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Evaluation of integrated nutrient management of coconut (*Cocos nucifera*) based cropping system in the central zone of Karnataka

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The area under coconut (*Cocos nucifera* L.) plantation in Karnataka has increased from 3,35,996 ha in 2000–01 to 6,18,360 ha in 2020–21 with productivity of 7,963 nuts/ha (CBD 2021). Coconut, the main crop of Peninsular India, when cultivated as a pure crop, frequently causes challenges for farmers mainly due to crop losses related to insect and disease outbreaks and fluctuations in price. However, it is known that switching to a coconut-based cropping system (CBCS) can increase unit area yield (Maheswarappa and Sumitha 2018). Integrated nutrient management (INM) is currently considered as the most viable approach in augmenting agricultural production with optimum use of farm wastes through on-farm generation of organic manures and recycling, to substitute inorganic fertilizers (Sudha *et al.* 2021). Coconut yield in CBCS with INM (recycling of organic manures) has been reported to increase substantially in different agro-climatic regions, viz. Bihar (Deepak *et al.* 2021), Gujarat (Bhalerao *et al.* 2021), Maharashtra (Shinde *et al.* 2021) and Tamil Nadu (Rani *et al.* 2021). Given the potential socioeconomic, eco-friendly and agronomic benefits of integrated use of chemical, organic and bio-fertilizers, it is important for researchers to continue exploring ways to establish measurable yardsticks for INM strategies for CBCS. With this background, there is a research void regarding the impact of integrated and organic nutrient management systems under CBCS. Therefore, an experiment was conducted to study the impact of INM practices on yield and economics of coconut-based cropping systems in central zone of Karnataka.

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An experiment was conducted at Horticultural Research and Extension Station, Arsikere, Bagalkot, Karnataka ($13^0 15^1$ N, 76.5^0 E and altitude 800 m amsl). The soil of the experimental site was sandy loam with *p*H 7.5, low in available nitrogen and phosphorous (254.1 and 19.6 kg P_2O_5 kg/ha) and medium in available potassium (245.6 kg K_2O/ha). The study was carried in a coconut (*Cocos nucifera* L.) garden with Tiptur Tall variety and palms planted at spacing of 10 m × 10 m during 1964. Coconut based cropping system with cocoa + lime + drumstick was initiated in this coconut field during 2008, later banana was added to the cropping system during 2012 and managed with the INM up to 2019. The details of treatments are coconut based cropping system with three integrated nutrient management (INM) practices, viz. T_1, 75% of recommended dose of fertilizers (RDF) + 25% of N through organic recycling with vermicompost; T_2, 50% of RDF + 50% of N through organic recycling with vermicompost + vermiwash application + biofertilizer application + *in situ* green manuring (cowpea); T_3, fully organic: 100% N through organic recycling with vermicompost + vermiwash application + biofertilizer application + *in situ* green manuring (cowpea) and green leaf manuring + composted coir pith, husk incorporation, and mulching with coconut leaves were imposed in coconut-based cropping system. For comparison, T_4, control: monocrop of coconut with recommended NPK was maintained. Data pertaining to nut production, estimated copra out turn and intercrop yield recorded from 2015–19.

The quantity of different fertilizers and manures applied for intercrops was as per the package of practice of University of Horticultural Sciences (UHS), Bagalkot. Vermicompost was generated using recyclable biomass from the coconut system in specially made pits. In order to treat different crops, the vermiwash was applied after being diluted to a 1:10 proportion. In addition to this, *Gliricidia* leaves (grown in border) and cowpea (basin) were used as green manure crop and were applied for coconut and intercrops in the month of June and September. During the summer (February-May), dried coconut leaves were used as mulch to reduce evaporation of moisture from the soil.

From July to June, the nuts were periodically picked when they reached maturity and pooled to get nut yield/ palm/year. Copra output per palm was quantified based on the copra content in the nut. The harvest period varied as a result of the intercrops' different growth habits. The indicated input costs include labour (both actual and imputed), fertilizer, irrigation, crop protection measures and other adhoc overhead costs. The market rates of various inputs and outputs (coconut and other crop produces) during different years were considered to work out the economics. The Coconut equivalent yield (CEY) of intercropping systems and economics were calculated based on the prevalent market price for input and output:

$$\text{Coconut equivalent yield (CEY)} = \frac{\text{Yield of intercrop (kg/ha)} \times \text{Market price (₹/kg)}}{\text{Prevailing market price of a nut (₹)}}$$

The statistical design was non-replicated, however the experimental block for each treatment was set up in a 0.10 ha coconut garden with intercropping cocoa, banana, lime, and drumstick. The productivity of the system is affected by weather conditions throughout the year. The study therefore employed the treatment effect as the error and the year effect as the fixed effect in the ANOVA table. Statistical Analysis System 9.3 was used to carry out the statistical analysis (SAS Institute Inc., 1995). The significance between treatments was calculated using the DMRT approach at the P=0.05 level.

The mean data over 4 years (2015–16 to 2018–19) revealed that under a coconut-based cropping system with INM practises, annual leaf production, number of leaves on the crown, and number of bunches of coconut were not significantly different. In the current study, the nut yield over 4 years indicated that the nut yield (117.0) was numerically higher with the T_2 treatment, although statistically on par with other treatments (Table 1). As a result, the nut yield exhibited that all treatments had a slight increase in production over time when compared to the pre-experimental yield. With regard to copra output and oil content, significant improvements have been noted with various INM module, T_2 recorded the highest copra and oil content (15.5 kg/palm and 10.14 kg/palm) followed by T_3 (15.04 and 9.62 kg/palm) when compared to coconut monocrop. Shinde *et al.* (2020) and Bhalerao *et al.* (2021) reported that use of 50% RDF + 50% organic fertilizers has increased the coconut nut yield. The yield from intercrops in terms of no of lime fruit/ tree (kg/ha), drumstick (no of pods harvested kg/ha), cocoa dry bean yield (kg/ha) and banana bunch weight (kg/ha) documented over a 4-year period (Table 1). Even though it was not statistically significant, T_3 was recorded the highest yield (kg/ha) of intercrop like drumstick pods (1146.1 kg), lime fruits (1205.5 kg) banana (9701.6 kg) and cocoa dry bean (284.4 kg) followed by treatment T_2. Although the banana and cocoa yields were below expectations, these intercrops helped with biomass recycling. The improved system output in coconut-based cropping system using INM modules was attributed to better plant development, which was reflected in the intercrops yield (Naveen Kumar *et al.* 2016).

Coconut Equivalent Yield (CEY) for an intercrop was significantly higher under T_3 (24760.1 nuts/ha/year) followed by T_2 (23960.2 nuts/ha/year) in coconut based intercropping system (Table 2). The coconut monocrop had significantly the lowest CEY (9568.1 nuts/ha/year). Higher CEY in above mentioned systems can be attributed to a rather better performance of intercrops and also superior market values for their products (Table 2). Naveen Kumar *et al.* (2016) and Basavaraju *et al.* (2018) both observed a similar rise in CEY in the coconut-based cropping system in Karnataka. The yield of intercrops in terms of coconut equivalent was not significantly impacted by INM.

Profitability in the system was explained by economic analysis in terms of gross return, net return and BCR. A review of data (Table 2) revealed that out of the 4 treatments, the treatment T_3 and T_2 recorded the highest value of

Table 1 Yield parameters of coconut and intercrops under coconut-based integrated nutrient management system (2015–16 to 2018–19)

Treatment	Nut yield (No./palm/year)			Copra (kg/palm)	Oil content (kg/palm)	Drumstick (kg/ha)	Lime (Fruit kg/ ha)	Banana (kg/ha)	Cocoa dry bean yield (kg/ha)
	Pre-treatment (2008–12)	Transit period yield (2012–15)	Post-treatment yield (2015–19)						
T_1	92.2	93.4	109.0	14.28	9.40	1058.9	1043.8	9246.0	237.2
T_2	96.5	101.3	117.0	15.55	10.14	1127.4	1124.8	9447.6	261.4
T_3	95.1	97.7	102.0	15.05	9.61	1146.1	1205.5	9701.6	284.6
T_4	93.4	94.6	101.2	14.16	9.15	--	--	--	--
Mean	94.2	96.7	107.3	14.76	9.57	1110.8	1124.7	9465.1	261.1
S.Em±	0.59	3.08	2.17	0.13	0.08	206.4	53.4	1765.0	25.7
CD (P=0.05)	NS	NS	5.46	0.37	0.24	NS	NS	NS	NS

Refer to methodology for treatment details.

Table 2 Coconut equivalent yield and economics of coconut-based cropping system (2015–16 to 2018–19)

Treatment	Coconut equivalent yield in CBCS (No. of nuts/ha/year)	Economics of CBCS			
		Gross returns (₹/ha)	Cost of production (₹/ha)	Net returns (₹/ha)	B:C Ratio
T_1	22214.5	199041	80900	118141	2.40
T_2	23960.2	246497	89121	157376	2.73
T_3	24760.8	247627	88652	158975	2.79
T_4	9568.1	116270	48500	67770	2.30

Selling price: 2015–16
Coconut: ₹12/-nut; Cocoa: ₹130/kg;
Lime fruits: ₹30/kg; Drumstick: ₹20/kg; Banana: ₹15/kg

Selling price: 2016–17
Coconut: ₹13/nut; Cocoa: ₹140/kg;
Lime fruits: ₹30/kg; Drumstick: ₹20/kg

Selling price: 2017–18 & 2018–19
Coconut: ₹13/nut; Cocoa: ₹140/kg;
Lime fruits: ₹30/kg; Drumstick: ₹22/kg

Refer to methodology for treatment details.

2.4 lakh/ha (gross return), 1.5 lakh/ha (net returns) and 2.79 benefit cost (B:C) ratio respectively, followed by T_1. Whereas, the lowest net return of ₹67,770/ha with a BCR of 2.30 was obtained under coconut monocrop. These findings demonstrated that crop diversity could enable farmers to generate higher profits even if the price of one product drops in any given year. Integrated nutrient management by using 2/3 recommended fertilizer dose beside vermicomposting gave the best benefit of CBSC in different ago climatic regions, viz. Maharashtra (Shinde *et al.* 2020), Gujarat (Bhalerao *et al.* 2021) and Tamil Nadu (Rani *et al.* 2021).

SUMMARY

The present study has indicated non significant difference among integrated and organic nutrient treatments under coconut-based cropping system (CBCS) and there is a trend towards a positive impact of organic treatment on maintaining the productivity in the system. The experimental results proved the fact that treatment with a 50% RDF + 50% N through organic recycling-vermicompost (12.5 kg/tree) + vermiwash (5.0 litre/tree) + *Azospirillum* (100 g/tree) and *in situ* green manuring (cowpea) (15 kg/tree) gives maximum benefit (T_2). The findings of the field trials over a period of 6 years offered useful information for an agronomic assessment of various INM modules in coconut based cropping system for central zone of Karnataka. In summary, integrating organic compost into INM module can not only help to replace chemical fertilizers in whole or in part, on the other hand also encourage farmers to recycle various farming wastes into a more viable, cost-effective, environmentally friendly and substitute product through composting.

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