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Integration of soil and foliar nutrition in influencing the yield related characters, yield and economics of nendran banana (musa aab group) and the soil nutrient status of cropped field

E. K. BASHMA AND B. SUDHA

Integrated Farming System Research Station, Karamana, Nedumcaud,
Kerala Agricultural University, Thiruvananthapuram,
Kerala, India. Pin - 695002

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ABSTRACT

A field experiment on crop nutrition of Nendran banana (Musa AAB group) was conducted at the Coconut Research Station, Balaramapuram, Kerala Agricultural University during 2016 April to 2017, to assess the influence of an integrated nutrient management schedule combining both soil and foliar nutrition on the yield and economics of crop and properties of soil. The experiment was laid out in Randomised Block Design with eight treatments and three replications. Yield, Net returns and B: C ratio were found higher for the treatment which received 100 per cent of the recommended dose of fertilizers (RDF) + foliar spray of KAU Banana micro mix (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 KAU Banana micro mix (1%) at 3 MAP. The yields were 25.34 and 24.58 t ha^{-1}; net returns 5.88 and 5.64 lakh Rs ha^{-1} and B: C ratios 2.37 and 2.33 respectively. Significant earliness in bunch emergence and favourable yield attributes (number of hands and fingers bunch^{-1}) were also noticed with these two treatments. The nutrient status of soil after crop harvest was found declined in treatments which received only foliar sprays of 19:19:19 fertilizer mixture (0.5%) at monthly intervals except for soil application of 10 t ha^{-1} of FYM as basal. In all other treatments wherein soil and foliar nutrition were applied in an integrated way in addition to basal FYM, the soil nutrient status was maintained well above the initial level.

Keywords: Banana, B: C ratio, foliar nutrition, micronutrient mixture, net returns, soil available nutrients, yield

Banana, the major tropical fruit is a heavy feeder of plant nutrients especially nitrogen and potassium followed by phosphorus (Abdullah *et al*.,1999). Being nutrient exhaustive, proper scheduling of plant nutrition is very important in banana for realising potential yields. For varieties like *Nendran*, six top dressings of N and K fertilizers are recommended apart from the addition of organic manures and P fertilizer as basal dose (KAU, 2016). However, the fertilizers are costly, energy intensive and their continuous use can lead to soil ill health. Hence any measure to bring down fertilizer addition is always appreciated especially in terms of ecological point of view.

Foliar nutrition, the application of fertilizer material to foliage is considered far efficient compared to soil application and is gaining popularity as a supplement to soil nutrition. Only lesser quantities of fertilizers are made used in foliar nutrition. There are several reports of yield enhancement in crops with foliar application of nutrients. Based on nutrition trials, Malhotra (2016) reported that water soluble multinutrient fertilizers like 19:19:19 when applied as foliar spray can positively augment the yield of fruits. Based on these reports, a study on integration of soil and foliar nutrition was formulated with the objective to assess its impact on the yield related attributes, yield and economics of *Nendran* banana as well as residual soil nutrients of the cropped field.

There are reports on wide spread deficiencies of micronutrients in Kerala soils as documented by Kerala State Planning Board (KSPB, 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 which suits foliar application with reported yield advantage in *Nendran* banana (Mathew, 2014) was experimented in this study. The results of this crop nutrition experiment which combined soil and foliar nutrition in evaluating the yield performance and economics of *Nendran* banana as well as residual soil nutrients are detailed below.

MATERIALS AND METHODS

The study was carried out 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 and was at an altitude of 26 m above mean sea level. The red soil of the experimental

Email : sudha.b@kau.in

site had a sandy loam texture, was acidic in reaction (5.2), low in available nitrogen (201 kg ha^{-1}) and potassium (200 kg ha^{-1}) and medium in available phosphorous (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 organic carbon status was estimated as 0.91 per cent.

The plot size was 6 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 %), Rock Phosphate (20 %) and Muriate of Potash (60%) 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 eight treatments experimented in this study are detailed in table 1. The KAU Package of Practices nutrient recommendation for 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 were attempted 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 yield attributes and yield were recorded and thereafter net returns as well as B: C ratio were worked out. The soil properties of the cropped field after crop harvest were estimated for pH, organic carbon and available N, P and K nutrients following standard procedures. Further the data generated from the study were subjected to statistical analysis (Panse and Sukhatme, 1967)

RESULTS AND DISCUSSION

Yield attributes

Time of bunch emergence

The data on the time of bunch emergence of *Nendran* banana managed under different crop nutrition are presented in table 2**.** Bunch emergence was significantly early and comparable with treatments T_4 (183.33 days), T_5 (187 days) and T_1 (191 days). This could be attributed to the well balanced plant nutrition for these treatments supplying major as well as micro nutrients. Increased availability of plant nutrients in the rhizosphere as ensured with soil addition and the quick entry of nutrients into the plant system as assured with foliar application leads to better and faster plant growth and earliness in bearing as reported by several scientists who experimented with soil and foliar nutrition in a conjunctive manner (Mustaffa and Kumar, 2012; Uma and Karthik, 2017). Krishnamoorthy *et al*. (2017) reported an earliness of 13 days with regard to shooting of *Poovan* banana when the recommended dose of fertilizers were supplemented with soil and foliar application of micro nutrients. Bunch emergence was considerably delayed up to 234.33 days in treatment T_7 which was comparable to T_8 (223 days). This could essentially be related to the poor supply of nutrients leading to slower growth and delay in attaining the reproductive phase.

Crop duration

Data on total crop duration recorded for different treatments (Table 2) followed a similar trend as that with time of bunch emergence. In treatment T_7 (Foliar nutrition using 19:19:19 (0.5%) alone at monthly intervals apart from soil application of basal organics), the crop duration was significantly prolonged up to 324.33 days. The treatment T_8 also registered prolonged duration of 313.67 days. This could definitely be related with the reduced addition of plant nutrition which influenced the crop physiology leading to slow growth and prolonged crop harvest.

Table 1: Treatment combinations

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 + KAU Banana micro mix (1%) foliar spray at 3 MAP
T_5	T_2+ KAU Banana micro mix (1%) foliar spray at 3 MAP
T_6	T_3+ KAU 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 + KAU Banana micro mix (1%) foliar spray at 3 MAP

*Note: *KAU Recommended Nutrient Package - 10 kg FYM + 190:115:300 g N, P and K $plant^{-1}$*

RDF - Recommended Dose of fertilizers - 190:115:300 g N, P and K $plant^{-1}$

Table 2: Effect of treatments on major yield related characters of *Nendran* banana

Treatments	Time of bunch emergence (Days)	Crop duration (Days)	No. of hands bunch^{-1}	No. of fingers bunch^{-1}	Peduncle length (cm)
T_1	191.00	277.00	4.00	39.11	30.00
T_2	192.33	282.00	4.00	38.87	31.50
T_3	192.00	287.00	3.97	37.22	33.00
T_4	183.33	270.00	4.33	41.66	29.83
T_5	187.00	274.00	4.11	40.33	30.60
T_6	192.00	289.00	4.00	37.55	32.00
T_7	234.33	324.33	3.11	28.55	35.60
T_8	223.00	313.67	3.66	29.55	35.17
SEm(±)	**2.587**	**3.251**	**0.098**	**1.154**	**0.564**
LSD(0.05)	**7.922**	**9.957**	**0.354**	**3.521**	**1.690**

Significant earliness in crop maturation was noticed with treatments T_4 (270 days) which was on a par with T_5 (274 days) and T_1 (277 days). T_4 thus had an advantage of one week earliness in crop harvest compared to T_1, the KAU recommended nutrient addition. The role of micro nutrients especially that of zinc in the physiological mechanisms leading to early crop maturity are well established by many scientists. In similar studies, Hafeez *et al.* (2013) reported delayed maturity and late harvest of many crops under zinc deficient conditions. Hence it could be assumed that the right combination of all essential nutrients including micro nutrients provided for T_4 definitely had a favourable influence in the physiology of crop leading to faster growth and early maturity of crop.

Hand and finger numbers bunch^{-1}

Data pertaining to the hand and finger numbers per banana bunch is presented in table 2. Comparable and significantly higher number of hands bunch^{-1} were recorded in treatments T_4 (4.33), T_5 (4.11), T_1 (4.0), T_2 (4.0), T_6 (4.0) and T_3 (3.97). Number of hands bunch^{-1} was significantly inferior for treatment T_7 (3.11) which could be related with the limited nutrient supply provided.

As observed with number of hands bunch^{-1}, treatments T_4 (41.66), T_5 (40.33), T_1 (39.11) and T_2 (38.87) recorded comparable and significantly higher values for number of fingers. These treatments received sufficient quantities of nutrients either as soil application or else conjunctive soil and foliar nutrition which could be well related with the improvement in this yield attribute. The number of fingers bunch^{-1} was found significantly lower for the two treatments T_7 (28.55) and T_8 (29.55) which received only lower doses of nutrients in the form of foliar application at monthly intervals.

Peduncle length

The data on peduncle length of fruit bunches obtained under different treatments is presented in table 2. Significantly shorter peduncle lengths were observed with treatments T_4 (29.83cm) T_1 (30 cm), T_5 (30.6 cm) and T_2 (31.5 cm). For treatments T_7 (35.6cm) and T_8 (35.17 cm), the peduncle lengths were significantly elongated compared to all other treatments. Short or elongated peduncle lengths observed for the same crop variety under different management situations could be related with the difference in nutrient supply. Especially nutrients like potassium are required in necessary levels to produce stronger peduncle. In line with this theory, Mahato *et al.* (2014) reported conspicuously reduced fruit yield in banana under conditions of low potassium with thin and fragile bunches.

Table 3: Yield and economics of *Nendran* banana as influenced by different treatments

Treatments	Yield		Net returns (lakh Rs ha^{-1})	B: C ratio
	Weight Bunch^{-1} (kg)	t ha^{-1}		
T_1	9.00	22.5	4.76	2.12
T_2	8.67	21.67	4.50	2.07
T_3	8.11	20.27	4.00	1.97
T_4	10.14	25.34	5.88	2.37
T_5	9.83	24.58	5.64	2.33
T_6	8.27	20.66	4.14	1.99
T_7	5.62	14.04	1.53	1.37
T_8	5.82	14.54	1.70	1.40
SEm(±)	**0.124**	**0.311**	**0.125**	**0.026**
LSD(0.05)	**0.381**	**0.942**	**0.377**	**0.081**

Yield

Average bunch weight plant^{-1} as well as yield data in t ha^{-1} were worked out and is presented in table 3. Significantly higher and comparable bunch weights were observed with treatments T_4 (10.14 kg) and T_5 (9.83 kg).Well balanced nutrition as ensured with these two treatments could be related with their better yield performance. The increased availability of plant nutrients in the rhizosphere as ensured with soil addition and the quick entry of nutrients into the plant system as assured with foliar application leading to better plant response in terms of enhanced growth and yield has been reported by several scientists who experimented with soil and foliar nutrition in a conjunctive manner (Mustaffa and Kumar, 2012; Uma and Karthik, 2017) and is in agreement with the result of the present study. Bunch weight was significantly reduced in treatments T_7 (5.62 kg) and T_8 (5.82 kg) definitely due to very low addition of nutrients supplied through foliage only that too at longer intervals.

Table 4: Soil properties of cropped field as influenced by different treatments

Treatments	Soil pH	Organic C	Available soil nutrients (kg ha-1)		
			N	P	K
T_1	5.04	0.91	270.38	32.33	255.11
T_2	5.02	0.90	269.23	31.63	252.98
T_3	5.02	0.91	251.18	31.45	251.25
T_4	5.05	0.91	271.99	31.48	257.00
T_5	6.07	0.82	271.02	32.51	252.87
T_6	5.04	0.70	248.78	31.02	240.87
T_7	4.99	0.89	217.35	30.86	193.68
T_8	4.98	0.85	211.55	30.73	196.44
SEm(±)	**0.005**	**0.077**	**8.479**	**0.428**	**11.517**
LSD(0.05)	**NS**	**NS**	**24.523**	**NS**	**20.491**

Yield data in t ha^{-1} followed the same trend as with average bunch weight plant^{-1}. T_4 and T_5 recorded significantly superior and comparable yields of 25.34 t ha^{-1} and 24.58 t ha^{-1} respectively. In treatments T_4 and T_5, in addition to the supply of major nutrients in substantial quantities, micronutrient addition also was ensured which could have directly influenced crop yield. Micronutrients as decisive factors in improving growth and hence yield of banana plant has been reported by researchers like Kadar *et al*. (1992). Soil application of inorganic fertilizers though reduced in T_5, foliar sprays supplying major and micro nutrients were provided and it proved as equivalent to full dose of inorganics with respect to 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 allows for a reduction in the recommended dose of soil applied fertilizers. Crop yield (t ha^{-1}) was significantly reduced in treatments T_7 (14.04) and T_8 (14.54) which could be related with lesser nutrient addition.

Economics of cultivation

Net returns

Net returns were worked out in Rs. ha^{-1}**.** Significantly higher and statistically comparable net income were recorded in treatments T_4 (5.88 lakhs) and T_5 (5.64 lakhs) as presented in Table 3. T_1, the KAU recommended nutrient addition recorded a net income of 4.76 lakhs ha^{-1} and it was on par with the net income of Rs. 4.5 lakhs ha^{-1} generated by T_2 (75% of KAU recommended nutrients + foliar spray of 19:19:19 (0.5%) at 2and 4 MAP). A reduction in the recommended nutrient dose to the tune of 25 per cent, when supplemented with foliar nutrition thus proved equivalent to 100 per cent of nutrient addition in influencing the net income from *Nendran* banana. In both T_4 and T_5, micro nutrient supply was ensured which resulted in yield advantage and hence better economic returns. Several researchers have arrived at similar results of yield enhancement in banana with foliar sprays of micronutrients given in addition to supply of major nutrients. A nutrition trial conducted in KAU by Paul (2015) recorded yield advantage and higher net returns in *Nendran* banana with supplemental foliar application of micronutrients (Zn, Fe, Cu, B and Mo) provided in addition to recommended nutrients. In comparison to the KAU recommended nutrient addition (T_1), net income generated by treatments T_4 and T_5 were respectively 23.53 and 18.49 per cent higher. Net returns were significantly lower for treatments T_7 and T_8 which generated only Rs.1.53 lakhs and Rs.1.7 lakhs respectively on per hectare basis.

B : C ratio

The Benefit: Cost ratios were worked out for each treatment and is presented in table 4. Significantly higher and comparable B:C ratios of 2.37 and 2.33 were obtained with treatments T_4 and T_5 respectively. This was followed by T_1, the KAU recommended nutrient addition (2.12) which was comparable to T_2 (2.07). Significantly lower and comparable B:C ratios were recorded with treatments T_7 (1.37) and T_8 (1.40) which received lesser dose of nutrients.

Treatments T_4 and T_5 received well balanced nutrition including micronutrients and therefore recorded higher yields which contributed to higher B:C ratios. In treatments T_7 and T_8, the yield obtained were low which is attributed to the under nutrition of the crop. This led to decline in returns and hence lower B:C ratio. Also it could be assumed that foliar nutrition in T_5 was efficient enough to generate comparable yields as that with treatment T_4 and hence both the treatments recorded comparable B:C ratios. Narayanan *et al.* (2012) observed higher B:C ratio in tomato when the recommended NPK dose was reduced by 12.5 per cent and supplemented with two foliar sprays of 19:19:19 (2%) given at vegetative and flowering stages.

In both T_4 and T_5, micronutrient supply was ensured which resulted in yield advantage and hence better B:C ratios. Certain nutrition studies conducted by Patel *et al*. in *Basrai* banana during 2010 revealed that micronutrients applied through foliage (0.5% Zn SO_4 and 0.5% Fe SO_4) in addition to the RDF at 3, 5 and 7 months of planting could result in the highest B: C ratio of 1.94 whereas supply of 100 per cent RDF alone could achieve a lower B:C ratio of 1.29 only.

Soil properties of cropped field after harvest

The data on soil analysis with regard to pH, organic carbon and available status of nitrogen, phosphorous and potassium after the experiment are presented in table 4. None of the treatments could significantly influence the pH and organic carbon status of the soil.This could be related with the fact that organic manure addition was uniformly given (FYM @ 10 kg plant^{-1}) for all the treatments. The buffering action provided by the added organic manure might have been sufficient to maintain the pH levels. Also, liming done at the time of land preparation at a common dose which also could be a reason why there was not much fluctuations with soil pH.

The initial status of available nutrients (nitrogen and potassium) in soil were 201 and 200 kg ha^{-1} respectively. Available soil nitrogen was found maintained above the initial status in all the treatments after the cropping phase. The treatments which supplied nutrients through soil addition or through soil + foliar applications (T_4, T_5, T_1, T_2, T_3 and T_6) recorded comparable and higher status of available nitrogen after the experiment. It could be assumed that the supply of nutrients through organics and soil/foliar fertilizer materials were sufficient enough such that the soil reserves were not depleted and soil N was well maintained. In treatments T_7 and T_8, significant decline in soil available N was noticed after the cropping phase which could be related with the reduction in the supply of the nutrient.

Similar trend was noticed with soil available potassium also. Comparable and higher status of potassium were observed in treatments T_4, T_5, T_1, T_2, T_3 and T_6. Significant decline in soil available K (even below the initial status of 200 kg ha^{-1}) was noticed in treatments T_7 and T_8 (193.68 and 196.44 kg ha^{-1} respectively). An insufficient addition of the nutrient might have resulted in depletion of available soil reserves in treatments T_7 and T_8. Several researchers have confirmed potassium as a key element in banana nutrition. Bhalerao *et al*. (2008) reported that the crop intake of potassium is as high as 1500 kg of K_2O ha^{-1}. Potassium requirement for *Nendran* banana is regarded as 1.58 times more than nitrogen as evident from the NPK recommendation of 190:115: 300 g plant $^{-1}$ as per KAU (2016). This could be related with the finding that though soil N was not depleted, soil K was.

The study concludes that recommended NPK fertilizers applied at 25 per cent reduced rate when supplemented with foliar nutrition using 19:19:19 fertilizer mixture (0.5%) at 2 and 4 MAP and KAU banana micro mix (1%) at 3MAP proved as good as 100 per cent recommended NPK + KAU banana micro mix (1%) at 3MAP with respect to improvement in yield attributes leading to better yield and economics of *Nendran banana*. Also, the properties of soil of the cropped field were better maintained under these treatments. 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 good yields, better profits and for maintaining soil nutrient status.

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