Environment and Ecology 41 (1C) : 693—697, January–March 2023
ISSN 0970-0420

Comparative Assessment of Organic and Inorganic Nutrient Management in Pineapple (*Ananas comosus* (L.) Merr.) Cultivar Mauritius in Humid Tropics of Kerala

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Received 21 November 2022, Accepted 13 January 2023, Published on 16 March 2023

ABSTRACT

India is the sixth largest producer of pineapple [*Ananas comosus* (L.) Merr.], one of the choicest tropical fruits in the world market. The world market for organic food is expanding rapidly, but the supply of organic pineapple is limited. But organic pineapple cultivation is very rare mainly due to the lack of profitable organic crop management methods. The effect of four organic nutrient management practices and one inorganic nutrient management practice was studied in 'Vazhakulam Pineapple', the GI tagged Mauritius cultivar, in laterite soils of humid tropical climate. In this experiment, the highest average fruit weight (1370.6 g) was recorded in chemically fertilized plants (T5) followed by T1 (1340.11 g), the best organic nutrient management practice and the estimated yield of T1 was 53.60 MT ha^{-1} whereas it was 54.82 MT ha^{-1} in T5. The study suggests a successful organic management strategy that is simple to implement in pineapple farming, where the observed yield drop (2.22%) can be offset by the higher price of the organic produce.

Keywords Organic, Vazhakulam pineapple, Mauritius, Humid tropical climate, Laterite soil.

INTRODUCTION

India is the sixth largest producer of pineapple [*Ananas comosus* (L.) Merr.], one of the choicest tropical fruits in the world market. In India, next to West Bengal, Kerala stands second in pineapple production (3,10,320 MT) (GOI 2018) and Ernakulam district, accounts for 63% of total pineapple production in Kerala (GOK 2020). Pineapple cultivation consumes large amounts of agrochemical inputs (Loeillet 2013), especially nitrogen (N) and potassium (K_2O) fertilizers. Pineapple plants have high nutritional requirements, so fertilization is generally necessary to make a profit (Souza 1999, Owureku-Asare *et al*. 2015). Due to the long growth cycle of pineapple and the low nutrient status of tropical soils, farmers often apply excessive amounts of N fertilizers for tropical pineapple production (Rothé *et al*. 2019).

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Intensive crop management practices with excessive application of inorganic fertilizers have detrimental environmental consequences and therefore alternative strategies need to be developed to ensure environmental sustainability without compromising yield. Many studies have been conducted on the application of various organic fertilizers to pineapple plants, such as the use of composted poultry manure (Aiyelaagbe *et al*. 2010), composted pineapple residues (Liu *et al*. 2013) and other composted materials (Maeda *et al*. 2011, Teixeira *et al*. 2011, Arshad and Armanto 2012, Orluchukwu and Adedokun 2015). Rothé *et al*. (2019) found that the use of organic fertilizers to replace some chemical N fertilizers could meet the nutrient requirements for pineapple growth. Reducing the amount of inorganic chemical fertilizer inputs could improve fruit quality in pineapples (Darnaudery *et al*. 2018). The world market for organic food is expanding rapidly, but the supply of organic pineapple is limited. But organic pineapple cultivation is very rare mainly due to the lack of profitable organic crop management methods. The effect of various organic nutrient management practices in comparison to inorganic nutrient management practice on pineapple growth and fruit yield is evaluated in this study.

MATERIALS AND METHODS

Location

The experiment was laid out at Vazhakulam (9°56'01.7"N 76°38'45.1"E) situated 40 m above mean sea level. The climate of the experimental site is humid tropical with an average annual rainfall of 2115 mm and the soil type was laterite.

Experimental design

The experiment was laid out in the Randomized Completely Block Design (RCBD) with five treatments and four replications with 30 plants in each treatment. Cow dung, rajphos (20% P_2O_5), sulfate of potash (50% K_2SO_4) and Grow Star (Bio NPK with organic carbon) of Indus valley fertilizers were purchased from the local market and biofertilizers viz., PGPR Mix, Azospirillum, Phosphobacteria and K Solubilizer was purchased from Kerala Agricultural University, Thrissur. The effect of four organic nutrient management practices and one inorganic nutrient management practice in 'Vazhakulam Pineapple', the GI tagged Mauritius cultivar was studied. The treatments in the experiment were as follows:

T1: Cowdung (100g), sulfate of potash [SOP (1.5g)], Azospirillum (1g), Phosphobactor (1g) and K Solubilizer (1g) was applied for each plant 45 days after planting (DAP) and mild earthing up was done. Application of SOP (1.5 g plant^{-1}) in cow dung solution (10%) at 90,120,150 and 180 DAP, 45 days after ethephone application (DAE) and 75 DAE was followed. Second application of Azospirillum (1g), Phosphobactor (1g) and K Solubilizer (1g) was given for each plant 180 DAP.

T2: Cowdung (100g), sulfate of potash [SOP (4g)], Azospirillum (1g), Phosphobactor (1g) and K Solubilizer (1g) for each plant was applied at bimonthly interval starting from 45 DAP up to 240 DAP. Dolomite (10 g plant^{-1}) was applied 3.5 and 7.5 MAP.

T3: Cowdung (100g), sulfate of potash [SOP (4 g)], PGPR mix (1g) and K Solubilizer (1g) for each plant was applied at bimonthly interval starting from 45 DAP up to 240 DAP.

T4: Grow Star (5g L^{-1}) at monthly intervals starting from 45 DAP up to 240 DAP.

T5: Inorganic nutrient management practice with 2g N and 2g K plant^{-1} at bimonthly intervals starting from 45 DAP up to 240 DAP.

Planting and aftercare

Suckers of 'Vazhakulam Pineapple' weighing 500-750 g were planted in small pits of 10 cm depth in the paired rows in a triangular method so that the plants in two adjacent rows were not opposed to each other. A spacing of 150 cm x 45 cm x 30 cm was adopted to get a planting density of 40,000 plants ha^{-1}. Cow dung (8 t ha^{-1}) and P_2O_5 (160 kg ha^{-1}) were applied in pits at the time of planting. Plants were earthed up along with the first top dressing at 45 DAP. Irrigation was provided from January to March at two weeks intervals. Hand weeding was adopted for weed control. Preventive application of *Lecanicillium lecanii*

(10 g L^{-1}) and *Pseudomonas fluorescence* (20 g L^{-1}) was followed against mealybug and heart rot disease respectively. Plants were artificially induced to flower with Ethrel 25 ppm + urea 2% + calcium carbonate 0.04% at 7 MAP.

Observations

Soil samples taken from the experimental plot before and after planting were analyzed for physical and chemical properties. Twenty plants from each replication were randomly selected and tagged for recording vegetative growth characteristics. Plant height and number of leaves were recorded at 1, 2.5, 4, 5 and 6 months after planting (MAP). The fruits were harvested when the skin color of the basal one eye turned yellow. Six fruits were randomly selected from each plot and fruit weight (g) and fruit firmness (kg cm^{-2}) were recorded. Pure juice extracted from fully ripe fruit was used to determine pH and total soluble solids (TSS). Fruit firmness was checked using a digital penetrometer (G-Tech GY-4) with a probe radius of 4 mm. Total soluble solids in fruit juice were measured using a handheld refractometer (ERMA) in the 0-32°Brix range and pH was measured using an Elico digital pH meter. Data were statistically analyzed by one-way analysis of variance (ANOVA) and when significant, treatments were compared using Duncan's multiple range test (DMRT).

RESULTS AND DISCUSSION

Analysis of the physico-chemical properties of the soil taken from the experimental field before the start of the experiment is given in Table 1. The soil was seen as extremely acidic and found deficient in available calcium (169.7 mg kg^{-1}) and magnesium (43.9 mg kg^{-1}). Four organic nutrient management practices were compared with inorganic treatment (T5) with respect to the growth and yield characteristics of pineapple. The plant height ranged from 114.33 cm to 105.11 cm and the number of leaves was from 45 to 46 in the experimental plants. Maximum plant height was observed in inorganic treatment (T5) throughout the vegetative growth phase (Table 2). However, the number of leaves showed no significant differences between treatments (Table 3). Mahmud *et al.* (2020) reported no significant difference could be noticed between the plants treated with vermicompost and chemical fertilizer in terms of the plant height, number of leaves, length and width of D-leaves.

The highest average fruit weight (1370.6 g) was recorded in chemically fertilized plants (T5) followed by T1 (1340.11 g), the best organic nutrient management practice. The yield reduction was only 2.22% in T1 compared to T5. The estimated yield of T1 was 53.60 MT ha^{-1} whereas it was 54.82 MT ha^{-1} in T5 (Fig. 1). Monthly supply of nitrogen and potash may have contributed to the higher yield in T1 compared to the other three organic treatments. Bimonthly application of organic manure with biofertilizer and SOP

Table 1. Soil physico-chemical properties of the experimental plot before planting.

Parameters	Quantity	Remarks
pH	4.1	Extremely acid
Electrical conductivity (ds m^{-1})	0.06	Normal
Organic carbon (%)	1.66	High
Available phosphorus (kg ha^{-1})	68.70	High
Available potassium (kg ha^{-1})	283.6	High
Available calcium (mg kg^{-1})	169.7	Deficient
Available magnesium (mg kg^{-1})	43.9	Deficient
Available sulfur (mg kg^{-1})	9.24	Sufficient
Available iron (mg kg^{-1})	51.07	Sufficient
Available manganese (mg kg^{-1})	43.52	Sufficient
Available zinc (mg kg^{-1})	3.38	Sufficient
Available copper (mg kg^{-1})	5.46	Sufficient
Available boron (mg kg^{-1})	1.35	Sufficient

Table 2. Effect of treatments on plant height of pineapple cultivar 'Mauritius' in laterite soils of tropical humid climate.

Treatments	1 MAP	2.5 MAP	4 MAP	5 MAP	6 MAP
T1	61.11 ^{b}	73.89 ^{b}	84.89 ^{b}	101.56 ^{b}	106.44 ^{b}
T2	61.67 ^{b}	73.89 ^{b}	85.33 ^{b}	101.67 ^{b}	105.11 ^{b}
T3	62.11 ^{b}	73.67 ^{b}	85.00 ^{b}	102.56 ^{b}	106.33 ^{b}
T4	61.78 ^{b}	73.89 ^{b}	84.67 ^{b}	102.44 ^{b}	106.33 ^{b}
T5	71.67 ^{a}	84.11 ^{a}	102.33 ^{a}	108.11 ^{a}	114.33 ^{a}

Table 3. Effect of treatments on leaf number of pineapple cultivar 'Mauritius' in laterite soils of tropical humid climate. * Non-Significant.

Treatment	1 MAP*	2.5 MAP*	4 MAP*	5 MAP*	6 MAP*
T1	24.11	29.33	34.89	37.44	41.78
T2	24.11	30.67	33.56	37.33	41.22
T3	26.89	31.67	37.56	41.00	44.22
T4	26.33	30.78	37.22	41.33	44.22
T5	25.22	32.67	37.44	42.00	45.11

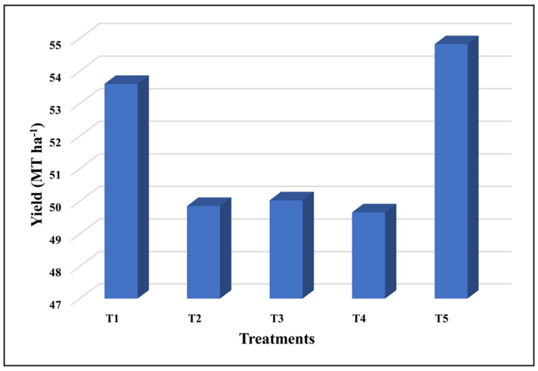

Fig. 1. Effect of treatments on estimated fruit yield of pineapple cultivar 'Mauritius' in laterite soils of tropical humid climate.

(T2 and T3) was recorded comparable yield with T4, monthly application of bio NPK with organic carbon. Similarly, Murray and Manicom (2007) reported organic pineapple fruit yields ranging between 71 and 104 MT ha^{-1} comparable to standard inorganic pineapple yield of 73 MT ha^{-1}. According to Devadas and Kuriakose (2002) highest yield could be achieved by the addition of Azospirillum and Phosphobactor each at 625 mg plant^{-1}. Adding organic fertilizer could increase pineapple fruit weight and total sugar content (Liu et al. 2013, Sossa *et al*. 2019). But Marca-Huamancha *et al*. (2018) opined that organic fertilizer had no significant effect on pineapple yield and quality.

Even though to correct Ca and Mg deficiency, dolomite (800 kg ha^{-1}) was applied in equal split doses in treatment 2, no significant result in terms of yield could be obtained. Fruit firmness and pH were not affected significantly by different treatments (Table 4) but TSS showed significant differences. Maximum TSS value was observed with T2 (16.22) where dolomite was applied and the least value was observed with T5, the inorganic treatment. The organic fertilizer, Phos-K, could improve the physical and chemical quality attributes of pineapple juice. (Owureku-Asare *et al*. 2015). Similarly, 'Queen Victoria' pineapple fruits produced with organic fertilization produced the highest total soluble solids (TSS) and lowest titratable acidity (TA) compared to inorganic fertilization (Darnaudery *et al*. 2018).

Table 4. Effect of treatments on yield and fruit quality of pineapple cultivar 'Mauritius' in laterite soils of tropical humid climate.

Treatments	Fruit weight (g)	*Fruit firmness (kg cm^{-2})	*pH	TSS(°Brix)
T1	1340.11 $^{(b)}$	6.11	3.69	15.41 $^{(bc)}$
T2	1246.43 $^{(c)}$	5.59	3.70	16.22 $^{(a)}$
T3	1250.79 $^{(c)}$	5.42	3.66	15.78 $^{(ab)}$
T4	1241.58 $^{(c)}$	5.44	3.62	15.10 $^{(cd)}$
T5 (PoP)	1370.61 $^{(a)}$	5.24	3.66	14.77 $^{(d)}$

The values with different superscripts differ significantly at 1% level, * Non-Significant.

CONCLUSION

One of the biggest issues in modern agriculture is the need to adopt methods that preserve ecological and natural resources, reduce financial outlays and foster social stability while maintaining high agricultural yields. The study suggests a successful organic management strategy that is simple to implement in pineapple farming, where the observed yield drop (2.22%) can be offset by the higher price of the organic produce.

ACKNOWLEDGMENT

The authors thereby acknowledge the financial assistance and necessary facilities rendered by Kerala Agricultural University for the smooth conduct of the experiment.

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