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Biochemical Properties of Banana and Pineapple Intercropped in Organically Managed Young Arecanut Based Cropping System

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Abstract

The present investigation was carried out at the instructional and research field of the Department of Plantation Crops and Processing, Faculty of Horticulture, Uttar Banga Krishi Viswavidyalaya, Pundibari during the Month of March 2019–20 to 2020–21, to study the influence of organic treatments on biochemical properties of banana (*Musa* sp., cv. Grand Naine) and pineapple (*Ananas comosus* cv. Kew) grown in an organic arecanut-based cropping system. The experiment was carried out in a Randomized Block Design with four replications for estimating the biochemical properties of banana and pineapple viz. total soluble solids (°Brix), total sugar (%), reducing sugar (%), titrable acidity (%) and ascorbic acid (mg 100 g^{-1}) against six differently formulated organic treatments. Results revealed that among five different treatments, N_5 (vermicompost @ 2.0 kg $plant^{-1}$ $year^{-1}$ in banana and 18 kg $plot^{-1}$ of 9.0 m^2 in pineapple along with biofertilizers i.e. *Azotobacter* +*Azos perillium*+PSB+VAM+*Trichoderma*) exhibited the highest value for TSS (23.07°Brix and 17.96°Brix in banana and pineapple), total sugar content (18.28% and 12.36% in banana and pineapple), reducing sugar content (9.28% and 2.99% in banana and pineapple) and ascorbic acid content (10.69 mg 100 g^{-1} and 34.69 mg 100 g^{-1} in banana and pineapple), respectively. These highlights the benefits of organic based cropping system with regard to biochemical properties of banana and pineapple intercropped under young arecanut plantations.

Keywords: Arecanut, banana, pineapple, organic cropping, biofertilizers, vermicompost

1. Introduction

Arecanut is a widely cultivated high value commercial plantation crop believed to have originated in the tropical region of Southeast Asia (Heatubun et al., 2012, Hiremata et al., 2022). In India, about 16 million people are directly and indirectly dependent on arecanut industry for their livelihood (Kumar et al., 2023). The nut of arecanut is a significant source of income for small and marginal farmer, wrapped and chewed with betel leaves and slaked lime (Toprani and Patel, 2013, Bhat et al.2024).

The practice of intercropping which includes growing two or more crops together offers several advantages, which includes proper utilization of resources, supplying nutrients for nearby plants, enhanced disease and pest control, reduced weed populations and increased overall yield and resilience. The potential for intercropping in plantation crops has also been widely documented by Sujatha et al. (2011) in inter cropping of medicinal and aromatic plants in Arecanut; Sujatha and Bhat (2015) in arecanut.

Banana, botanically known as *Musa paradisiaca* belongs to family Musaceae (Archith et al., 2021, Paul et al., 2023) is considered as the best suited fruit crops under the arecanut shade. Banana forms a major mid-storey intercrop in perennial based cropping systems (Arunachalam et al., 2023). The fruit is very popular due to its high nutritive value and are rich source of nutrients, vitamin such as vitamin A and C, starch, sugar and calcium, potassium, sodium and magnesium (Subba et al., 2024).

Pineapple (*Ananas comosus* L.), is a tropical fruit crops which belongs to the family bromeliaceae (Maneesha et al. 2022; Parameshwar et al., 2024) is considered as one of the important shade tolerant fruit crop which performs well under the arecanut shade.Pineapple is grown mainly as an intercrop in rubber and coconut (Girija and Menon, 2019). It is one of

the top ranking fruit crop and can be grown for the socio economic upliftment of farmers (Das et al., 2017).

Paull et al. (2020) also stated that the biochemical composition is an essential determinant of fruit quality, affecting consumer preference and marketability. Total soluble solids (°Brix), total sugar content (%), titrable acidity (%) and ascorbic acid (mg 100 g^{-1}) are critical parameters that influence the ripeness, flavour and nutritional value of fruits like banana and pineapple. Total soluble solid and sugar levels contribute to sweetness whereas ascorbic acid content plays a vital role in the fruit's nutritional quality and antioxidant properties, with all these factors being influenced by cultivation practices, nutrient management and storage conditions (Sahu et al., 2023 and Fernandez et al., 2019).

Organic practices is a useful tool to minimize soil contamination while improving environmental issue, increase fruit yield and quality due to the fact that the applied doses of organic manures and biofertilizers increases microbial activity in the soil (Esitken et al., 2010; Roy and Hore, 2011 and Pratap et al., 2024). Given the growing demand for organically produced fruits, understanding how organic amendments such as vermicompost and biofertilizers influence biochemical parameters can provide valuable perceptions for farmers and policymakers.

Based on all above mentioned facts with respect to efficient utilization of land, and biochemical importance of the intercropped crops under organic production system, a field experiment was carried out to assess the biochemical parameters of banana and pineapple under organically managed arecanut based intercropping system with an objective to address the gaps by providing empirical data on how intercropping banana and pineapple with arecanut under organic management influences biochemical parameters, which are crucial indicators of fruit quality and consumer acceptance.

2. Materials and Methods

The present investigation was conducted during the Month of March 2019–20 to 2020–21 at the instructional and research field of the Department of Plantation Crops and Processing, Faculty of Horticulture, UBKV, Pundibari, Cooch Behar, West Bengal, India. The area lies under the *Terai* Agro-Climatic Zone of West Bengal geographically located at 26°19'86" North latitude and 89°23'53" East longitude at an elevation of 43 m above MSL. An arecanut based cropping system was established with bananacv. Grand Naine and pineapple cv. Kew and were incorporated as intercrops to maximize land use efficiency and promote a sustainable agro ecosystem. Under the present experiment, three year old arecanut plant was used as a mono crop for the establishment of the cropping system with banana and pineapple. Organic farming practices were strictly followed to assess the influence of different organic treatments on fruit quality in which the treatment details were as follows: N_1 (farm yard manure @ 8.0 kg $plant^{-1}$ $year^{-1}$ in two equal splits-at the time of planting and150 days after planting for banana and for pineapple @ 13.5 kg $plot^{-1}$ of 9.0 m^2 in two equal splits - at the time of planting and 150 days after planting), N_2 (vermicompost @ 2.0 kg $plant^{-1}$ $year^{-1}$ in two equal splits- at the time of planting and 150 days after planting for banana and forpineapple @ 18 kg $plot^{-1}$ of 9.0 m^2 in two equalsplits-at the time of planting and 150 days after planting), N_3 (farm yard manure @ 6.0 kg $plant^{-1}$ $year^{-1}$ in two equal splits – at the time of planting and 150 days after planting for banana and forpineapple @ 13.5 kg $plot^{-1}$ of 9.0 m^2 in two equalsplits-atthe time of planting and 150 days after planting)+biofertilizers-*Azotobacter*+*Azosperillium*+PSB+VAM), N_4 (farm yard manure @ 4.0 kg $plant^{-1}$ $year^{-1}$ in two splits – at the time of planting and 150 days afterplantingfor banana and for pineapple @ 13.5 kg $plot^{-1}$ of 9.0 m^2 in two equal splits-at the time of planting and 150 days after planting+biofertilizer -*Azotobacter*+*Azosperillium*+PSB+VAM+*Trichoderma*), N_5 (vermicompost @ 2.0 kg $plant^{-1}$ $year^{-1}$ in two splits - at the time of planting and before shooting of flower for banana and for pineapple @ 18 kg $plot^{-1}$ of 9.0 m^2 in two equal splits - at the time of planting and 150 days after planting+Biofertilizer-*Azotobacter*+*Azosprillium* +PSB+VAM+*Trichoderma*). Biofertilizers used in the present experiment were acquired from the Department of Plant Pathology, Faculty of Agriculture, UBKV and were applied only at the time of planting @ 5 g $plant^{-1}$ for banana and @ 2.0 g $plant^{-1}$ for pineapple.

The experiment was carried out in a Randomized Block Design with four replications to assess the impact of organic treatments on the biochemical composition like total soluble solids (°Brix), total sugar (%), reducing sugar (%), titrable acidity (%) and ascorbic acid content (mg 100 g^{-1}) of banana and pineapple. Biochemical analyses were conducted during the month of March, 2019–20 and 2020–21 cropping season. Bunches of banana were harvested by cutting the bunch from the plant when fingers in the upper most hand turned light green and pineapples were harvested by cutting the fruits from the plants with the help of shears when the eyes became shallower and half of the fruit turned yellow and brought to the laboratory for analysis Five randomly selected fully ripen fruits of pineapple and five ripen fingers of banana were chosen from the third hand from top of the bunch and their biochemical properties were evaluated following standard methods suggested by (Ranganna, 1977).

The experimental data was analyzed using Agri Analyze software developed by ML Monkey Analytics LLP (founded by trio Radhika, Geetaben and Bhumikaben at Navsari, Gujarat).

3. Results and Discussion

3.1. Qualities parameters of banana

The results presented in Table 1 clearly illustrate the significant impact of organic amendments on the biochemical characteristics of banana in an organically managed arecanut-

Table 1: Effect of different treatments on biochemical characteristics of banana

Treatments	TSS (°Brix)			Total sugar (%)			Reducing sugar (%)		
	2020–21	2021–22	Pooled	2020–21	2021–22	Pooled	2020–21	2021–22	Pooled
N_1	19.82[d]	19.94[d]	19.88[d]	15.88[d]	15.97[d]	15.93[d]	7.54[d]	7.59d	7.57[d]
N_2	19.86[e]	19.12[e]	19.49[e]	15.33[e]	15.45[e]	15.39[e]	6.87[e]	6.90e	6.89[e]
N_3	21.77[b]	21.95[b]	21.86[b]	17.44[b]	17.58[b]	17.51[b]	8.72[b]	8.80b	8.76[b]
N_4	20.84[c]	20.88[c]	20.86[c]	16.76[c]	16.89[c]	16.82[c]	8.12[c]	8.16c	8.14[c]
N_5	22.97[a]	23.10[a]	23.07[a]	18.23[a]	18.34[a]	18.28[a]	9.25[a]	9.31a	9.28[a]
SEm±	0.245	0.110	0.077	0.022	0.046	0.025	0.016	0.017	0.012
CD (*p*=0.05)	0.756	0.341	0.226	0.067	0.141	0.074	0.051	0.051	0.034

Table 1: Continue...

Treatments	Titrable acidity (%)			Ascorbic acid (mg 100 g^{-1})		
	2020–21	2021–22	Pooled	2020–21	2021–22	Pooled
N_1	0.39[b]	0.41[a]	0.40[b]	12.49[b]	12.60[b]	12.54[b]
N_2	0.43[a]	0.45[a]	0.44[a]	13.05[a]	13.21[a]	13.13[a]
N_3	0.33[c]	0.35[b]	0.34[c]	11.30[d]	11.36[d]	11.33[d]
N_4	0.35[c]	0.36[b]	0.35[c]	11.85[c]	11.90[c]	11.88[c]
N_5	0.28[d]	0.29[c]	0.29[d]	10.64[e]	10.75[e]	10.69[e]
SEm±	0.010	0.016	0.009	0.026	0.030	0.019
CD (*p*=0.05)	0.032	0.048	0.027	0.079	0.093	0.058

based cropping system. For banana, the total soluble solids (°Brix) content was recorded highest (23.07°Brix) in the N_5 (vermicompost+biofertilizers which includes *Azotobacter* +*Azosprillium*+PSB+VAM+*Trichoderma*), followed by N_3 (farmyard manure+biofertilizer-*Azotobacter*+*Azospirillum*+PSB+VAM) *i.e*., 21.86°Brix. The enhancement in fruit quality (TSS) is likely due to the combined effects of organic manures, which may have provided essential micronutrients along with the beneficial effects of biofertilizers. Similar results were also noted by Mahato et al. (2014) and Hussain et al. (2015) in banana cv. Grand Naine and Imran et al. (2023) in banana cv. Amritsagar.

Similarly, N_5 also recorded highest values for total sugar and reducing sugar content, where application of vermicompost +biofertilizers which includes *Azotobacter*+*Azosperillium*+ PSB+VAM+*Trichoderma* exhibited the highest value (18.28% and 9.28%) followed by N_3 (farmyard manure + biofertilizer-*Azotobacter*+*Azospirillum*+PSB+VAM) (17.51% and 8.76%). The improvement in fruit quality could be due to improved nutrient availability and soil health achieved through the combined application of organic manures and biofertilizers (Kumar and Pandey, 2008; Mayadevi, 2016 and Rahman et al., 2021). However, N_2 (application of vermicompost) recorded the lowest value for biochemical properties i.e. total soluble solids (19.49°Brix), total sugar (15.39%) and reducing sugar (6.89%). The results are comparable with the findings of Hema et al. (2016) and Dagnew et al. (2021) in banana cv. Grand Naine, and Subba et al. (2023) in banana *cv.* Martaman and Meghwal et al. (2021) in banana cv. Nendran. The highest ascorbic acid (13.13 mg 100 g^{-1}) and titrable acidity content (0.44%) was recorded in N_2 (application of vermicompost) followed by N_1 (12.54 mg 100 g^{-1} and 0.40 %). Application of organic manure such as vermicompost usage in fruit crops improved fruit quality (Singh et al., 2010). This is likely due to enhanced nutrient availability and microbial activity (Rahman et al., 2021). The results are comparable to the findings of Chamling and Bhowmick (2021). In contrast, the lowest value for ascorbic acid and titrable acidity were recorded in N_5 (vermicompost+biofertilizers -*Azotobacter*+*Azosperillium*+PSB+VAM+*Trichoderma*) (10.69 mg 100 g^{-1} and 0.29%). This may be possibly due to altered nutrient dynamics and microbial balance from the combination of vermicompost with biofertilizers. Similar results were obtained by Kowsalya and Rajkumar (2019), Thatayaone et al. (2020), Subba et al. (2024) and Sujatha et al. (2024) in banana.

3.2. Quality parameters of pineapple

For pineapple (Table 2), the application of organic amendments significantly influenced the biochemical properties. The biochemical parameters such as total soluble solids (17.96°Brix), total sugar (12.36%) and reducing sugar content (2.99%) were found to be highest in N_5 (vermicompost +biofertilizers-*Azotobacter*+*Azosperillium*+PSB +VAM+*Trichoderma*), followed by N_3*i.e*., total soluble solid (17.04°Brix), total sugar (12.30%) and reducing sugar (2.95%).

Table 2: Effect of different treatments on biochemical characteristics of pineapple

Treatments	TSS (°Brix)			Total sugar (%)			Reducing sugar (%)		
	2020–21	2021–22	Pooled	2020–21	2021–22	Pooled	2020–21	2021–22	Pooled
N_1	15.21^{d}	15.27^{d}	15.24^{d}	10.92^{c}	10.96^{c}	10.94^{c}	2.86^{cd}	2.90^{d}	2.88^{d}
N_2	14.86^{e}	14.92^{a}	14.89^{e}	10.49^{d}	10.54^{d}	10.52^{d}	2.84^{d}	2.86^{e}	2.85^{e}
N_3	17.02^{b}	17.07^{b}	17.04^{b}	12.27^{a}	12.33^{a}	12.30^{a}	2.94^{ab}	2.97^{b}	2.95^{b}
N_4	15.83^{c}	15.98^{c}	15.90^{c}	11.67^{b}	11.74^{b}	11.71^{b}	2.91^{bc}	2.93^{c}	2.92^{c}
N_5	17.94^{a}	17.98^{a}	17.96^{a}	12.34^{a}	12.38^{a}	12.36^{a}	2.97^{a}	3.01^{a}	2.99^{a}
SEm±	0.046	0.039	0.030	0.062	0.067	0.046	0.016	0.010	0.009
CD (*p*=0.05)	0.142	0.119	0.088	0.193	0.207	0.134	0.049	0.030	0.027

Table 2: Continue...

Treatments	Titrable acidity (%)			Ascorbic acid (mg 100 g^{-1})		
	2020–21	2021–22	Pooled	2020–21	2021–22	Pooled
N_1	0.66	0.69	0.67	35.16	37.32	36.24
N_2	0.68	0.72	0.70	35.68	37.08	36.38
N_3	0.61	0.64	0.63	34.84	35.52	35.17
N_4	0.65	0.66	0.66	35.82	36.12	35.96
N_5	0.60	0.62	0.61	34.39	34.99	34.69
SEm±	0.008	0.011	0.006	0.583	0.662	0.441
CD (*p*=0.05)	NS	NS	NS	NS	NS	NS

The improvement in fruit quality (TSS) is probably the result of both the positive impacts of biofertilizers and organic manures, which may have supplied vital micronutrients. Similar findings were observed by Bhowmick et al. (2022), Shuvo et al. (2019) and Mandal et al. (2015). In contrast, the lowest value for all the biochemical properties was recorded in N_2 *i.e*., total soluble solids (14.89°Brix), total sugar (10.52%) and reducing sugar (2.85%). The data are comparable with the findings of Bhowmick et al. (2017) in pineapple cv. Mauritius, Imchen et al. (2022). In N_2 (application of vermicompost), ascorbic acid content was recorded highest *i.e*., (36.38 mg 100 g^{-1}) followed by N_1 (application of farmyard manure) *i.e*. (36.24 mg 100 g^{-1}). This is probably brought on by increased microbial activity and nutrient availability (Rahman et al., 2021). Similar finding was also reported by Angami et al. (2019) whereas, it was recorded lowest in N_5 (vermicompost+biofertilizers -*Azotobacter*+*Azosperillium*+PSB+VAM+*Trichoderma*), *i.e*., (34.69 mg 100 g^{-1}). Similar result was observed for titrable acidity in N_2 (0.70%) where highest acidity was recorded followed by N_1 (0.67%) but the lowest acidity was observed in N_5 (vermicompost+biofertilizers which includes *Azotobac ter*+*Azosperillium*+PSB+VAM+*Trichoderma*), *i.e*., 0.61%. The study strongly supports the integration of vermicompost and biofertilizers as a sustainable practice to enhance fruit biochemical characteristics in an arecanut-based cropping system which was in accordance with the findings of Mahmud and Yaacob (2020).

4. Conclusion

The treatments having vermicompost as organic manure combined with bio-fertilizers (*Azotobacter*+*Azosperillium* +PSB+VAM+*Trichoderma*) significantly enhanced the biochemical properties of banana and pineapple in an arecanut-based intercropping system. This treatment could be used to obtain high qualitative yield in banana and pineapple intercropped together under organically based arecanut plantation under *Terai* region of West Bengal.

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