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Impact of Integrated Nutrient Management on Quality of Guava (*Psidium guajava* L.*)* Grown as a Component Crop in Coconut Based Cropping System

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted under coastal Odisha conditions. The experiment was laid out in a Randomized Block Design with 9 treatments replicated thrice. The treatments consisting of T_1: 75% RDF + 25% N through Vermicompost; T_2: 75% RDF + 25% N through Vermicompost + FYM; T_3:75% RDF + 25% N through Vermicompost + FYM +Bio fertilizers; T_4:50% RDF + 50% N through Vermicompost; T_5:50% RDF + 50% N through Vermicompost + FYM; T_6: 50% RDF + 50% N through Vermicompost + FYM +Bio fertilizers; T_7: 100% N through Vermicompost.; T_8: 100% N through Vermicompost + FYM; T_9:100% N through Vermicompost + FYM +Bio fertilizers. The result

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of the study revealed that maximum total soluble solids (11.42^{0}Brix and 10.93 ^{0}Brix), Vitamin-C (199.60 mg/100g and 189.08 mg/100g), total phenol contents (113.05 mg GAE/100g fresh weight and 88.21 mg GAE/100g fresh weight), total flavonoid contents (38.64 mg QE/100g fresh weight and 34.14 mg QE/100g fresh weight), FRAP value (21.61 mM Fe(II)/100g fresh weight and 18.39 mM Fe(II)/100g fresh weight), scavenging activity (62.03 % and 58.65 %) were observed with the plants treated with 50% RDF +50% N through Vermicompost + FYM +Bio fertilizer in both *mrig* and *hasth bahar*. The incorporation of nutrients through organic and inorganic resources leads to enhanced quality attributes of guava in Coconut Cropping System.

Keywords: Coconut based cropping system; nutrient management; quality; guava; coconut.

1. INTRODUCTION

Coconut (*Cocos nucifera* L.) is the only known main species of the genus Cocos and belongs to the Arecaceae family. It is one of the most attractive and profitable palms in the world. Coconut is mostly grown as a single crop. However, this does not make efficient use of natural resources. It also gives low income to the farmers even with an optimal planting density, because a large area under the plant canopy is unexploited. Therefore, intercropping systems based on coconut could be adopted for better use of natural resources and more income on a long-term basis. During the initial years of coconut cultivation, the interception of sunlight is high but it is not fully used by the plantation. But when intercrops are grown, sunlight and other resources are used more efficiently. The cropping system based on coconut can be diversified by intercropping with cash crops, such as cocoa, coffee, banana, pineapple, guava, etc. and shifting to multi-layered cropping systems, which can generate much higher returns [1]. In this system, solar radiation interception and other micro-climatic factors such as canopy temperature and relative humidity affect the growth, yield and fruit quality of intercrops directly or indirectly.

Many crops such as vegetables, fruits, flowers, medicinal and aromatic plants, etc., have been found suitable to grow as intercrop in the empty spaces of a coconut garden under irrigated or rain-fed conditions in different parts of the country. Among fruit crops, guava is considered a good crop to be included as one of the components of the cropping system based on coconut because of its canopy shape, pruning effect, and root pattern.

Guava is said to be the fourth most important fruit crop after mango, banana, and citrus, and is a rich source of dietary fibre (5.4g/100g) and Vitamin C (260 mg/100g), with moderate levels of folic acid (49µg/ 100g). It is one of the most suitable intercrops in coconut plantations because of its short stature, wide adaptability, and early bearing habit. Generally, the guava tree produces 90% crop in the rainy season, 8-9% in the winter season, and 1-2 % in the Spring season [2]. A small separate crop is produced from November to mid-February (winter season) and is more valuable [3]. Though the production is high in the rainy season [4], it offers poor quality due to blandness [5] and pest infestation [6] compared to the winter season. On the other hand, the winter season gives quality fruit and fetches high monetary returns [4].

Proper nutrition is essential for the production, productivity, and quality of fruits when grown as a sole crop or intercrop. Therefore, it is important to provide an adequate amount of nutrition to the plant for proper growth and development. The combined use of fertilizers, bio-fertilizers, and organic manures, including vermicompost and crop residues, improves soil fertility and crop yield [7]. Combining organic substances with mineral nutrients can have a significant effect on the chemical, microbiological, and physical properties of soil, which in turn supports plant growth [8].

2. MATERIALS AND METHODS

The investigation was conducted in AICRP on Palms, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha. The soil of the experimental site is taxonomically described as loamy sand. The entire plot is divided into 3 blocks, based on nutrients provided. Loamy sand soil, with a pH of 5.51, 0.24 dSm-1 (EC) and 0.39% organic carbon content was found in the experimental plot. It had 165$^{kg/ha}$ of available nitrogen content, 36.09$^{kg/ha}$ of Available phosphorus and 246.16 $^{kg/ha}$ of Available Potassium found in the experimental plot before conducting the trial. The mean maximum and minimum temperature during the entire cropping season were found to be 32.65ºC and 22.22ºC, respectively with an annual rainfall of 199.21mm. The experiment was carried out in a 16-year-old coconut garden with Guava (cv. Arka Amulya), banana (cv. Poovan) & pineapple (cv. Queen) as component crops. The coconut crop (cv. Sakhigopal Local) was grown at a spacing of 7.5m x 7.5m. The study was mostly undertaken in guava grown as a component crop in the coconut plantation.

The details of the treatments are as follows:

- 75% RDF + 25% N through Vermicompost (T1)
- 75% RDF + 25% N through Vermicompost + FYM (1:1) (T2)
- 75% RDF +25% N through Vermicompost + FYM +Bio fertilizer (1:1:1) (T3)
- 50% RDF +50% N through Vermicompost (T4)
- 50% RDF +50% N through Vermicompost + FYM (1:1) (T5)
- 50% RDF +50% N through Vermicompost + FYM +Bio fertilizer (1:1:1) (T6)
- 100% N through Vermicompost (T7)
- 100% N through Vermicompost + FYM (1:1) (T8)
- 100% N through Vermicompost + FYM +Bio fertilizer (1:1:1) (T9)

The experiment was planned in Randomized Block Design, with 9 treatments replicated thrice. The statistical analysis was carried out as per the standard protocol suggested by [9].

The quality parameters analysed included Total Soluble Solids (estimated by hand-held digital refractometer), titratable acidity (estimated by titration of alliquot with 0.1N NaOH [10]. Ascorbic acid (estimated by using 2, 6 dichlorophenol - indophenol visual titration method [11]), Total sugar, reducing and non-reducing sugar (estimated by Shaffer Shomogi method [10]), and anti-oxidative properties. The anti-oxidative parameters included estimation of total phenolic content (estimated with Folin-Ciocalteu (FC) reagent), total flavonoid content (estimated by aluminium chloride colourimetric method [12]), and antioxidant capacity in terms of ferric reducing antioxidant power i.e. FRAP [13] and scavenging activity i.e. SCA (determined based on 2,2-diphenyl- 1-picrylhydrazyl (DPPH) free radical assay [14]).

3. RESULTS AND DISCUSSION

The combined application of 50% recommended dose of fertilizers + 50% N through organic manures and bio-fertilizers resulted in an improvement of the biochemical parameters of guava both in *mrig* and *hasth* bahar. However, no significant effect of this combination was observed with non-reducing sugar parameters.

The highest values of TSS (11.42 ^{0}Brix and 10.93 ^{0}Brix), total sugar (9.73 % and 9.57 %) , reducing sugar (5.98 % and 6.05 %), Vitamin-C content (199.60 mg/100g and 189.08 mg/100g), total phenol contents (113.05 mg GAE/100g fresh weight and 88.21 mg GAE/100g fresh weight), total flavonoid content (38.64 mg QE/100g fresh weight and 34.14 mg QE/100g fresh weight), FRAP value (21.61 mM Fe(II)/100g fresh weight and 18.39 mM Fe(II)/100g fresh weight) and the SCA (62.03 % and 58.65 %) were observed in the T6 (50% RDF + 50% N through Vermicompost + FYM+ Biofertilizers) in both mrig and hasth bahar.

On the other hand, the lowest FRAP value in fruit was observed in T1 (75% RDF + 20% N through Vermicompost) and at the same time the minimum Vitamin C and total flavonoid content were estimated in T3 (75% RDF + 25% N through Vermicompost + FYM+ Bio fertilizers) in both mrig and hasth bahar respectively.

The above positive results might be due to the integrated application of organic manures and chemical fertilizers with bio-fertilizers, which not only improved the yield but also enhanced the fruit quality. Guava responds well to manures and fertilizers application, but when biofertilizers are included, it enhances the growth of the plant, fruit yield per tree and chemical composition of the fruit through rapid mineralization and transformation of plant nutrients in the soil. The improvement in several chemical characteristics owing to NPK application might be due to phosphorus, which is the main composition of phospholipids as well as nucleic acids. Nucleic acid upon combining with proteins results in the formation of nucleoproteins, which are the key constituent of the nuclei of the cells. Another important mineral, Potassium acts as a catalyst towards the formation of substances that are more complex and in the acceleration of enzyme activity. These carbohydrates and coenzymes are necessary for the proper development of the quality of fruit. Finally, Nitrogen, enhances the uptake of phosphorus and potassium. The chain reactions involving these components possibly would be the main reason for the improvement in the quality of the fruit. The above findings were in line with Shankar [15], Kundu [16], Kumar [17] and Kumar [18].

Table 1. Effect of INM on bio-chemical quality attributes of by guava when grown as a component crop in coconut based cropping system

Treatment	TSS (ºBrix)		Acidity (%)		Sugar content (%)					
	MBC	HBC	MBC	HBC	MBC			HBC		
					TS	RS	NRS	TS	RS	NRS
T_1	10.09	9.77	0.80	0.90	8.26	4.74	3.29	8.42	4.92	3.33
T_2	9.83	9.63	0.73	0.83	8.36	4.82	3.36	8.43	4.98	3.26
T_3	10.20	9.66	0.74	0.84	8.56	5.11	3.27	8.57	5.23	3.17
T_4	11.09	10.31	0.70	0.80	8.84	4.83	3.81	8.66	5.58	2.92
T_5	11.15	10.27	0.68	0.78	8.88	5.46	3.25	8.84	5.67	3.01
T_6	11.42	10.93	0.66	0.76	9.73	5.98	3.56	9.57	6.05	3.34
T_7	11.22	10.73	0.63	0.73	9.37	5.94	3.25	9.40	6.02	3.21
T_8	11.26	10.84	0.67	0.74	9.42	4.79	4.44	9.36	5.67	3.50
T_9	11.34	10.91	0.63	0.73	9.67	4.98	4.45	9.53	5.74	3.60
SE(m)±	0.19	0.17	0.02	0.03	0.26	0.19	0.32	0.27	0.18	0.17
CD (P=0.05)	0.64	0.58	0.12	0.14	0.86	0.64	NS	0.87	0.61	NS

MBC= Mrig bahar crop, HBC= Hasth bahar crop, TS= Total Sugar, RS= Reducing Sugar, NRS= Non-reducing sugar, NS= Non-significant

Table 2. Effect of INM on antioxidant quality attributes of *mrig bahar* and *hasth bahar* crops

Treatment	Bioactive constituents					
	Vitamin C (mg/100g)		TPC (mg GAE/100g FW)		TFC (mg QE/100g FW)	
	MBC	HBC	MBC	MBC	HBC	MBC
T_1	189.32	175.66	105.64	82.11	30.78	26.74
T_2	185.51	175.18	104.59	80.23	30.42	26.41
T_3	184.86	174.86	104.76	82.41	30.38	26.38
T_4	186.20	176.22	105.47	83.84	34.02	27.43
T_5	187.55	177.47	106.35	84.32	36.35	27.02
T_6	199.60	189.08	113.05	88.21	38.64	34.14
T_7	197.59	187.58	110.56	84.99	36.71	27.28
T_8	187.45	177.45	104.73	82.48	35.22	30.77
T_9	198.25	188.25	110.65	87.92	37.27	30.56
SE(m)±	2.80	2.46	1.97	1.64	1.83	1.45
CD (P= 0.05)	8.52	7.46	6.01	5.01	5.56	4.43

TPC= Total phenolic content, TFC= Total flavonoid content, GAE: Gallic acid equivalent, QE: Quercetin equivalent, FW: Fresh weight, MBC= Mrig bahar crop, HBC= Hasth bahar crop

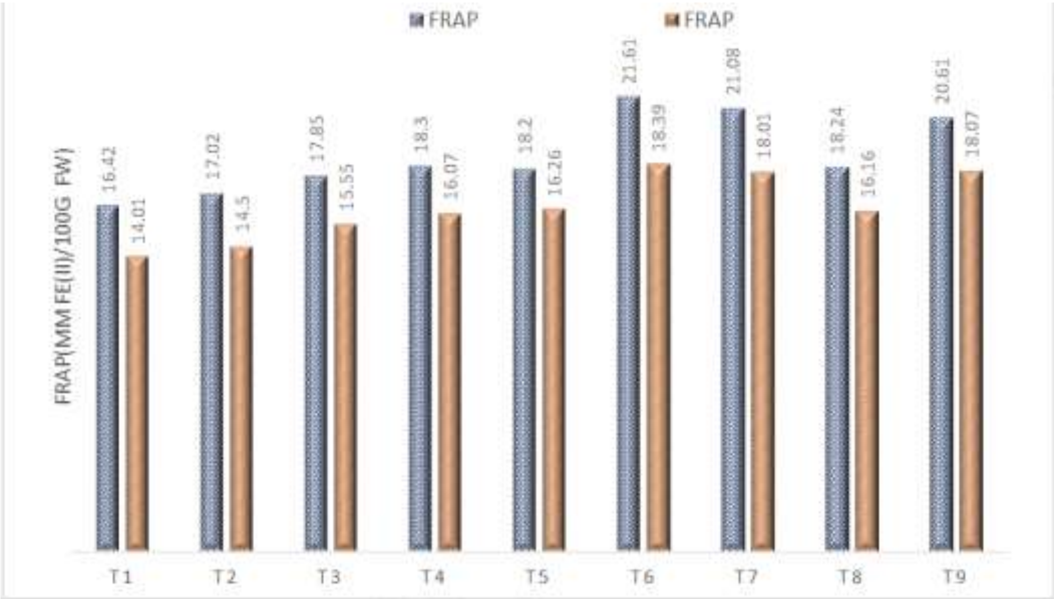

Fig. 1. Effect of INM on antioxidant capacity of guava- FRAP (mM Fe(II)/100g FW) in both *mrig and hasth bahar*

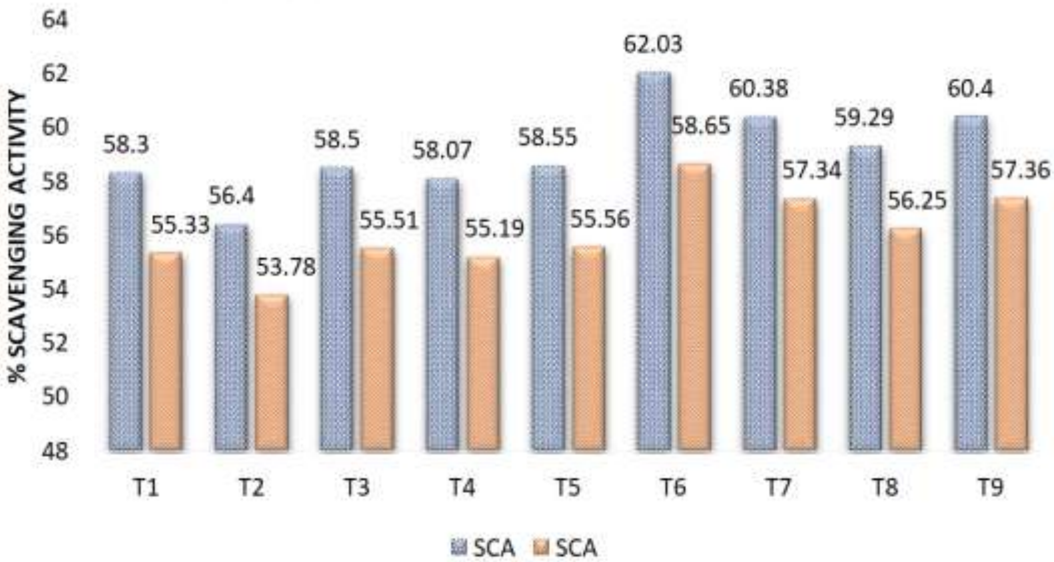

Fig. 2. Effect of INM on antioxidant capacity of guava- % Scavenging activity in both *mrig and hasth bahar*

The application of FYM in the soil is beneficial for the growth of soil microorganisms, which also excretes several important plant-promoting substances, essential vitamins and amino acid content. The increase in fruit quality due to vermicompost application might be due to the beneficial effect of worms, which is majorly due to the mucus deposit of epidermal cells and the coelomic fluids of earthworms. These fluids are rich in plant growth-promoting substances. Also, microorganisms of biofertilizers might have resulted in the improvement in fruit quality due to rapid mineralization and transformation of plant nutrients in soil [19].

The application of a 50 percent dose of recommended NPK+50 kg FYM+250 g Azotobacter significantly increased the TSS (14^0Brix), ascorbic acid (198.30 mg/100 g pulp), reducing sugar (4.77 %) and total sugars (8.10 %) in high-density plantation of Sardar guava [20].

4. CONCLUSION

Among different integrated nutrient management treatments tried, application of 50 % RDF + 50 % N through Vermicompost +FYM + Biofertilizer (T6) resulted in significantly higher total soluble solids, total sugar, reducing sugar, Vitamin-C, total phenol content, total flavonoid content, FRAP value and scavenging activity. The investigation concluded that among all the treatments, the aforementioned treatment was found to be the best one, and superior to the application of 75 % RDF +25%N through organic sources and over complete organic nutrient source application.

Hence, based on the above findings, the very treatment combination T6 (50 % RDF + 50 % N through Vermicompost + FYM + Biofertilizer) was adjudged as the best treatment for improved fruit quality in *mrig* (winter season), and *hasth* (summer season) under coconut based cropping system. Besides application of 50% RDF + 50% N through either Vermicompost alone or Vermicompost and FYM combination can also be judged as the next best treatment for the quality of guava when grown as a component crop in coconut-based cropping system.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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