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Performance and Profitability Study of Different Leafy Vegetables as Intercrops in Mango

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Abstract

The study was conducted during *rabi* season (December to March) 2022 to 2024 at Dr. YSRHU-Mango Research Station, Nuzvid, Andhra Pradesh, India to investigate the compatibility and effectiveness of leafy vegetables as intercrops in mango orchard. Intercropping is one of the techniques of land utilization for optimum production which can provide substantial yield advantage compared with sole cropping. Mango is the most important fruit crop of India which is primarily characterized by monocropping, low-density planting and low productivity. The mango equivalent yield was found highest in mango+palak (6.52 t ha^{-1}) followed by mango+fenugreek (6.11 t ha^{-1}) and lowest was recorded in mango+amaranthus (4.22 t ha^{-1}). The Land Equivalent Ratio (LER) of intercropping with leafy vegetables in mango showed >1 indicating the better biological efficiency of the intercropping system. However, mango+palak recorded highest value (1.6) of land equivalent ratio (LER) while lowest value was recorded in mango+basalla (1.28). The monetary advantage index (MAI) values were positive for all the intercrops. However, mango+roselle had highest value of MAI (₹ 134625.74) followed by mango+palak (₹ 121706.88) while mango+amaranthus had lowest values (₹ 61257.5). The highest net returns were obtained in mango+roselle cropping system (₹ 248802) which was followed by mango+palak (₹ 244898). Similarly highest benefit-cost ratio (2:1) was found in mago+roselle and Mango+Palak. These results indicated the definite yield advantage with Palak and roselle as intercrops in bearing mango orchard.

Keywords: Mango, inter crops, LER, MAI, MEY, economic components

1. Introduction

Intercropping is an important strategy for ensuring the long-term sustainability of fruit crops cultivation. It involves growing two or more different species of crops simultaneously on the same piece of land and this practice adds diversity to the farm's plant population, leading to increased cropping intensity and higher productivity. The space between fruit trees is used to grow short-duration crops, which help support the farmers during the off-season when the main crops are not in fruiting stage (Manjunath et al., 2026a). The intercrops not only generate an extra income but also help to check the soil erosion through ground cover, improving physico-chemical properties of soils (Raut et al., 2013, Manjunath, 2021, Subba and Dhara, 2017). Intercropping is one of the techniques of land utilization for optimum production which can provide substantial yield advantage compared with sole cropping (Begum et al., 2020, Bindu et al., 2022). Intercropping generates additional employment and income for farm families and improves the socio-economic status of farmers (Ponnusamy et al., 2015, Usamah et al., 2025). This practice, besides providing income to the grower, suppresses weed growth, improves soil fertility and prevents leaching of nutrients and erosion of soil, achieves higher gross return per unit area (Mehta et al., 2025). Mango (*Mangifera indica* L.), popularly known as the "King of Fruits". It occupies a prominent position in the country's horticultural economy due to its extensive cultivation area, high consumer demand, export potential, and contribution to farmers' livelihoods. However, mango orchards require several years to attain full bearing capacity, leaving considerable inter-row space underutilized during the juvenile stage. Even in bearing orchards with wider spacing, sufficient sunlight reaches the orchard floor, creating opportunities for the cultivation of compatible intercrops. Efficient utilization of this available space through intercropping can significantly improve land productivity, resource use efficiency, and farm profitability. Mango is the most important fruit crop of India which is primarily characterized by monocropping, low-density planting and low productivity (Kishore et al., 2025). In order to achieve higher yield under monoculture system, fertilizers, irrigation water and energy are excessively used which not only cause improper management of resources but also aggravate the emissions of greenhouse gases (GHGs) and degradation of natural resources (Chen et al., 2014). Although mango is a potential crop, due to seasonal nature in which fruits are harvested only once in a year in most of the commercial varieties makes challenging especially small and marginal farmers to rely solely on mango crop for their livelihood (Rani, 2026). Moreover, practices in fruit orchards have resulted in critical issues such as soil degradation, nutrient depletion, biodiversity loss and reduced system resilience (Tiwari and Baghel, 2014, Mirjha and Rana, 2016,) and susceptibility to various biotic and abiotic stresses (Jitendra et al., 2024). Mango is grown at wider spacing of 10–12 m between the rows and between the plants as well. Hence, there is an ample space available for growing short duration crops as intercrops (Pradhan et al., 2018). Among the vegetables, leafy vegetables are rich sources of dietary fibre, vitamin A, vitamin C and minerals like iron, calcium, phosphorus, folic acid (Akhilesh et al., 2024). Being short duration crops they can easily be grown as inter crops in mango. Therefore, this study was executed with the objective to find out suitable leafy vegetable crops to be grown in bearing mango orchard as intercrops to get additional income.

2. Materials and Methods

This study was executed at Dr. YSRHU-Mango Research Station (MRS), Nuzvid, Eluru District, Andhra Pradesh. The experimental site was geographically situated at 16^{o} 46’ 48’’ N latitude and 80^{o} 50’ 59’’E longitude. The orchard soil type is red loamy soil. The study was conducted in a Randomized Block design with three replications during *rabi* season (December to March) 2022 to 2024. Seven types of leafy vegetables *viz*., amaranthus, palak, coriander, fenugreek, sorrel, basella and roselle were taken as treatments grown as intercrops in mango orchard. The varieties of palak and amaranthus were collected from IIHR Bangalore, fenugreek and coriander varieties were collected from Horticulture Research Station, LAM, Guntur, Dr. Y.S.R. Horticultural University. Local varieties were used in remaining leafy vegetables. The intercrops were planted during 3^{rd} week of December between the interspace of four mango trees. Uniform cultural operations were followed for the intercropped leafy vegetables besides the main crop. The schedule followed for their cultivation is presented in Table 1.

Observations on yield and dry weight were recorded and analyzed as per the procedure described by Panse and Sukhatme, 1987. The economic produce of leafy vegetables was harvested plot wise and quantified per hectare. Economics of different leafy vegetables were worked out by considering the prevailing cost of inputs like seeds, manures and fertilizers, labour, pesticides, sale price of produce during the experimental period from 2022 to 2024. The gross returns were estimated by multiplying the average yield per hectare of leafy vegetables with prevailing market price and similarly net returns were calculated by deducting the cost of cultivation from gross returns. The Benefit Cost Ratio (B:C) was estimated to find out the most profitable and remunerative intercrop using the following formula

B:C=Gross returns of the intercrop/Cost of cultivation of the intercrop

The biological efficiency of mango based intercropping systems was calculated through some indices such as mango equivalent yield and land equivalent ratio in order to know the yield advantages of associated crops over main crop.

2.1. Mango equivalent yield (MEY)

The mango equivalent yield (MEY) of the intercropping system was calculated using the following formula.

Mango equivalent yield (t ha^{-1})=Yield of intercrop (kg ha^{-1})× Price of intercrop (₹ kg)/Price of mango (₹ kg).

2.2. Land equivalent ratio (LER)

The land equivalent ratio of mango based intercropping system was calculated by summing up the partial LER of component crops such as mango and intercrops. It is calculated as per the following formula.

LER of crop=Yield obtained in intercropping/Yield obtained in sole crop

When LER is unity (=1) there is no additional production advantage of mixed culture; when LER is less than unity, there

Table 1: Agro techniques adopted for leafy vegetable crops used as inter crops in mango

Treatments	Crop	Variety	Spacing (cm^2)	Seed rate (kg ha^{-1})	Crop duration (month)	NPK (kg ha^{-1})
T_1	Amaranthus	Arka Suguna	20×20	2.5	3	50:50:20
T_2	Palak	Arka Anupama	30×10	35	3	70: 50:50
T_3	Coriander	Suguna	20×15	10-12	3	20:40:20
T_4	Fenugreek	Lam Methi 2	30×10	10-12	3	40:20:20
T_5	Sorrel	Local variety	30×10	2	3	50: 50:50
T_6	Basalla	Local variety	30×10	10	3	50: 20:20
T_7	Rosella	Local variety	50×20	12	3	70: 50:50

is disadvantage and when LER is more than unity, there is advantage of mixed culture. Economic valuation of mango-based intercropping was calculated using measured yields for each crop component and the prevailing market price in INR during the study period.

2.3. Monetary advantage index (MAI)

To analyze the economic yield advantage of intercropping system, Monetary Advantage Index (MAI) was calculated by using the following formula.

MAI=Value of combined intercrops×(LER−1)/LER

Higher the MAI value, the more profitable is the cropping system

Table 2: Yield and Dry weight of different leafy vegetables as inter crops in mango

Treatments	Intercrop yield (kg sqm^{-1})	Intercrop yield (t ha^{-1})	Dry weight (%)
Mango+Amaranthus	2.49	4.15	14.3
Mango+Palak	3.86	6.44	18.2
Mango+Coriander	1.36	2.26	14.1
Mango+Fenugreek	1.89	3.15	17.5
Mango+Sorrel	3.25	4.96	14.6
Mango+Basalla	2.45	4.09	14.7
Mango+Rosella	3.39	5.63	19.5
CD (p=0.05)	0.47	0.91	3.4
SEm±	0.16	0.31	1.12
CV%	11.8	13.9	13.9

Table 3: Economics of leafy vegetables as intercrops in mango orchard

Treatments	Cost of cultivation ha^{-1} (₹)	Gross returns ha^{-1} (₹)	Net returns ha^{-1} (₹)	B:C ratio
T_1	174600	296115	121515	1.7
T_2	214033	458931	244898	2.1
T_3	185866	339766	153900	1.8
T_4	219666	366938	147272	1.7
T_5	214033	382762	168729	1.8
T_6	215766	379949	164183	1.8
T_7	225300	474102	248802	2.1
Mango sole crop	107000	171200	64200	1.6

1 US$= INR? Average during harvesting months

3. Results and Discussion

The pooled results of 3 years from 2022 to 2024 on yield and economic components were presented in Table 2 to 4.

Among the different leafy vegetables studies as intercrops in mango during *rabi* season 2022 to 2024, palak recorded highest yield (3.86 kg 6sqm^{-1} and 6.44 t ha^{-1}) which was on par with roselle recorded 3.39 kg 6sqm^{-1} and 5.63 t ha^{-1}. Coriander recorded lowest yield of1.36 kg 6sqm^{-1} and 2.26 t ha^{-1}. Dry weight percentage was found highest in roselle (19.5%), palak (18.2%) and fenugreek (17.5%) while lowest as observed in coriander (14.1%). The higher yield of palak and rosella between the rows of mango trees is an indicative of efficient utilization of solar radiation as they prefer moderate light intensity for growth. Similar results were reported by Tasmima et al., 2021 in their study on performance of leafy vegetables intercropped with brinjal.

Table 4: Effect of leafy vegetables as inter crops on competitive function in mango

Treatments	LER 1 (Mango)	LER 2 (Inter-crops)	LER (LER 1+LER 2 (Cropping system)	MAI	MEY (t ha^{-1})
T_1	0.77	0.58	1.35	61257.5	4.22
T_2	0.82	0.83	1.65	121706.88	6.52
T_3	0.89	0.50	1.39	98496	5.64
T_4	0.86	0.51	1.37	92781.36	6.11
T_5	0.86	0.58	1.44	100768.71	5.82
T_6	0.75	0.53	1.28	95226.14	5.13
T_7	0.79	0.67	1.46	134625.74	4.28

LER: Land equivalent ratio; MAI: Monetary advantage index; MEY: Mango equivalent yield

Economics of sole crop (Mango) and with different intercrops are presented in Table 3 and the data showed that among the different intercropping systems with leafy vegetables, the cost of cultivation was found highest in mango+roselle (₹ 225300) followed by mango+fenugreek (₹ 219666), whereas lowest was found in mango+amaranthus (₹ 174600). This difference could be due to cost of inputs like seed and other resources used by the crops. Similar results were reported by Islam et al., 2016 in intercropping garlic with brinjal. Among the different intercrop combinations, mango+roselle recorded highest gross returns (₹ 474102) followed by mango+palak (₹ 458931) and lowest was recorded in mango+amaranthus (₹ 296115). This could be attributed due to the sale price of crops during that period. Highest net returns were obtained in mango+roselle cropping system (₹ 248802) which was followed by mango+palak (₹ 244898) whereas lowest net returns were observed in mango+amaranthus (₹ 121515). These results are in collaborated with the findings of Manjunath et al., 2026b in mango. Similarly highest Benefit: Cost (B:C) ratio was found in mago+roselle and mango+palak as 2:1 compared to Other intercropping systems and mango sole crop (1.6). These results indicating the Roselle and Palak were remunerative crops when grown as intercrops in bearing mango orchard during *rabi* season.

The land equivalent ratio (LER) indicates proportionate land area required under a sole cropping to yield the same amount of produce as obtained under an intercropping system at the same management level. The LER values of intercropping system with various leaf vegetables of present study showed >1. However, among the different crops, palak recorded highest value of LER (1.65) while lowest value was recorded in basalla (1.28). These results indicated that yield benefit in intercropping due to efficient land use, solar light, temperature etc. Similar results were reported by Khati Malo et al., 2025 in cauliflower. Monetary advantage index (MAI) was calculated by multiplying the respective yields of the component crops by their market prices during the period of experimentation and divided by respective LER. The positive values of monetary advantage index (MAI) showed a definite yield advantage to intercropping compared to sole crop. Monetary advantage index values further highlighted the economic benefit of intercropping, as higher LERs were associated with higher MAI. In the present study MAI values were positive for all the intercrops. However, mango+roselle had highest value of MAI (₹ 134625.74) followed by mango+Palak (₹ 121706.88) while Mango+Amaranthus had lowest values (₹ 61257.5). These results indicating the definite yield advantage with intercropping when compared to sole crop mango. It is an indicator of the economic feasibility of intercropping systems as compared to sole crop. These findings are in conformity with the findings of Islam et al. (2016). Mango equivalent yield (MEY) was found highest in palak (6.52 t ha^{-1}) followed by fenugreek (6.11 t ha^{-1}) and lowest was recorded in amaranthus (4.22 t ha^{-1}). Sahoo (2016) also reported that mango+roselle recorded highest MEY in his study.

4. Conclusion

Intercropping leafy vegetables in bearing mango orchard during *rabi* season provided additional income.. All the crops studied were suitable, however, the highest net returns were obtained in mango+roselle cropping system (₹ 248802) which was followed by mango+palak (₹ 244898). Similarly highest Benefit:Cost (B:C) ratio was found in mago+roselle and mango+palak as 2:1 compared to other intercropping systems and mango sole crop (1.6). Hence, these crops could be considered as effective remunerative crops.

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