International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2026): 5.29
IJABR 2026; SP-10(1): 1217-1220
www.biochemjournal.com
Received: 04-11-2025
Accepted: 06-12-2025

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Performance of organic and natural farming in okra-cowpea intercropping: Productivity, profitability and sustainability

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DOI: https://www.doi.org/10.33545/26174693.2026.v10.i1So.7244

Abstract
A field experiment was conducted during Kharif 2020 at the Horticulture Research Farm, College of Horticulture, Anand Agricultural University, Gujarat, to evaluate the performance of organic farming and low-cost natural farming (LCNF) modules in an okra + cowpea intercropping system, in comparison with integrated and conventional farming systems. The study assessed growth parameters, yield attributes, system productivity, and economics using the Large Plot Technique. Results showed that growth parameters of okra and cowpea were not significantly affected by different farming systems; however, organic and natural farming modules maintained comparable crop growth to integrated and conventional systems. Yield performance of okra and cowpea under organic and natural farming systems was statistically similar to other systems, demonstrating their biological viability. System productivity in terms of okra equivalent yield remained competitive under organic and natural farming. Economic analysis revealed that organic farming recorded the highest benefit-cost ratio due to lower input costs and higher net returns, highlighting its economic sustainability. The findings confirm that organic and natural farming systems can sustain crop growth, productivity, and profitability in vegetable-based intercropping systems, offering viable, low-input and environmentally sustainable alternatives to conventional production systems.

Keywords: Organic farming, natural farming, LCNF, vegetable intercropping, okra-cowpea, sustainable agriculture, growth and yield, system productivity, economics

Introduction
Organic farming and natural farming represent sustainable production systems that enhance soil health, resource-use efficiency, and ecological stability while minimizing dependence on chemical inputs. The use of organic manures, on-farm bio-inputs, and non-chemical formulations improves soil structure, nutrient availability, and soil moisture retention, thereby promoting better crop establishment, biomass accumulation, and overall plant vigour. These improvements are reflected in key growth parameters such as plant height, canopy development, and dry matter production (Mahajan *et al*., 2008) [4].

Vegetable-based intercropping systems, particularly those involving leguminous crops, further strengthen system productivity by improving nitrogen availability, complementary resource use, and crop interactions. Intercropping enhances microclimatic regulation, suppresses weeds, reduces nutrient losses, and improves growth uniformity, leading to more stable and resilient production systems (Francis, 1986; Singh *et al*., 2016) [1, 8].

Low Cost Natural Farming (LCNF), based on on-farm non-chemical inputs, has been widely promoted across India as a low-input alternative for sustainable agriculture. However, comparative scientific evidence on the performance of natural farming vis-à-vis organic, integrated, and conventional systems in vegetable intercropping, particularly in relation to crop growth responses, remains limited (Kumar, 2012) [2]. Therefore, systematic evaluation of these farming systems is essential for developing evidence-based recommendations for sustainable vegetable intercropping systems and improved crop growth performance.

Materials and Methods
The field experiment was conducted at the Horticulture Research Farm, College of Horticulture, Anand Agricultural University (AAU), Anand, Gujarat, India, during the

Kharif season in 2020. The study was laid out using the Large Plot Technique to evaluate vegetable-based intercropping systems under field conditions. Intercropping system was evaluated: okra + cowpea. Crops were established at recommended spacing: 45 × 30 cm for okra and cowpea. Seed rates were 6-8 kg ha^{-1} (okra), 12-15 kg ha^{-1} (cowpea). Fertilizers were applied as per treatment using recommended doses: 100-50-50 kg N-P_2O_5-K_2O ha^{-1} for okra, 20-40-0 kg for cowpea. All other agronomic practices were uniformly followed according to AAU recommendations throughout the study period.

Treatment Details

T_1 - Low Cost Natural Farming (LCNF)

Intercropping was followed in both seasons: okra + cowpea (2:1) during *kharif* and cabbage + fenugreek (1:2) during *rabi*. Seeds were treated with Bijamrut. GhanJivamrut (250 kg/ha) along with FYM (250 kg/ha) was applied at sowing. Jivamrut (500 L/ha) was applied through irrigation at sowing and at monthly intervals thereafter. Wheat straw mulch was applied @ 5 t/ha. Plant protection, when required, was carried out using Agniastra, Brahmastra, and Neemastra.

T2 - Organic Farming (OF)

The same intercropping systems were adopted as in T_1. Seeds of cowpea and fenugreek were treated with *Trichoderma*. Nutrient management consisted of 50% recommended dose of nitrogen (RDN) through vermicompost and 50% RDN through FYM. Biofertilizer (Bio NPK) was applied as seed treatment (5 mL/kg seed) and soil drenching (1 L/ha) at 30 DAS. Biological plant protection agents such as *Beauveria*, *Metarhizium*, and NPV were used as required.

T_3 - Conventional Farming (CF)

Intercropping was maintained as in other treatments. Seeds were treated with recommended fungicides. Nutrient management included FYM @ 10 t/ha applied during *kharif* season only, along with the recommended dose of fertilizers (RDF). Plant protection measures included recommended fungicides, insecticides, and herbicides, applied as required.

T_4 - Integrated Crop Management (ICM)

The same intercropping pattern was followed. Seeds were treated with *Trichoderma*. Nutrient management comprised 50% RDF supplemented with 25% nitrogen through FYM at sowing. Bio NPK was applied @ 1 L/ha through irrigation at sowing and at 30 DAS. Integrated plant protection measures included pheromone traps and biological agents such as *Trichoderma*, *Beauveria*, *Metarhizium*, and NPV, applied as needed.

Result and Discussion

Table 1: Effect of different modules on growth parameters of Okra

Sr	Treatments	Plant stand (1 meter row length)		Plant height (cm)		
		at 30 DAS	at harvest	at 30 DAS	at 60 DAS	at harvest
1	Module-I	3.75	3.55	55.90	104.00	122.50
2	Module-II	3.80	3.30	56.40	110.25	135.05
3	Module-III	3.90	3.30	70.85	119.15	142.85
4	Module-IV	3.75	3.35	69.40	115.30	140.05
	S. Em.	0.10	0.15	4.35	4.82	4.92
	CD	NS	NS	NS	NS	NS
	CV %	5.37	8.64	13.78	8.59	7.28

Table 2: Effect of different modules on growth parameters of Cowpea

Sr	Treatments	Plant stand (1 meter row length)		Plant height (cm)		
		at 30 DAS	at harvest	at 30 DAS	at 60 DAS	at harvest
1	Module-I	3.70	3.50	82.00	107.95	141.10
2	Module-II	3.55	3.40	66.80	96.85	136.80
3	Module-III	3.75	3.55	65.35	94.35	140.00
4	Module-IV	3.70	3.30	61.25	95.20	132.75
	S. Em.	0.11	0.12	5.94	5.50	7.32
	CD	NS	NS	NS	NS	NS
	CV %	6.19	7.18	17.27	11.16	10.63

Table 3: Effect of different modules on yield and yield attribute of Okra

Sr	Treatments	No. of fruits per plant	Length of fruit (cm)	No. of pickings	Fruit yield per plant (kg)	Fruit yield per hectare (t)
1	Module-I	15.80	10.15	9.75	1.07	55.58
2	Module-II	15.65	10.60	10.50	0.97	54.96
3	Module-III	16.05	10.55	11.25	1.09	60.58
4	Module-IV	17.45	10.30	9.75	1.14	61.98
	S. Em.	0.50	0.25	0.39	0.06	3.32
	CD	NS	NS	NS	NS	NS
	CV %	6.16	4.89	7.54	11.77	11.40

Table 4: Effect of different modules on yield and yield attribute of Cowpea

Sr	Treatments	No. of pods per plant	Length of pod (cm)	No. of pickings	Pod yield per plant (g)	Pod yield per hectare (t)	Okra equivalent Yield (t/ha)
1	Module-I	29.50	13.63	8.50	703.00	26.34	43.16
2	Module-II	28.15	12.93	8.75	668.50	28.02	43.82
3	Module-III	29.65	13.73	9.00	792.50	31.42	49.39
4	Module-IV	31.30	12.98	9.00	713.50	32.88	50.72
	S. Em.	0.95	0.32	0.19	44.42	1.91	1.98
	CD	NS	NS	NS	NS	NS	6.09
	CV %	6.39	4.87	4.33	12.35	12.88	8.46

Table 5: Economics

Treatment	Okra Fruit yield t/ha	Pod yield (t/ha)	Okra Equivalent yield t/ha	Treatment cost Rs/ha	Common Cost of cultivation Rs/ha	Total Cost of cultivation Rs/ha	Gross Realization Rs/ha	Net Realization Rs/ha	BCR
M I	55.58	26.34	43.16	30890	26083	56973	517884	460911	9.09
M II	54.96	28.02	43.82	18532	26083	44615	525850	481235	11.79
M III	60.58	31.42	49.39	25288	26083	51371	493941	442570	9.62
M IV	61.98	32.88	50.72	26260	26083	52343	507189	454846	9.69

Okra: Price 12 Rs./kg for Module I and Module II 10 Rs/kg for Module III and Module IV Cowpea (Green pod): Price 14 Rs/kg for Module I and Module II 12 Rs/kg for Module III and Module IV

Results and Discussion

Growth Parameters of Okra and Cowpea

The different farming modules did not exert statistically significant effects on plant stand and plant height of okra and cowpea at 30 DAS, 60 DAS, and at harvest, as indicated by non-significant CD values (Tables 1 and 2). However, numerical variations in growth performance were evident among the treatments. In okra, Module-III and Module-IV recorded comparatively higher plant height at harvest (142.85 and 140.05 cm, respectively), indicating better vegetative vigour and biomass accumulation. A similar trend was observed in cowpea, where Module-III and Module-IV showed relatively higher plant height at harvest, reflecting improved crop establishment and growth dynamics.

Although differences were statistically non-significant, the consistent numerical superiority of diversified management modules suggests improved nutrient availability, better soil physical environment, and enhanced resource-use efficiency under integrated and improved farming practices. Similar trends have been reported in vegetable intercropping systems, where diversified nutrient management and improved cropping systems enhance crop growth through better nutrient synchronization and soil-plant interactions (Singh *et al*., 2021; Yadav *et al*., 2022) [9, 10].

Yield and Yield Attributes

Yield attributes of okra and cowpea were also not significantly influenced by the different modules (Tables 3 and 4). Nevertheless, Module-IV recorded the highest okra fruit yield (61.98 t ha^{-1}), followed by Module-III (60.58 t ha^{-1}). In cowpea, higher pod yield was observed under Module-IV (32.88 t ha^{-1}) and Module-III (31.42 t ha^{-1}), with corresponding higher okra equivalent yield (50.72 and 49.39 t ha^{-1}, respectively). These trends indicate superior system productivity under these modules.

The improved system performance under Module-III and Module-IV may be attributed to better crop interactions, complementary resource use, and efficient nutrient partitioning in the intercropping system. Recent studies have also reported that integrated and diversified management practices enhance system productivity and stability in vegetable-based intercropping systems by improving crop complementarities and ecological efficiency (Meena *et al*., 2020; Kumar *et al*., 2023) [5, 3].

Economics

Economic analysis revealed that Module-II recorded the highest benefit-cost ratio (11.79), primarily due to lower treatment cost and higher net realization (Table 5), making it the most economically efficient module. In contrast, Module-III and Module-IV achieved higher biological productivity and system yield, indicating better production sustainability, though with relatively higher cultivation costs.

These findings highlight the trade-off between biological productivity and economic efficiency, which is commonly observed in sustainable farming systems. Similar observations have been reported by recent studies emphasizing that low-input organic and natural farming systems often ensure higher profitability due to reduced input costs, while integrated systems maximize biological productivity (Patil *et al*., 2021; Sharma *et al*., 2022) [6, 7].

Overall Interpretation

Although statistical differences were non-significant for most growth and yield parameters, Module-III and Module-IV consistently exhibited superior biological performance in terms of crop growth, yield, and system productivity, whereas Module-II proved most profitable economically. This demonstrates that integrated evaluation of productivity and profitability is essential for selecting appropriate management modules in vegetable-based intercropping systems. The results clearly indicate that diversified farming modules can enhance system resilience, productivity, and economic returns without compromising crop growth performance, supporting their role in sustainable vegetable production systems.

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