DOI : 10.5958/0974-0112.2021.00060.8

Indian J. Hortic. 78(4), December 2021: 417-422

System approach in rainfed mango for sustainable productivity, profitability and livelihood security

B. L. Manjunath*, R. H. Laxman, M. S. Puneeth Raj and Karnam Veeresha

ICAR-Indian Institute of Horticultural Research, Hesaraghatta-560 089, Bengaluru, Karnataka, India.

ABSTRACT

Results of a field trial for four years to standardize an integrated farming system revealed that harvesting rainwater and intercropping can be profitably practiced under rainfed mango. Mango + sweet corn intercropping + dairy system gave significantly higher system productivity (15,303 kg/ha/year), net returns (₹ 2,61,870/ha/year), and benefit-cost ratio (2.43) followed by mango + pigeon pea (13,062 kg/ha/year, ₹ 233 × 103/ha/year and 2.40, respectively). The economics of dairy (two milch cows) integration showed an average milk production of 9.7 litres/day/cow, leading to regular returns. In addition, there was a reduction in the cost of maintenance of dairy due to on-farm generated fodder resources in the system approach. With intercropping, the organic carbon content accumulated in the mango basin (0.54 % to 1.28 %), although in the interspace, the differences were non-significant. Further, with intercropping, mango yield increased from 20.7 kg/plant to 66.6 kg/plant over four years. The total net returns were increased from ₹ 41,800/ha /year from monocropping mango to ₹ 261.87 × 103/ha/year by following integrated farming systems. Further, the system approach resulted in periodic returns to the family, with the distribution of income spreading out from a mere three months to all twelve months in the year with a minimum of ₹ 6,520/month to a maximum of ₹ 750/month thereby suggesting the sustainable livelihood opportunity for the dependent farm family.

Keywords: Integrated farming system, intercropping, monthly income, mango, sustainable livelihood

INTRODUCTION

The average size of farm holding in India has declined over time and out of a total 137.8 million farm holdings in India, 85 per cent are less than two hectares (Anonymous,1). This doubles up the challenge of making farming on these fragmented pieces of land gainful, if not viable. The concept of Integrated Farming Systems (IFS) is more feasible for these small farm holdings as it serves as a tool for linking allied agri- enterprises with the crop production besides offering scope for environment safety and conservation of agro-biodiversity (Kathiresan, 4).

Mango is the main fruit crop of India and is extensively cultivated under rainfed conditions (68%) with wider spacing without much care. At present mango is cultivated in an area of 2.29 M ha with a production of 20.8 Mt, the productivity being 9.08 t/ha (Anonymous, 1). Irregular bearing, fruit drop, pests and diseases and dwindling prices in the market leading to poor returns from the crop (Rajan, 7). The crop diversification with mango may result in enhanced profitability, reduce pest, spread out labour more uniformly, different planting and harvesting times can reduce risks from weather and new crops can be renewable resources of high value products (Reddy and Suresh, 9). Hence, there is a need for integrated, system-oriented impact assessments and a realistic consideration of the adoption constraints in smallholder systems (Descheemaeker *et al.*, 2). Further, integration of livestock into diverse cropping systems highly benefits the system (Sulc and Tracy, 12). In particular, using the crop by-products to feed livestock enables recycling nutrients back to farm fields, which reduces the need for fertilizers and enhances desirable soil (Hendrickson *et al.*, 3). The benefits of system approach lies in the interactions among the components. With farming system approach in mango, it is presumed that risk in dealing with single component is avoided through integration with compatible crops and allied enterprises. IFS models have been suggested by several workers for the development of small and marginal farms across the country (Kathiresan, 4). By adopting these models farmer's income can be increased many folds as well as sustainability and economic viability of small and marginal farmers can be maintained (Sanjeev *et al.*, 11). However, such information on system approach in mango is limited.

Keeping these points in view, efforts were made to assess the impact of integrated farming system approach in rainfed mango with an objective to study productivity, profitability and livelihood security.

*Corresponding author: blmanjunathagri@gmail.com

MATERIALS AND METHODS

Field experiments were conducted for developing integrated system approach on rainfed mango for four years during 2017-2020 at ICAR-Indian Institute of Horticultural Research, Bengaluru. The rainfall received during 2018 was 763.3mm while in 2019 it was 1,078 mm as against the normal 850 mm. The experimental soil was sandy loam in texture with a pH of 6.14 and an EC of 0.067 dS m^{-1}. At the beginning, the soil had a nutrient content of 152.4 kg available N/ha, 38.7 kg available P/ha and 385.3 kg available K/ha.

A farm pond was constructed with a hectare catchment without disturbing the mango plants by placing earthern bunds fortified with grass and legume plants. The middle 5 m between two plant lines was used for farm pond construction leaving 2.5 m on either side for the mango root growth. With the inter-space available in mango - 5 m as the top width, 45 m as length (the space of 6 mango plants on either side) and a depth of 3.3 m, the storage capacity created was for five lakh litres of water. Silpaulin lining with 750 gsm was covered for farm pond to prevent the seepage losses.

Thirty years old mango (variety-Totapuri) orchard spaced at 10 m x 10 m in a hectare of plot was evaluated for feasibility of intercropping during rainy seasons from 2017 to 2020. The performance of seven intercrops *viz*., pigeonpea ('BRG-2'), forage grass ('hybrid napier BH-18'), sweet corn ('Sugar 75'), cowpea ('Goa Cowpea-3'), drumstick ('PKM-1'), finger millet ('GPU-28'), field bean ('Hebbal Avare-3'), cultivated on fixed plots leaving the active root zone of mango were compared with the control (no intercrop) in RBD design with three replications. Mango and all the intercrops were managed with recommended package of practices purely under rainfed conditions.

The feasibility study of mango based intercropping with integration of two milch (HF breed) cows was studied. The ragi straw, sweet corn green stover, border grown *Sesbania* loppings, weeds in the mango basins and inter spaces along with the intercropped hybrid napier forage grass formed the combination of grass-legume mixture for balanced diet of the milch cows. The feed and fodder supplied to the dairy animals were quantified along with milk and cowdung production and the returns were worked out based on market prices. The recyclable resources generated within a ha of mango system were quantified and used periodically for the preparation of the vermi compost. Mixed cultures of earth worms viz., *Eisinea foetida, Eudrillus Eugenia* and *Perionicus excavates* were used in the process of decomposition.

The impact of system approach on soil fertility parameters through intercropping on fixed plots and recycling of manurial resources over a period of four years was studied through standard analytical procedures. The mango equivalent yield was worked out taking into consideration the yield and the value of the intercrop produce in terms of mango and expressed as system productivity. The economics of the system including the enterprises was worked out by considering the market value of the inputs and produces during the period.

The observations on all the yield and economic parameters were recorded at periodic intervals. All the experimental data were statistically analysed as per the standard methods and the differences in means were compared at 5 % level of significance.

RESULTS AND DISCUSSION

The rainfall received during 2018 was 763.3mm while in 2019 it was 1,078 mm as against the normal 850 mm. An analysis of rainfall during different standard weeks, runoff and its collection in the farm pond has indicated that atleast 1.93 lakh litres of water could be collected in the farm pond by July first week. By September end, the farm pond collection was as high as 3 lakh litres and normally by November first fortnight, the farm pond got totally filled up.

The farm pond water thus stored was available for use in maintenance of vermi composting (3600 litres/year) and for life saving irrigation to both drumstick and curry leaf grown on the berms of the farm pond. Leaving about 30 % of the total storage towards evaporation, a total quantity of 2,35,150 litres (out of five lakh litres) was available for protective irrigation. The available water was used for growing of high value short duration crops around the farm pond area and for the protective irrigation to the base crop- mango at fruit initiation and development stage and for intercrops in their critical stages.

Results of intercropping revealed that mango + sweet corn system gave significantly higher system productivity (6,123 kg/ha/year) Higher productivity and returns from mango + sweet corn system may be attributed to the high yielding potential of the short duration C_4 sweet corn crop with average productivity of 11.7 t/ha (Table 1). Further, the system showed significantly higher returns owing to stable prices for the green cobs of sweet corn. In addition, the green fresh stover from sweet corn was also available for use as fodder. With staggered sowing, it was possible to obtain the green cobs and the stover for a longer period. Pigeonpea was observed as next

Table 1. System productivity and economics of mango based intercropping systems under rainfed conditions (pooled means for 2017-2020)

Treatment	Yield of mango (kg/ha)	Yield of intercrop (kg/ha of mango garden)	Secondary produce of intercrop (kg/ha)	Mango equivalent yield of intercrop (kg/ha)	Mango equivalent yield of dairy (kg/ha)	Total system productivity (kg mango /ha)	Total cost (Rs/ha) x 10^3	Gross returns (Rs/ha) x 10^3	Net returns (Rs/ha) x 10^3	Benefit cost ratio
Mango + Forage grass+ Dairy	1,054	71,897	71,897	3,142	6570	10766	187.94	308.82	120.88	1.64
Mango + Pigeonpea+ Dairy	3,511	1,464	5,260	2,981	6570	13062	166.23	399.24	233.00	2.40
Mango + Sweet Corn+ Dairy	2,610	11,661	8,768	6,123	6570	15303	183.07	444.93	261.87	2.43
Mango + Cowpea / Dolichus+ Dairy	4,310	432	219	1,154	6570	12034	168.02	346.86	178.84	2.06
Mango + Finger millet+ Dairy	172	2,805	3,507	2,981	6570	9723	168.82	277.53	108.71	1.64
Mango +Sweet potato/Field bean+ Dairy	123	7,891	--	5,354	6570	11924	191.89	347.25	155.36	1.81
Mango alone (Control)	1,536	--	--	--	--	1536	17.09	46.08	28.99	2.70
S.Em±	5.63	--	--	118.24	--	323	5.80	15.35	10.54	0.14
C.D (P=0.05)	16.97	--	--	347.19	--	908	13.12	29.92	14.15	0.19

best intercrop. In a study conducted by Rathore *et al*., (8) the cowpea–toria crop rotation with mango gave maximum benefit: cost ratio followed by okra–toria under rainfed conditions.

The results indicated a good potential for forage grass production with a total of 18.2 tonnes in a hectare of mango garden from bund cropping and additional cultivation in about 500 m^2. It was observed that using these fodder resources, maintenance of two milch cows was practically feasible round the year. Further, it was observed that by feeding the cows from the farm generated produce, cost of maintenance of dairy was reduced substantially. This shows the ability of livestock to take advantage of underutilized resources can improve the overall efficiency of the farm operation and capture new sources of income (Russelle *et al*., 10).

The economics of dairy (two milch cows) integration was quite encouraging with an average milk production of 9.7 litres/day/cow leading to regular returns from the system accounting to ₹ 15,245/ month as gross returns and ₹ 5,120/month as net returns. With the reduction in cost of maintenance due to on farm generated fodder resources in the system approach (₹ 10,120/month), the net returns were not only substantial but also regular. Further, the integration generated valuable cowdung (2.25 tonnes/month) within the system that was available for compost/vermi compost preparation. Using this cowdung and other recyclable resources, five tonnes of good quality FYM/compost could be prepared besides using it as an ingredient for on-farm vermi compost preparation (1.2 tonnes/ha) (Table 1).

The soil test results of four years of continuous intercropping on fixed plots indicated that the organic carbon content of the soil found to accumulate in mango basin (0.54 % to 1.28 %) which may be due to the addition of crop wastes to the basins (Table 2). In general nitrogen content of soil in the mango basins improved over four years both with intercropping (196 kg/ha to 464.5 kg/ha) or without intercropping (381.0 kg/ha). Compared to an initial status of 152.4 kg N/ha in the interspaces, the mean increase with intercropping was 60.9 % (245.2 kg/ha).

Phosphorus content also improved substantially over four years in the mango basin with continuous application of recommended fertilizers to the mango crop. The build-up of phosphorus over the years in the mango basin with application of recommended phosphorus suggests that there is scope for reduction in recommendation of phosphorus to the mango crop. However, phosphorus in general was depleting in the interspaces due to four years continuous intercropping on fixed plots.

Table 2. Effect of intercropping on soil fertility in the mango basin and the interspace after four years (pooled means for 2017-2020).

Treatments	OC (%)		N (kg/ha)		P (kg/ha)		K (kg/ha)	
	Mango basin	Interspace	Mango basin	Interspace	Mango basin	Interspace	Mango basin	Interspace
Initial	0.54	0.42	196.0	152.4	61.3	38.7	907.2	385.3
Intercrops								
Forage grass	1.26	0.56	457.3	203.2	127.2	29.9	963.2	147.5
Pigeonpea	1.29	0.55	468.2	199.6	139.5	46.4	1282.4	365.9
Sweet corn	1.46	0.51	529.9	185.1	157.0	32.1	1088.3	246.4
Cowpea/Dolicus	1.05	0.60	381.0	217.8	158.1	29.0	1129.3	265.1
Drumstick	0.97	0.78	352.0	283.1	142.6	26.9	862.4	311.7
Finger millet	1.48	0.95	537.1	344.8	187.0	23.8	845.6	207.2
Sweet potato/ Field bean	1.45	0.78	526.2	283.1	195.4	20.7	802.7	250.1
Mean	1.28	0.68	464.5	245.2	158.1	29.81	996.3	256.3
Control (without intercropping)	1.24	0.85	449.1	307.5	52.7	32.8	1044.9	366.2
S.Em ±	0.15	0.13	54.3	45.4	23.4	5.2	129.9	42.9
C.D (P=0.05)	-	-	-	-	-	-	-	131.4

Compared to an initial status of 907.2 kg/ha of potassium in the mango basin, with four years of intercropping, there was a marginal accumulation of potassium with intercropping (996.3 kg/ha). Further, the K content in mango basin was only marginally higher for without intercropping (1,022.9 kg/ha). In contrast, without intercropping there was only a marginal decrease in potassium content of soil (from the initial 385.3 kg/ha to 341.6 kg/ha). In an intercropping study conducted by Swain *et al.,* (13), mango + guava + cowpea system resulted in most improvement in organic carbon along with the other parameters.

Significant influence of intercrops was observed in mango when grown on fixed plots over four years. Intercropping sweet corn (49.8 kg/plant) and drumstick (47.0 kg/plant) in general showed significantly higher mango productivity. The increase was to an extent of 19.1% and 12.4 % over without intercropping (40.3 kg/plant), respectively. Similar results of improved yield of mango with intercropping was noticed by Rathore *et al*., (8) in cowpea–toria crop rotation followed by black gram–toria and minimum fruit yield realized with sole mango. Further it was observed that intercropping finger millet was more detrimental to mango (17.7 kg/plant) which may be attributed to the higher uptake of nutrients by the intercrop being closely spaced with four months duration (Fig. 1).

From the results it was observed that the food grains required for maintenance of the dependent family size of five *viz.*, finger millet -the staple food crop of the region (730 kg /year) and the pulse-pigeonpea (146 kg /year) could be produced on the one ha farm of mango garden under rainfed conditions. Further, sufficient returns to meet the cash requirement of the dependent farm family were generated within the system. The total net returns could be increased from ₹ 41,800/ha /year from monocropping of mango to ₹ 1,57,850/ha /year by following integrated farming systems. This works out to an increase of 278 per cent from ₹ 3,480 /month/ha to ₹ 13,155 /month/ha of mango garden. Further, the analysis of the interval of returns indicate that the integrated system approach resulted in periodical returns to the family, with the distribution of income spreading out from a mere three months to all the twelve months in the year with a minimum of ₹ 6,520/month (during the month of January, April, August) to a maximum of ₹ 22,750/month (June) facilitating the re-investment for purchase of inputs, thereby suggesting the sustainable livelihood opportunity for the dependent farm family. The complimentary and synergy through the recycled resources inturn reducing the cost of production/maintenance resulted in this enhanced returns. In a similar study conducted by Ponnusamy *et al*., (6), horticulture + crop + dairy + poultry was not only perceived to be eco-friendly but also ensured high level of food security. Similarly, Patel *et al*., (5) inferred that integrated farming system is good enough to provide daily average income of 617/

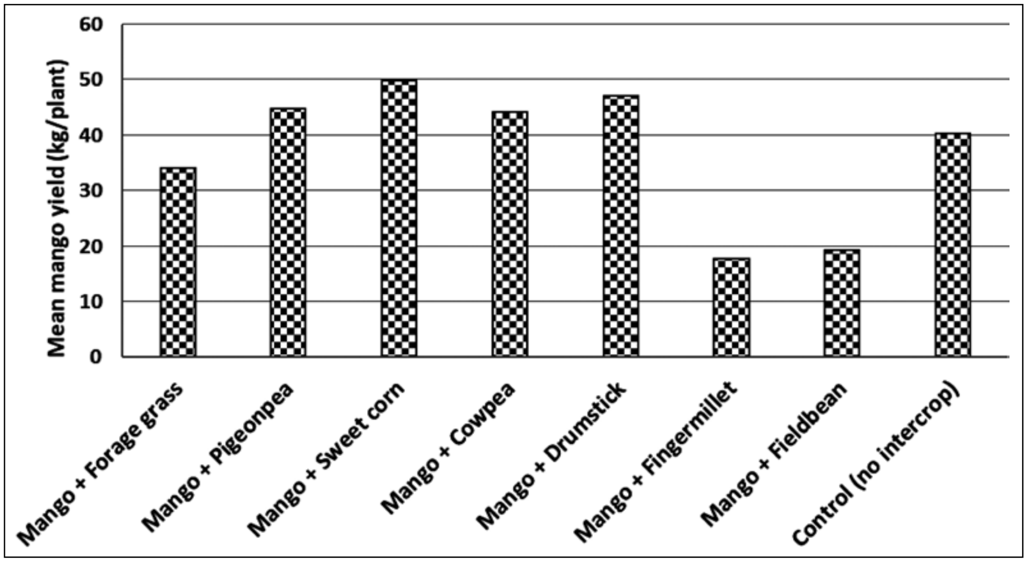

Fig. 1. Impact of intercropping on mean mango yield over four years (pooled means for 2017-2020).

day with engagement of 0.93 unit of labour/day in a ha of land.

Thus, the study clearly brought out the practical feasibility of rain water harvesting and recycling with profitable selection of intercrops and recycling of resources in rainfed mango through integrated farming systems for sustainable livelihood of poor farm families which would be improved better, if appropriately sensitized on systems approach.

ACKNOWLEDGEMENT

Authors gratefully acknowledge the financial assistance supported by ICAR- NICRA Project for the conduct of the experiment. Authors also thank the Director ICAR-Indian Institute of Horticultural Research for providing necessary facilities in the conduct of field experiment.

AUTHORS' CONTRIBUTION

Conceptualization of research (B. L. Manjunath, R. H. Laxman), Designing of the experiments (B. L. Manjunath, R. H. Laxman), Contribution of experimental materials (B. L. Manjunath, R. H. Laxman, M. S. Puneeth Raj and Karnam Veeresha), Execution of field/ lab experiments and data collection (B. L. Manjunath, R. H. Laxman, M. S. Puneeth Raj and Karnam Veeresha). Analysis of data (M. S. Puneeth Raj and Karnam Veeresha). Interpretation of data (B. L. Manjunath). Preparation of the manuscript (B. L. Manjunath, R. H. Laxman).

DECLARATION

The authors declare no conflict of interest.

REFERENCES

1. Anonymous 2019. *Area and Production of Horticulture Crops for 2018-19* (3rd Advance Estimates), National Horticultural Board, India.

2. Descheemaeker, K., Oosting, S.J., Tui, S.H.K., Masikati, P., Falconnier, G.N. and Giller, K.E. 2016. Climate change adaptation and mitigation in smallholder crop–livestock systems in sub-Saharan Africa: a call for integrated impact assessments. *Reg. Environ. Change,* **16**: 2331-43.

3. Hendrickson, J.R., Hanson, J.D., Tanaka, D.L. and Sassenrath. G., 2007. Principles of integrated agricultural systems: introduction to processes and definition. *Renew. Agric. Food Syst.* **23**: 265–71.

4. Kathiresan, R.M. 2009. Integrated farm management for linking environment. *Indian J. Agron.* **54**: 9-14.

5. Patel, A.M., Patel, K.M. and Patel, P.K. 2019. Sustainability of farm and farmers through integrated farming system approach. *Indian J. Agron.* **64**: 320-23.

6. Ponnusamy, K., Shukla, A.K. and Kundan K. 2015. Studies on sustainable livelihood of farmers in horticulture-based farming systems. *Indian J. Hortic*. **72**: 285-88.

7. Rajan, S. 2012. Phenological responses to temperature and rainfall: A case study of mango,

In: Tropical Fruit Tree Species and Climate Change (Ed: Bhuwon Sthapit, Ramanatha Rao, V. and Sajal Sthapit), Biovarsity International, New Delhi, 71-96.

8. Rathore, A.C., Saroj, P.L., Lal, H., Sharma, N.K., Jayaprakash, J., Chaturvedi, O.P., Raizada, A., Tomar, J.M.S. and Dogra, P. 2013. Performance of mango based agri-horticultural models under rainfed situation of Western Himalaya, India. *Agrofor. Syst.* **87**: 1389-404.

9. Reddy, B. N. and Suresh, G. 2009. Crop diversification with oilseed crops for maximizing productivity, profitability and resource conservation. *Indian J. Agron.* **54**: 206-14.

10. Russelle, M.P., Entz, M.H. and Franzluebbers, A.J. 2007. Reconsidering integrated crop-livestock systems in North America. *Agron*. *J*. **99**: 325-34.

11. Sanjeev, K. Bhatt, B.P., Dey, A., Shivani., Ujjwal, K., Idris., Mishra, J.S. and Santosh Kumar. 2018. Integrated farming system in India: Current status, scope and future prospects in changing agricultural scenario. *Indian J*. *Agric*. *Sci*. **88**: 1661-75.

12. Sulc, R.M. and Tracy. B. F. 2009 Integrated crop-livestock systems in the U.S. Cornbelt. *Agron. J.* **99**: 335–45.

13. Swain, S.C., Dora, D.K., Sahoo, S.C., Padhi, S.K. and Sanyal, D. 2012. Influence of mango based intercropping systems on improvement of soil health under rainfed situation. *Commun*. *Soil Sci*. *Plant Anal*. **43**: 2018-26.

Received : January, 2021; Revised : October, 2021;
Accepted : November, 2021