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Original Research Paper

Effect of diverse nutrient management regimes on banana plant growth and bunch yield

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ABSTRACT

The growth and yield responses of a local banana variety, Velchi (Ney poovan type-AB), and a commercial banana variety, Grand Naine (Dwarf cavendish type -AAA) were evaluated in five nutrient management regimes, *viz*., T_1: recommended dose of fertilizers (RDF), T_2: RDF + integrated specific nutrient (ISN) mix; custom made with organic, inorganic and biological components, T_3: RDF + integrated general nutrient (IGN) mix available in market, T_4: organic nutrient management (ONM) and an absolute control (AC) without any nutrients. Results revealed that RDF along with IGN mix and ISN mix accelerated the vegetative growth in terms of plant height (203.87 and 202.20 cm, respectively) and stem girth (53.77 and 52.50 cm, respectively). The highest number (13.07) and width (65.73 cm) of leaves were recorded in RDF + ISN treatment. Banana plants treated with RDF + ISN mix yielded an average bunch weight (19.28 kg), twice that of absolute control. Other yield-contributing parameters such as fruit weight (79.75 g), fruit length (15.71 cm), and fruit circumference (11.20 cm) were also high in the same treatment. A single application of 1 kgplant^{-1} ISN mix along with RDF in 3rd month after planting produced 1.5 times heavier bunches than the plants treated with RDF alone. Both Grand Naine and Velchi banana production with ISN mix together with RDF was profitable with a B: C ratio of 1.82 and 1.15, respectively. The effect of ISN mix on other crops and multiple cropping systems needs to be further studied.

Keywords: Banana, integrated nutrient management, location-specific, lateritic soil, West coast

INTRODUCTION

Banana (*Musa* sp.) is one of the most traded tropical fruits in the world and India ranks first in banana production with a global share of 25.56% (FAO, 2022). On the West Coast of India, banana is primarily cultivated in Maharashtra, Karnataka, Kerala, and Goa where the productivity is less than the national average (34.86 tha^{-1}) except in Maharashtra (52.04 tha^{-1}) (Debnath et al., 2021). Banana, though a shallow feeder, is a nutrient-exhaustive crop and mines substantial amounts of nutrients which are often limited in soil. In coastal Karnataka and Kerala, bananas are grown in coconut and arecanut plantations as an intercrop and in Goa, bananas are an essential part of the homestead farming systems known as '*Kulagars*' where farmers usually follow organic cultivation practices.

Comparative studies on the impacts of conventional cultivation methods and integrated nutrient management methods on bananas were focused on the alluvial, saline, red, mixed red, and black soils and were limited to the replacement of fertilizer quantity with organic compounds or biofertilizer or with their combination (Rahate et al., 2020; Dipta et al., 2021; Rajput et al., 2022). However, there are no studies dealing with the effects of contrasting nutrient management regimes on bananas in acid laterites of the humid tropics addressing the site specific secondary and micronutrient deficiency. A customized integrated nutrient management mixture for such soils holds great promise in terms of both productivity and profitability by allowing convenient usage, storage, and transportation. The major objective of the present study was to compare the effect of the specific and general integrated nutrient mixes on the growth and

yield of a local as well as a commercial banana variety in acid lateritic soils.

MATERIALS AND METHODS

A field experiment was conducted at ICAR-Central Coastal Agricultural Research Institute, Old Goa, Goa (15048/ 58// N Longitude, 73092/ 29// E Latitude, 18.60 MSL altitude) during 2018-19 to study the effect of different nutrient management treatments including integrated specific and general nutrient mixtures on growth, yield, and quality of two banana varieties, Velchi (V) (diploid-Ney Poovan type, AB) and Grand Naine (GN) (triploid-Dwarf Cavendish type, AAA). The five nutrient management treatments were, T_1: recommended dose of fertilizers (RDF) (400:200:400 g NPK plant^{-1} year^{-1} at 3rd, 5th and 7th months after planting (ICAR-CCARI DSS, 2024), T_2: RDF + integrated specific nutrient (ISN) mix at 1 kg plant^{-1} at 3rd month after planting, T_3: RDF + integrated general nutrient (IGN) mix available in the market with a known nutrient composition at 1 kgplant^{-1} at 3rd month after planting, T_4: organic nutrient management (ONM) and absolute control (AC) without nutrients. The recommended dose of fertilizers was applied as soil application with urea (46% N), rock phosphate (18% P_2O_5), and muriate of potash (60% K_2O). The ISN mix was a custom-made integrated nutrient mixture (Maneesha et al., 2025).

The experimental site had acidic red laterite soil with a soil pH of 5.25, electrical conductivity of 0.05 dsm^{-1}, and soil organic carbon of 1.80%. Soil available nitrogen (N), phosphorus (P), and potassium (K) were 208.5, 25.39 and 290.37 kgha^{-1}, respectively. Approximately two months old uniform sword suckers of the var. Velchi and hardened tissue culture plants of the var. Grand Naine were planted in 50 cm^3 pits in 2 m × 2 m spacing in the plot. Surface irrigation was provided to the plants once every two days excluding the monsoon season. All the regular cultural operations including staking and earthing up were executed in the orchard uniformly during the experiment. The data on vegetative growth was observed at the time of flowering, yield and quality were recorded after harvest. Leaf total chlorophyll content was estimated at the time of flowering, and fruit total soluble solids (TSS) was measured by a hand-held refractometer (ERMA, Japan). Fruit acidity was estimated by the standard NaOH titration method. The data were subjected to analysis of variance (ANOVA) as a factorial randomized block design with three replications. Each replication had eight plants and the total number of plants per treatment were 24. Statistical analyses for differences among each plant parameter were compared against varieties and nutrient management treatments and their interactions at $p \leq 0.05$ using R Studio version 4.2.3. The cost of cultivation of each treatment was calculated and the B: C ratio was calculated as per the formula, B: C ratio= net income/ total cost of cultivation.

RESULTS AND DISCUSSION

Growth parameters

The mean plant height of the var. Velchi was recorded 219.99 cm and for var. Grand Naine (157.38 cm) at the time of flowering (Table 1). The variety Velchi registered a stem girth (53.23 cm) and Grand Naine mean stem girth (48.90 cm). The number of leaves was significantly higher ($P<0.05$) in Velchi (13.61) than Grand Naine (11.88) at the time of flowering, which added the improved photosynthetic efficiency. However, there was no significant difference in leaf length and leaf width between these two varieties. The chlorophyll content, another indicator of the photosynthetic efficiency, was the highest in Grand Naine plants (2.42 mg/100 g), while Velchi recorded 1.58 mg/100 g. Ney poovan-type (253 days) bananas takes more time to flower than Grand Naine (268.09 days), as also reported by Kumar et al. (2022). The diploid variety Velchi seems to be more adapted to the hardy Goan soil conditions as it is one of the local cultivars.

The application of IGN mix and ISN mix along with RDF recorded the highest plant height and stem girth (203.87 cm and 202.20 cm; 53.77 cm and 52.50 cm, respectively). The organic management practices and absolute control recorded shortest plants with the lowest stem girth. The IGN and ISN mix were applied at the critical growth period (3rd month after planting) when the plant actively grows and the secondary and micronutrients in the IGN and ISN mix helps in the active metabolism. The organic management practices (ONM) recorded the maximum number of leaves (13.30), which was at par with RDF (13.10) and RDF + ISN mix (13.07). Interestingly, the RDF + ISN mix registered the highest leaf width (65.73 cm) compared to the other treatments. The integrated effect of the secondary and micronutrients along with the

Table 1 : Effect of varieties and nutrient management treatments on growth parameters of banana

Treatment	Plant height (cm)	Stem girth (cm)	No. of Leaves	Leaf length (cm)	Leaf width (cm)	Chlorophyll content (mg/100 g)	Days taken for shooting
Banana varieties (BV)							
Velchi (V)	219.99	53.23	13.61	153.68	59.18	1.58	268.09
Grand Naine (GN)	157.38	48.90	11.88	149.93	61.01	2.42	252.96
Nutrient management treatments (NMT)							
AC	171.23	48.96	11.65	143.13	54.83	1.97	282.93
T_1: RDF	197.97	51.43	13.10	154.33	61.80	1.75	263.37
T_2: RDF+ISN mix	202.20	52.50	13.07	159.25	65.73	1.91	250.77
T_3: RDF+IGN mix	203.87	53.77	12.60	156.10	62.30	2.12	252.43
T_4: ONM	168.18	48.68	13.30	146.20	55.83	2.24	253.13
*p values**							
BV	<0.001	0.009	<0.001	0.343	0.286	< 0.001	0.054
NMT	<0.001	0.036	0.046	0.077	0.002	0.36	0.064
BV × NMT	0.008	0.310	0.126	0.528	0.127	0.004	0.159

*$p \leq 0.05$ indicates significant difference between banana varieties (BV), nutrient management treatments (NMT) and interaction between banana varieties and nutrient management treatments (BV× NMT)

PGPRs might have increased the soil nutrient availability of plants as reported by Srinivasarao et al. (2021) and enhanced greater assimilation in vegetative organs of banana varieties.

The tallest plants were recorded in var. Velchi treated with RDF + IGN mix (241.47 cm) (Table 1), which was statistically at par with RDF (240.07 cm) and RDF + ISN mix (236.13 cm). The availability of all essential nutrients at the right time helped in the absorption and assimilation of nutrients by the ISN mix and IGN mix along with the RDF. However, the interaction between the varieties and the nutrient management treatments was significant (P= 0.004) for leaf chlorophyll content at the time of flowering. The variety Grand Naine is nutrient-responsive and the integrated nutrient mix with micronutrients including Mg might have helped enhance the chlorophyll content of the plants treated with IGN.

Yield and quality parameters

The variety Grand Naine took 353.84 days for harvest, while, var. Velchi took 16.32 days later (Table 2). According to Kumar et al. (2022) cv. Ney Poovan type takes 375±14 days and Grand Naine 310±12 days for maturity. The mean bunch weight of the var. Grand Naine was 18.68 kg, whereas it was 8.72 kg in Velchi. The variability in vegetative growth, yield, and quality of the banana varieties were also reported (Kumar et al., 2022). The number of hands per bunch was recorded highest in var. Velchi (8.92), followed by var. Grand Naine (8.00). There was no significant difference in the number of fruits per hand in both varieties. Grand Naine recorded higher fruit weight (110. 60 g), fruit length (16.55 cm), and fruit circumference (11.85 cm) than Velchi (24.94 g, 10.08 cm, 8.43 cm, respectively). TSS of both the varieties did not vary significantly, while, var. Velchi recorded significantly higher fruit acidity (0.29%) than var. Grand Naine (0.25%).

Plants treated with RDF + ISN mix registered a markedly higher bunch weight (19.28 kg) than RDF + IGN mix (15.44 kg) and RDF (12.47 kg). Plants treated with RFD + ISN mix consistently registered greater fruit weight (79.75 g), fruit length (15.71 cm), and fruit circumference (11.20 cm) and number of hands (9.10). Combined application of chemical fertilizers with organic manures and biofertilizers induced early flowering and increased the yield of bananas. The RDF provides the major nutrients required in larger quantities in the congenial soil environment created by the organic manures. Similarly, foliar applications of Zn, Fe, Cu, and B have enhanced the TSS content of the fruits in addition to the growth and yield parameters. RDF + IGN mix registered the highest TSS (22.62° Brix).

Table 2 : Effect of varieties and nutrient management treatments on yield and quality parameters

Treatment	Days taken for harvest	Bunch weight (kg)	No. of hands	No. of fruits/ hands	Fruit weight (g)	Fruit length (cm)	Fruit circumference (cm)	TSS (°Brix)	Acidity (%)
				Banana varieties (BV)					
Velchi (V)	370.16	8.72	8.92	12.69	24.94	10.08	8.43	19.66	0.29
Grand Naine (GN)	353.84	18.68	8.00	11.72	110.60	16.55	11.85	17.65	0.25
				Nutrient management treatments (NMT)					
AC	381.87	9.72	7.40	11.43	61.98	12.33	9.25	14.75	0.25
T1: RDF	367.03	12.47	8.57	12.82	69.39	13.93	10.43	19.75	0.30
T_2: RDF+ISN	354.77	19.28	9.10	12.20	79.75	15.71	11.20	20.92	0.29
T_3: RDF+IGN	352.57	15.44	8.80	12.46	63.12	12.12	9.50	22.62	0.25
T_4: ONM	353.75	11.57	8.43	12.14	64.62	12.52	10.33	15.23	0.25
				*p values**					
BV	0.027	<0.001	0.004	0.54	<0.001	<0.001	<0.001	0.205	0.008
NMT	0.06	<0.001	0.014	0.457	0.401	0.026	0.047	0.014	0.124
BV × NMT	0.164	<0.001	0.579	0.245	0.643	0.259	0.840	0.205	0.023

*$p \leq 0.05$ indicates significant difference between banana varieties (BV), nutrient management treatments (NMT) and interaction between banana varieties and nutrient management treatments (BV× NMT)

The flowering and fruit development in bananas were independent of plant nutrition (Table 2). However, the yield and yield contributing characters showed significant interaction between the varieties and the nutrient management treatments. The variety Grand Naine treated with RDF + ISN mix recorded significantly higher ($p \leq 0.001$) bunch weight (26.52 kg), which was 1.3 times higher than RDF + IGN mix (20.47 kg), which was 1.6 times higher than RDF and ONM in the var. Grand Naine. In var. Velchi, RDF + ISN mix recorded 1.15 times higher bunch weight than RDF + IGN; 1.85 times higher than ONM, and 1.42 times higher than RDF. Grand Naine provided essential nutrients at critical growth stages enhance growth and yield. The combined effect of the RDF and the ISN mix was higher in the nutrient responsive variety Grand Naine than Velchi. The fruit parameters and quality parameters recorded no significant interaction effect except fruit acidity which was the highest in Velchi plants treated with RDF+ ISN mix (0.34%) which was at par with Velchi plants treated with RDF (0.32%).

Profitability

The fixed costs of production including the land cost and irrigation facilities were Rs. 2000.00 and the operational costs excluding the cost of the treatment including the plant protection, electricity, transportation, manpower and miscellaneous were Rs. 10000.00 per treatment. The cost of the ISN mix was Rs. 25.48 kg^{-1} and the IGN mix was Rs. 60.00 kg^{-1}. The cost of production of each treatment was calculated based on the individual components used. The cost of the absolute control involved the cost of the planting material alone i.e. Velchi at Rs. 10.00) and Grand Naine at Rs. 15.00. The RDF treatment costs Rs. 23.35 $plant^{-1}$ and the RDF + ISN mix costs Rs. 48.73 $plant^{-1}$; RDF + IGN mix costs Rs. 83.25 $plant^{-1}$ and the organic treatment ONM costs Rs. 50 $plant^{-1}$.

The total cost of production includes fixed costs, operational costs, and treatment costs. The total cost of production was highest in Grand Naine treated with RDF + IGN (Rs. 14358.00) followed by Velchi treated with RDF + IGN (Rs. 14238.00) (Table 3). The average yield per plant was considered to calculate gross income based on the sale price of Velchi (Rs. 100 kg^{-1}) and Grand Nain (Rs. 60 kg^{-1}). The gross income and net income were recorded highest in Grand Naine treated with RDF + ISN (Rs. 38188.80 and Rs. 24659.28). The Grand Naine cultivated with RDF + ISN recorded highest B: C ratio (1.82) followed by Velchi (1.15). The variety Grand Naine treated with RDF + IGN were also profitable with a B: C ratio of 1.05.

CONCLUSION

Application of the ISN mix improved the bunch weight of the var. Grand Naine by 1.6 times than the RDF treatment leading to profitable cultivation with a B: C ratio (1.82), while, the bunch weight was enhanced by 1.42 times than the RDF in var. Velchi with a B:C ratio (1.15). The integrated nutrient mixtures, a novel attempt to foster synergistic use of organic sources, inorganic sources, and beneficial bacteria for application to bananas in laterite soils of humid tropics of India.

Table 3 : Cost benefit ratio of banana production under different nutrient regimes

Treatment	Treatment cost/plot (Rs.)	Total cost of production/plot (Rs.)	Yield (kg/ plant)	Total yield/plot (kg)	Gross income (Rs.)	Net income (Rs.)	B:C ratio
V × AC	240.00	12240.00	6.21	149.04	14904.00	2664.00	0.22
V × RDF	798.00	12798.00	8.44	202.56	20256.00	7458.00	0.58
V × (RDF+ISN)	1409.52	13409.52	12.03	288.72	28872.00	15462.48	1.15
V × (RDF+IGN)	2238.00	14238.00	10.40	249.60	24960.00	10722.00	0.75
V × ONM	1440.00	13440.00	6.51	156.24	15624.00	2184.00	0.16
GN × AC	360.00	12360.00	13.23	317.52	19051.20	6691.20	0.54
GN × RDF	918.00	12918.00	16.50	396.00	23760.00	10842.00	0.84
GN × (RDF+ISN)	1529.52	13529.52	26.52	636.48	38188.80	24659.28	1.82
GN × (RDF+IGN)	2358.00	14358.00	20.47	491.28	29476.80	15118.80	1.05
GN × ONM	1560.00	13560.00	16.64	399.36	23961.60	10401.60	0.77

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