Growth, nutrient uptake, yield and quality parameters of *Nendran* banana (*Musa* sp.) as influenced by combined application of soil and foliar nutrition

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Abstract

A field experiment was conducted at Coconut Research Station, Balaramapuram Thiruvananthapuram, Kerala Agricultural University during 2016 April to 2017 February to assess the impact of reduced dose of chemical fertilizers supplemented with foliar nutrition of major and micro nutrients on the uptake of major nutrients, growth, yield and quality of *Nendran* banana (*Musa* AAB group). The experiment was laid out in randomised block design with eight treatments and three replications. Growth parameters (pseudostem height, pseudostem girth and leaf area), uptake of major nutrients , yield attributes (index /D finger characters viz., length, girth and weight of finger) and yield were found higher for the treatment which received 100 per cent of the recommended dose of fertilizers (RDF) + foliar spray of micronutrient mixture (1%) at 3 MAP and was comparable with 75 per cent of RDF + foliar spray of 19:19:19 fertilizer mixture (0.5%) at 2 and 4MAP + foliar spray of micronutrient mixture (1%) at 3 MAP. These two treatments also registered higher content of total sugars and longer shelf lives. The treatment which received 100 per cent of RDF + foliar spray of micronutrient mixture (1%) at 3 MAP could register significantly higher TSS (34.67 ^{0}B), TSS/Acid ratio (114.92), pulp: peel ratio (2.58) and lower titratable acidity (0.31 per cent). Growth, yield, nutrient uptake and quality parameters were found significantly inferior for the treatment which received only foliar application of 19:19:19 mixture (0.5%) at monthly intervals in addition to the recommended basal dose of organic manures.

Keywords: Acidity, Banana, D finger, Growth, Nutrient uptake, Pulp: Peel ratio, Total sugars, TSS, TSS/ Acid ratio, Yield.

Introduction

Banana, the major tropical fruit, is popular globally for its nutritional significance as well as economic importance to small and marginal farmers. *Nendran* banana belonging to *Musa* AAB group is the most sought after banana variety in Kerala, both for domestic and export markets due to its unique taste, nutritive value and varied options for value addition.

Banana is a heavy feeder of nutrients and requires large amounts of nitrogen and potassium followed by phosphorus (Abdullah et al.1999). Being an exhaustive crop, proper scheduling of plant nutrition is important in banana for realising potential yield and good quality. Hence a study on conjunctive soil and foliar nutrition was formulated with the objective to assess the feasibility of foliar nutrition in reducing the fertilizer dose of *Nendran* banana and to study its impact on the uptake of nutrients, growth, yield and quality.

Foliar nutrition, the application of fertilizer material to foliage, is considered far more efficient compared

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to soil application and is gaining popularity as a supplement to soil nutrition. Fertilizers when applied to soil are subjected to various types of losses and often fail to provide the nutrients in the required quantity. To compensate for this, higher quantities of fertilizers are often applied to soil which eventually leads to environmental pollution. Foliar nutrition on the other hand, makes use of less quantity of fertilizers and is hence recognised as an environment friendly agro technique. Water soluble multinutrient fertilizers like 19:19:19 when applied as foliar spray can positively augment the yield of fruits (Malhotra, 2016).

Many types of multinutrient water soluble fertilizers suited for foliar application are available in the market, and their use is spreading in many states of India (Chander, 2014), including Kerala.

There are reports on spread wide deficiencies of micronutrients in Kerala soils as documented by Kerala State Planning Board (2013), which necessitates supply of micronutrients to realise full production potential of crops. KAU Banana micro mix, a micronutrient fertilizer mixture (1% Fe, 2% Mn, 4% Zn, 6% B, and 1% Cu) for banana developed at Kerala Agricultural University suitable for foliar application and with reported yield advantage in *Nendran* banana (Mathew, 2014), was experimented in the present study. The results of the study which combined soil and foliar nutrition in *Nendran* banana are detailed below.

Materials and Methods

The study was conducted at the Coconut Research Station of Kerala Agricultural University at Balaramapuram, Thiruvananthapuram. The experimental site was geographically located at 8^0 22' 53" N latitude and 77^0 1' 47" E longitude, at an altitude of 26 m above mean sea level. The red soil of the experimental site was sandy loam in texture, acidic in reaction (pH 5.2), low in available nitrogen (201 kg ha^{-1}) and potassium (200 kg ha^{-1}), and medium in available phosphorus (26.5 kg ha^{-1}). The bulk density and particle density of the soil were 1.48 and 2.36 Mg m^{-3} respectively.

The plot size was 6 m x 4 m. Six plants were maintained per plot. Vigorous and disease free suckers of *Nendran* banana of uniform age and size were selected for planting. The eight different treatments of the study are detailed in Table 1. Farm yard manure (0.53 % N, 0.20 % P_2O_5 and 0.48% K_2O) was used as organic manure. Urea (46 % N), Rock Phosphate (20 % P_2O_5) and Muriate of Potash (60% K_2O) were used as fertilizer sources of N, P and K respectively. The foliar nutrient used to supply the major nutrients was 19:19:19 mixture (0.5%) and the wetting agent was Stanowet (1ml $litre^{-1}$). KAU Banana micromix was used to supply the micronutrients. Pre harvest bunch sprays of K_2SO_4 (3%) were given twice, first at two weeks and the second at four weeks of bunch emergence, common for all treatments.

The different treatments experimented in the study are detailed in Table 1. The KAU Package of Practices nutrient recommendation for *Nendran*

Table 1. Treatments of the experiment

Treatments	Details
T_1	* Package of Practices recommendation of nutrients, KAU
T_2	75 % RDN* +19:19:19 (0.5%) foliar spray at 2 and 4 MAP
T_3	60 % RDN* +19:19:19 (0.5%) foliar spray at 2 and 4 MAP
T_4	T_1 + Banana micro mix (1%) foliar spray at 3 MAP
T_5	T_2 + Banana micro mix (1%) foliar spray at 3 MAP
T_6	T_3 + Banana micro mix (1%) foliar spray at 3 MAP
T_7	19:19:19 (0.5%) foliar spray 7 times at monthly intervals after planting
T_8	T_7 + Banana micro mix (1%) foliar spray at 3 MAP

*KAU Recommendation :10 kg FYM, 190:115:300 g N, P and K $plant^{-1}$

*Recommended Dose of Nutrients (RDN):190:115:300 g N, P and K $plant^{-1}$

banana (10 kg FYM, 190:115:300 g N, P and K plant^{-1}) was decided as control (T_1). Reduction in the recommended dose of chemical fertilizers up to 25 and 40 per cent was done by supplementing with foliar nutrition [19:19:19 fertilizer (0.5%) at 2 and 4 MAP] in four of the treatments (T_2, T_3, T_4 and T_5). Foliar spray of banana micromix (1%) was given at 3 months stage of crop in four of the treatments (T_4, T_5, T_6 and T_8). Apart from the basal dose of organic manures, treatment T_7 received only foliar sprays of water soluble nutrient 19:19:19 (0.5%) at monthly intervals up to 7 months. Treatment T_8 received an additional foliar spray of banana micromix (1%) compared to T_7.

Observations on growth characters including plant height, pseudostem girth and leaf area index were recorded at bimonthly intervals starting from two months of planting.The dry matter production (DMP) and uptake of major nutrients were worked out at harvest stage. Yield attributes including index (D) finger characters and yield in terms of bunch weight per plant and in t ha^{-1} were worked out.

Quality parameters including total soluble solids (TSS), titratable acidity, TSS/Acid ratio and total sugars were determined as per the method given by Ranganna (1977). To estimate titratable acidity, the fruit pulp was mixed thoroughly using mixer. The juice was separated through filtration using muslin cloth. Diluted aliquot of the sample were prepared with freshly boiled distilled water. Titratable acidity was estimated by titrating the fruit extract with 0.1 N NaOH using 1 % phenolphthalein solution as indicator. The titre values were recorded when the solution turned pink in colour. The % titratable acidity was expressed as percent citric acid equivalent using the formula.

$$\% \text{ titratable acidity} = \frac{\text{Titre value x Normality of the alkali x Vol. made up(ml) x Equi. weight of acid x 100}}{\text{Volume of sample taken for estimation(ml) x Weight of sample taken(g)}}$$

Shelf life and pulp: peel ratio were also recorded. The data were analysed statistically and the significance was tested using the technique of analysis of variance (Panse and Sukhatme,1967) and critical differences calculated.

Results and Discussion

Growth characters

Pseudostem height, pseudostem girth and leaf area index recorded at bimonthly intervals from 2 to 8 months of planting are presented in Table 2. At 4, 6 and 8 MAP, T_4 (100% RDF + banana micromix (1%) at 3MAP) recorded maximum pseudostem heights of 199.8 cm, 231.92 cm and 286.78 cm respectively and was on par with treatment T_5 [75% of RDF + foliar sprays of 19:19:19 (0.5%) and banana micromix (1%)]. Treatments T_7 and T_8 which received no soil addition of nutrients apart from basal organics, recorded lower and comparable pseudostem heights at crop stages 2, 4 and 8 MAP. The same trend followed for pseudostem girth also with treatments T_4 and T_5 registering higher and comparable pseudostem girth. The maximum pseudostem girth of 49.09 cm was recorded with

Table 2 . Growth parameters of *Nendran* banana as influenced by different treatments

Treatments	Pseudostem height (cm)				Pseudostem girth (cm)				Leaf area index			
	2 MAP	4 MAP	6 MAP	8 MAP	2 MAP	4MAP	6 MAP	8MAP	2MAP	4 MAP	6 MAP	8 MAP
T_1	105.88	176.94	230.64	271.47	34.23	37.78	42.22	47.26	0.73	2.52	3.98	2.67
T_2	103.19	174.17	219.26	259.64	32.25	38.37	41.27	46.10	0.61	2.39	3.83	2.66
T_3	109.01	166.38	206.32	244.58	30.19	34.82	37.67	41.39	0.56	2.27	3.39	2.30
T_4	111.48	199.80	231.92	286.78	35.86	40.46	44.37	48.77	0.66	3.54	4.69	2.89
T_5	106.08	194.09	231.45	281.07	36.20	38.39	42.49	49.09	0.63	3.21	4.37	3.03
T_6	101.28	183.45	221.23	275.16	30.55	33.86	38.85	43.28	0.59	2.64	3.77	2.35
T_7	102.38	158.00	177.13	231.69	27.31	29.57	32.39	35.50	0.51	2.08	3.07	1.37
T_8	106.68	165.31	189.49	241.30	25.41	30.35	33.26	39.73	0.54	2.19	3.68	2.30
SE m	4.729	4.308	9.554	7.478	0.864	0.892	0.827	0.876	0.092	0.157	0.120	0.202
CD (0.05)												

Table 3. Uptake of major nutrients, dry matter production and yield of *Nendran* banana as influenced by different treatments

Treatments	Nutrient Uptake (kg ha^{-1})			Dry matter production (t ha^{-1})	Bunch weight (kg)	Yield (t ha^{-1})
	N	P	K			
T_1	243.97	22.04	447.02	21.75	9.00	22.50
T_2	206.54	21.48	427.95	17.78	8.67	21.67
T_3	167.51	17.89	374.06	17.29	8.11	20.27
T_4	403.04	48.85	781.65	26.07	10.14	25.34
T_5	334.00	35.04	714.71	24.78	9.83	24.58
T_6	220.22	22.22	525.29	18.49	8.27	20.66
T_7	165.41	10.94	235.12	14.88	5.62	14.04
T_8	183.38	12.89	267.91	15.33	5.82	14.54
SEm (±)	11.614	1.154	0.428	1.046	0.124	0.311
CD (0.05)	35.569	3.498	72.109	3.202	0.381	0.942

treatment T_5 at 8 MAP which was comparable to T_4 (48.77 cm). In treatments T_7 and T_8 where the plant was nourished with foliar sprays of nutrients alone apart from the basal dose of organics, the pseudostem girth was found significantly reduced.

Leaf area index, a measure of intercepted radiation and hence a crucial determinant of crop growth and productivity, was also observed at bimonthly intervals. At 4, 6 and 8 MAP, T_4 and T_5 registered significantly superior and comparable LAI. In both these treatments, apart from the supply of major nutrients in substantial quantities, micronutrient addition also was ensured which could have directly influenced the growth of plants. In T_5, though a reduction was made in the recommended dose of soil applied chemical fertilizers, supplementation of major and micro nutrients was ensured with foliar sprays and it proved equivalent to full dose of soil applied fertilizers in influencing crop growth. This comparable status of T_4 and T_5 in positively influencing growth could thus be interpreted as the efficiency of foliar application of plant nutrients, which allowed for a reduction in the recommended dose of soil applied fertilizers.

Nutrient uptake and dry matter production

Nutrient uptake with regard to the major nutrients N, P and K were recorded at harvest stage and are presented in Table 3. Plant samples collected at harvest stage were analysed for nutrient content and the uptake values were worked out in kg ha^{-1}as the product of nutrient content and dry matter production. Significantly higher uptake of nitrogen and phosphorus was recorded by the treatment T_4, whereas T_4 and T_5 recorded higher and comparable potassium uptake of 781.65 and 714.71 kg ha^{-1} respectively. Uptake of all the three major nutrients were lower in treatments T_7 and T_8. DMP was higher with treatments T_4 and T_5 (Table 3) and this could be related with higher nutrient uptake. Pseudostem height, pseudostem girth and leaf area which are contributors to dry matter production were more with these two treatments resulting in better DMP and hence uptake. Well balanced supply of major and minor nutrients as ensured with treatments T_4 and T_5 resulted in better growth and hence more of DMP. This is in accordance with the findings of Thippesha et al.(2008) who recorded higher biomass accumulation in Robusta banana with higher levels of nutrient supply (360:250:500 g NPK hill^{-1}). According to them, low level of nitrogen and potassium restricted plant growth, thereby reducing total dry matter production.

Yield attributes

D finger characters

The middle finger in the top row of the D hand (second hand from the top of the bunch) is designated as the representative finger for studying fruit characters (Gottriech et.al.,1964). The data on the characters of the representative finger are abridged in Table 4. Comparable and superior D finger characters viz., weight, length and girth were observed for treatments T_4 and T_5. These treatments received a well balanced supply of major and micro nutrients throughout the growth period, as evidenced from the uptake of nutrients (Table 3),

Table 4. D finger characters of *Nendran* banana as influenced by different treatments

Treatments	Weight of D finger (g)	Length of D finger (cm)	Girth of D finger (cm)
T_1	229.40	19.36	12.73
T_2	214.46	18.75	12.17
T_3	210.63	18.30	10.73
T_4	245.46	21.81	14.97
T_5	233.13	20.95	14.61
T_6	214.95	19.33	12.5
T_7	185.86	16.00	8.60
T_8	193.09	17.49	10.62
SEm (±)	4.202	0.638	0.592
CD (0.05)	12.748	1.894	1.795

possibly leading to improved photosynthesis reflecting in index finger characters. Significantly inferior D finger characters as observed with treatments T_7 and T_8 could be related with the reduced supply of plant nutrients especially potassium, which is very important with regard to photosynthesis. Under low potassium supply, the conversion of carbohydrates to starch is greatly reduced and the translocation of carbohydrates from leaves to fruits is restricted.

Yield

Average bunch weight per plant as well as yield data in t ha^{-1} were worked out. Significantly higher and comparable bunch weights were observed with treatments T_4 (10.14 kg) and T_5 (9.83kg). Bunch weight was significantly reduced in treatments T_7 (5.62 kg) and T_8 (5.82 kg). Yield followed the same trend as average bunch weight per plant. T_4 and T_5 recorded significantly superior and comparable yields of 25.34 t ha^{-1} and 24.58 t ha^{-1} respectively. Crop yield was significantly reduced in treatments T_7 (14.04 t ha^{-1}) and T_8 (14.54 t ha^{-1}). Well balanced nutrition as ensured with T_4 and T_5 and higher nutrient uptake could be related with the better yield performance for these treatments.

Quality parameters

Quality parameters including total soluble solids (TSS), titrable acidity and total sugars were determined as per the method given by Ranganna (1977) and these were found to be significantly influenced by the treatments (Table 5). The treatments which received well balanced nutrition inclusive of major and micro nutrients (T_4 and T_5) recorded improvement in most of the quality parameters like lower titrable acidity, increase in TSS, TSS/Acid ratio, total sugars, pulp: peel ratio, enhancement in shelf life, etc whereas those which received lower dose of nutrients (T_7 and T_8) performed inferiorly with respect to these quality traits. Nutrition has a significant positive role on plant physiological mechanisms related to quality especially activation of many important enzymes aiding in accumulation and translocation of sugars (Malvi, 2011).

T_4 registered the lowest acidity of 0.31 per cent, followed by T_5 which registered an acidity of 0.32 per cent. Both these treatments received foliar spray of Banana micro mix. Micronutrients like Mn contained in the mix are reported to activate enzymes which are involved in conversion of polysaccharides to simple sugars thereby increasing TSS. Also micronutrients like B contained in the mixture could help translocation of more sugars

Table 5. Quality parameters of *Nendran* banana fruits as influenced by different treatments

Treatments	TSS (^{0}B)	Acidity (%)	TSS/Acid ratio	Total sugars(%)	Shelf life(Days)	Pulp : Peel ratio
T_1	32.13	0.46	0.46	17.92	8.05	2.25
T_2	30.13	0.49	0.49	17.25	8.31	2.41
T_3	29.93	0.63	0.63	16.95	7.74	2.38
T_4	34.67	0.31	0.31	19.11	8.66	2.58
T_5	33	0.32	0.33	18.82	8.82	2.46
T_6	33.10	0.51	0.51	16.66	7.59	2.36
T_7	26.37	0.70	0.70	13.04	7.19	2.26
T_8	27.23	0.65	0.65	14.21	7.56	2.32
SEm	0.160	0.003	1.780	0.158	0.336	0.044
CD (0.05)	0.486	0.002	5.390	0.473	1.012	0.131

thereby resulting in more total sugars and lowering of acidity in fruits. Patel et al. (2010) reported a similar reduction in acidity in banana fruits with accumulation of more sugars. Significantly highest value for acidity (0.70 per cent) was registered with treatment T_7. Increased level of potassium is also reported to reduce the acidity of fruits due to neutralisation of organic acids under an altered physiological mechanism under high level of potassium (Tisdale and Nelson, 1966; Pattee and Teel, 1967). Treatments T_4 and T_5 received sufficient quantities of potassium and this could be related to the lower acidity of fruits noticed with these treatments.

Treatment T_4 recorded the highest pulp: peel ratio of 2.58. Higher and comparable pulp: peel ratios were recorded by treatments T_5 (2.46), T_1 (2.41) and T_2 (2.38). The lowest pulp: peel ratio of 2.25 was recorded by T_7 and it was on par with T_8 (2.26). Ningavva et al. (2014) studied soil addition of fertilizers in conjunction with foliar nutrition of micronutrients B and Zn in *Grand Nain* banana and reported improved quality of fruits with regard to higher pulp content which was attributed mainly to the role of micronutrients in rapid synthesis of carbohydrates and their translocation to fruits. Apart from major nutrients, treatments T_4 and T_5 received foliar supply of micronutrients and this could be related with the improved quality traits. The shelf life of fruits was more with treatments T_5, T_4 and T_1. Ample supply of major nutrient potassium ensured with these treatments could be related to the extended shelf life. The role of potassium in extension of shelf life was well established by Kumar et al. (2008).

Banana responds well to supplemental foliar nutrition. A reduction in the recommended dose of N, P and K fertilizers up to 25 per cent when supplemented with foliar nutrition using 19:19:19 (0.5%) at 2 and 4 MAP and banana micronutrient mixture (1%) at 3MAP proved as good as 100 per cent of RDF + banana micronutrient mixture (1%) at 3MAP in improving the, growth, nutrient uptake, yield attributes including D finger characters, yield and quality parameters of *Nendran banana*. This suggests that foliar nutrition could conjunctively be practiced with soil application of nutrients for reducing the fertilizer load on soils, at the same time ensuring higher and quality produce from fruit crop banana.

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