Energy (MJ)	Energy Use Efficiency
Module 1	1,38,664	1,97,618	58,954	1.42
Module 2	1,12,627	2,19,205	1,06,578	1.37
Module 3	55,607	1,56,528	1,00,921	2.81
Module 4	20,560	21,200	640	1.03



Intercropping of cauliflower in mango orchard



Intercropping of pea in mango orchard



Intercropping of cauliflower in kinnow orchard



Intercropping of turmeric in mango orchard



Intercropping of pea in juvenile mango orchard

Intercropping has a profound effect on soil microbiological properties, positively influencing soil health and fertility through diverse interactions between crops and the soil environment. These interactions can enhance soil microbial activity, diversity, and population dynamics, which are crucial for maintaining soil structure, nutrient cycling, and overall ecosystem balance.

A significant increase in the total microbial population and activity of different enzymes involved in nutrient mineralization has been reported for the developed horticulture-based IFS Model. The highest bacterial count has been recorded for Module 1 ( $9.8 \times 10^6$ ) and the least for Module 2 ( $1.31 \times 10^7$ ) but the highest

fungal count has been recorded for Module 4 ( $8.3 \times 10^3$ ) followed by Module 2 ( $3.4 \times 10^4$ ) and the least for Module 3 at  $2.0 \times 10^4$  CFU/mL. Similar trend has been reported for actinomycetes status where highest colonies of actinomycetes has been reported for Module 3 ( $9.1 \times 10^5$  CFU/mL) followed by Module 4 ( $8.7 \times 10^4$  CFU/mL) and the least for Module 1 ( $6.2 \times 10^5$  CFU/mL).

### SUMMARY

Intercropping as evident from performance of Module 1 shows a positive impact on soil microbiological properties by increasing microbial diversity, enhancing soil enzyme activity, promoting nitrogen fixation, and improving nutrient cycling. The biodiversity fostered by intercropping systems creates an environment conducive for the growth of beneficial soil microbes that contribute to soil fertility, disease suppression, and improved soil structure. Through these mechanisms, intercropping not only supports more sustainable agricultural practices but also helps maintain soil health, making it an effective strategy for improving long-term agricultural productivity and ecological resilience.

**Table 3.** Microbial count of soil samples under different components in model

Module	Sample	Bacteria (CFU/mL)	Fungi (CFU/mL)	Actinomycetes (CFU/mL)
Module 1	Fruit+ Vegetable (intercrop)	$9.8 \times 10^6$	$3.2 \times 10^4$	$6.2 \times 10^5$
Module 2	Vegetables	$1.31 \times 10^7$	$3.4 \times 10^4$	$7.1 \times 10^5$
Module 3	Field crops	$9.6 \times 10^6$	$2.0 \times 10^4$	$9.1 \times 10^5$
Module 4	Pond dyke system	$3.5 \times 10^6$	$8.3 \times 10^3$	$8.7 \times 10^4$

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