Annals of the Sri Lanka Department of Agriculture. 2004. 6:217-226.

INFLUENCE OF NITROGEN ON CROP PERFORMANCES AND LEAF NITROGEN STATUS OF DENSE-PLANTED BANANA

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ABSTRACT

Nitrogen is a key fertilizer input for all the crops and, banana is not an exception. Under the dense-planting situation proper management of nitrogen is essential to obtain a good banana yield. An experiment was conducted at the Grain Legume and Oil Seed Crops Research and Development Centre, Angunakolapellessa in DL1 agroecological region with the objective of identifying the nitrogen management techniques for dense-planted banana. Results revealed that the non-application of nitrogen delayed the flowering of banana by nearly three months. The increase in nitrogen rate from 168 g N per plant to 504 g N per plant did not increase the bunch characteristics or bunch yield. However, application of nitrogen at two months interval at the rate of 168 g N per plant increased the fingers per hand and also the finger weight. Application of nitrogen at higher dosages (> 336 g N per plant) however, reduced the bunch yield by 20%. The leaf nitrogen content in the nitrogen-fertilized treatments remained significantly high compared to the no nitrogen treatment. Split application of nitrogen maintained a higher content of leaf nitrogen throughout the growth demonstrating the better supply of applied nitrogen. Results further revealed that it is necessary to maintain the nitrogen content of the third youngest leaf (lamina-3) greater than 3.0% during the early vegetative stage and around 3.5% at the latter vegetative stage to obtain a good yield.

KEYWORDS: Banana, Nitrogen, Leaf analysis, Lamina-3, Fertilizer.

INTRODUCTION

Banana is the most dominant fruit in Sri Lanka, accounting for nearly 60% of the area under fruit crop cultivation. Due to the increased popularity, most farmers tend to cultivate banana in commercial scale with optimum crop management. Dense-planting is becoming popular in most of the banana growing regions due to higher productivity.

Information available with respect to the nutrient management of banana under local conditions is limited. Nitrogen, the second most important nutrient for banana (Twyford, 1967), should be supplied frequently to assure continuous availability of the nutrient, as it cannot be stored in the corm as many other nutrients (Murray, 1962). Lack of research data regarding nitrogen management under local conditions is a constraint for the development of an effective nitrogen management practice for dense-planted banana. Thus, the present study was undertaken to investigate the influence of nitrogen fertilization on the growth and yield of dense-planted banana grown in the low country dry zone, and also to monitor the changes in nitrogen content in two leaf tissues at various growth stages in relation to different nitrogen fertilizer regimes.

MATERIALS AND METHODS

A field experiment was established at the Grain Legume and Oil Crops Research Centre, Angunakolapelessa of the DL1 agroecological region on Rhodustalfs. The banana cultivar used for the experiment was Kolikkuttu (Silk, AAB groups). Physical and chemical properties of the soil at the experimental site are given in table 1.

Table 1. Physical and chemical properties of the soil.

Property	*Depth*	
	0 – 20 cm	*20 – 40 cm*
pH	5.5	5.5
EC ms/cm	0.02	0.01
K mg/kg (1M NH_4OAc)	175	96
P mg/kg (Olsen)	4.9	5.5
Organic matter %	1.7	1.4
Texture	Sandy clay	Sandy clay

Field experimentation

Banana suckers (2½–3 months old) were planted at a spacing of 1 m (intra row) x 3 m (inter row) following the dense-planting system (Weerasinghe, 2000). In the first four treatments, four levels of nitrogen were applied in 3 splits (4 monthly intervals), each split application containing 0, 56, 112 and 168 g N per plant to each plot (total amounting to 0, 168, 336 and 504 g N per plant). The next three treatments also received the same amounts of total nitrogen but in six splits, where each split contained 28, 56 and 84 g N per plant per split. The experiment was conducted in a Randomized Complete Block Design with four replicates. Each treatment was applied to an experimental plot consisting of five plants. Border rows were left either side of each treatment row. Application of all fertilizer treatments commenced three weeks after planting. Phosphorus was applied only in two stages namely, as the basal dressing and at four months after planting, at the rate of 46 g P_2O_5 per plant for all treatments. Potassium was applied at the rate of 525 g K_2O per plant in three splits. The forms of fertilizer for N, P and K were urea, concentrated super phosphate and muriate of potash, respectively. All border rows were also fertilized with 168 g N, 92 g P_2O_5 and 525 g K_2O per plant. Surface irrigation was practiced in weekly intervals and crop management practices were performed as described by Weerasinghe (2000) for dense-planted banana.

Data collection

Border rows from both sides of the treatment row and two bordering plants on either sides of each treatment plot were left out when data were recorded. Total number of leaves produced was counted periodically. Plant girth was measured at 20 cm above the base and plant height was measured from the base of the plant at the time of harvesting. Bunch weight was recorded after removing the stalk form 25 cm away from the first hand and 10 cm away from the last hand. Mean finger weight and fingers per hands per bunch were determined by taking three fingers each from the three hands of top (second hand), middle and bottom (hand prior to the last hand) of each bunch. Brix values of the ripe fruits were determined using a hand held refractometer.

Leaf and midrib samples were collected from the 3rd youngest leaf (lamina-3 and midrib-3) of the plant according to the international reference method (MEIR) as described by Lahave (1995). Leaf tissue samples were collected from the three centre plants in each plot of four treatments namely, zero nitrogen, 168 g N per plant in 3 splits, 336 g N per plant in 3 splits and 168 g N per plant in 6 splits. Collected samples were washed with tap water followed by the distilled water and dried at 60°C to a constant weight. Both samples were ground to pass a 1.0 mm sieve and nitrogen contents were determined by semi-micro Kjeldhal digestion.

RESULTS AND DISCUSSION

Growth and development of banana, cultivar "Kolikuttu"

Crop performances did not show a marked variation among the nitrogen-treated plots (table 2). The treatment with no nitrogen showed a marked reduction in plant growth when compared to the other treatments. The reduction in plant height at the time of measurement and the time taken to flowering indicated the suppression in growth. Butlar (1960) also reported an increase in plant height due to application of nitrogen in Gross Michael banana. Plant girth at time of harvesting was not markedly affected without nitrogen application. However, crop in the plots without nitrogen application required an excess of three months of the time period to achieve the same girth as in the plots supplied with nitrogen.

The number of days taken for flowering was markedly affected by the nitrogen treatments. Table 2 shows that the time taken for flowering has extended beyond 100 days under no-nitrogen treatment when compared to supply of nitrogen. Arunachalem *et al.* (1976) reported that nitrogen shorten the time from planting to harvesting by nearly one month. Singh *et al.* (1990) also observed an early harvesting with respect Dwarf Cavendish banana due to application of nitrogen fertilizer.

Table 2. Influence of nitrogen fertilizer on plant performances and age at flowering of kolikuttu banana.

Treatment		*Plant girth (cm)*	*Plant height* (cm)*	*Total number of leaves per plant*	*Age at flowering (days)*
N g/plant	*No. of splits*				
0	0	71.2 (± 2.3)	193.8 (± 14.1)	38.2 (± 0.7)	522
168	3	73.8 (± 4.3)	272.4 (± 5.8)	38.1 (± 0.8)	402
336	3	71.9 (± 5.2)	241.9 (± 8.9)	37.4 (± 0.4)	393
504	3	69.8 (± 5.4)	221.7 (± 12.1)	38.2 (± 0.5)	426
168	6	72.8 (± 3.5)	263.3 (± 4.9)	37.6 (± 0.6)	390
336	6	71.1 (± 4.6)	251.3 (± 8.7)	38.6 (± 0.7)	410
504	6	70.8 (± 5.1)	242.2 (± 10.6)	37.6 (± 0.8)	403

*At 11 months after planting; Values in parentheses are standard errors of the estimates.

Although the total number of leaves produced was not markedly affected by the treatments, the extended growing cycle of nitrogen increased the time between the emergence of two leaves. In no nitrogen treatment, this was nearly two weeks while for the rest the time period was around 10 days. Murray (1962) showed that the absence of nitrogen increased the time between two leaves to 20 days in sand culture studies with Dwarf Cavendish banana.

Bunch and Finger Characteristics

The bunch and finger characteristics showed that the application of nitrogen has significantly affected the bunch weight, fingers per hand and finger weight (table 3) in "Kolikuttu" banana. All the tested parameters except the brix value, which represents the total soluble solids, were significantly reduced in the absence of nitrogen. The highest finger weight of 160.7 g was obtained with the nitrogen application of 336 g N per plant (112 g N in 3 splits). The application of a lower rate of nitrogen (168 g N per plant at a rate of 28 g N in 6 splits) in regular intervals, too, produced relatively similar weight of fingers (150.1 g). However, more frequent application of higher rates of nitrogen, *ie.* 84 g N per plant at 6 splits, did not increase the finger weight. This indicates that an uninterrupted and optimum supply of nitrogen is necessary to obtain the highest finger weight in "Kolikuttu" banana. The effect of nitrogen on increasing the number of hands and finger weight has also been reported by Butlar (1960), Mitra and Dhue (1988) and Singh *et al.* (1990).

Table 3. Influence of nitrogen and its frequency of application on bunch characteristics of "Kolikuttu" Banana.

Treatment		*Finger wt.*	*No. of Fingers*	*Brix value*	*Bunch*
N g/plant	*No. of splits*	*(g)*	*per hand*		*weight (kg)*
0	0	119.5	11.0	21.7	8.65
168	3	135.4	13.5	21.9	14.18
336	3	160.7	13.3	21.9	14.10
504	3	133.7	13.6	23.2	11.88
168	6	150.1	13.9	22.2	14.08
336	6	136.2	12.9	23.2	11.65
504	6	132.0	13.1	23.0	11.40
SED (df= 18)		8.91	0.66	NS	1.45
CV%		9.11	7.21	4.4	16.7

SED – Standard error of the difference; NS – Not significant

Application of nitrogen also increased the bunch weight (table 3), where a yield reduction was observed with the increase in level of nitrogen beyond total of 336 g N per plant applied in three splits. Though 112 g N per plant applied in three splits (336 g N per plant) did not reduce the bunch weight (table 3), application of 56 g N per plant in six splits (336 g N per plant) reduced the bunch weight and associated bunch characters. The highest bunch weight for plots that received nitrogen in six splits was obtained with 168 g N per plant. This result, too, indicates that the nitrogen supply should be maintained at an optimum level to obtain higher yields in "Kolikuttu" banana. Many authors (Samuels *et al.*, 1978; Kholi *et al.*, 1985) also reported a yield reduction in *Musa* due to the application of excess nitrogen.

Tissue Nitrogen content

The nitrogen contents of the lamina-3 and also the midrib-3 at various stages of the crop growth are shown in figures 1 and 2. The changes in nitrogen content of the lamina-3 showed a similar pattern irrespective of the nitrogen treatment. In all the treatments where the lamina-3 nitrogen content was monitored, there was an increase in nitrogen content at five months and a reduction at seven months and again an increase by 10 months except for the treatments that received six splits. This shows a heavy loading of nitrogen in lamina-3 during the vegetative phase (<5 months) followed by a decrease in the concentration (5-7 months) due to the rapid increase in dry matter caused by the faster growth. Thereafter the rate of growth slowed down but the uptake and loading in leaves continued. Mitra and Dhue (1988) reported a continuous uptake of nitrogen up to shooting in banana. Ram and Prasad (1985) observed an increase in the content of nitrogen up to flowering in banana. Figure 1 illustrates that the content of nitrogen in fertilized treatments was always significantly higher ($p<0.05$) when compared to the no-nitrogen treatment. Application of nitrogen in six splits have maintained the N content of the third youngest leaf (lamina-3) always at a higher level, when compared to applying

N at a 2-fold concentration of the said amount in three splits, during the vegetative stage. This indicates that nitrogen fertilizer is more efficiently absorbed and distributed within the plant when the frequency of application increases. This is in agreement with the data shown in finger and bunch weight, too (table 3). Therefore, more frequent application of nitrogen could be beneficial in growing banana under local conditions.

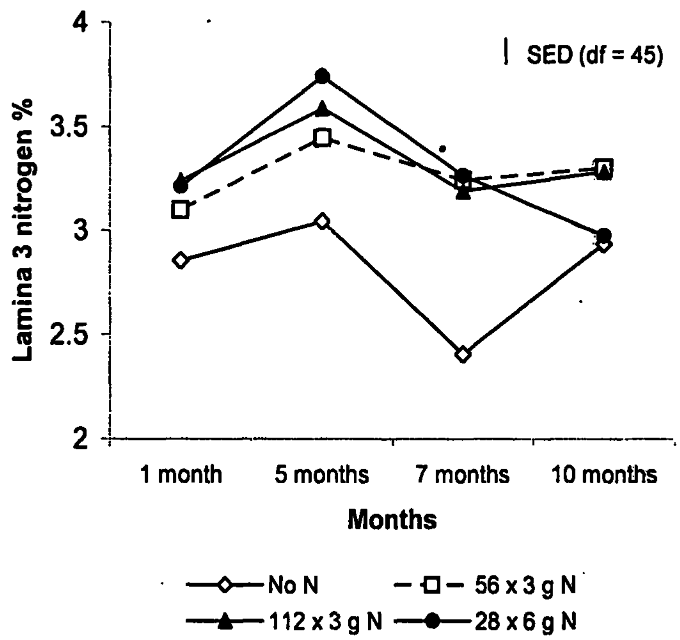

Figure 1. Changes in lamina-3 nitrogen content as affected by the different nitrogen fertilizer treatments (SED – Standard error of the difference).

Unlike in lamina-3, nitrogen content in midrib-3 continued to drop from the first month onwards (figure 2). Similar to N content in lamina-3, increase in number of split applications of N fertilizer helped maintain higher nitrogen content in the midrib-3. The nitrogen content in the midrib-3 was significantly reduced ($p<0.05$) in the no-nitrogen treatment when compared to the rest of the treatments, except at the 10^{th} month after planting.

The difference in the behavior of the nitrogen content of the two leaf tissues could be attributed to the differences in the growth of the plant. Kholi *et al.* (1985) reported that the application of nitrogen increases the biomass production in leaves, rachis and flower buds, whereas the lack of nitrogen supply confine the biomass production to the rhizome and the pseudo-stem.

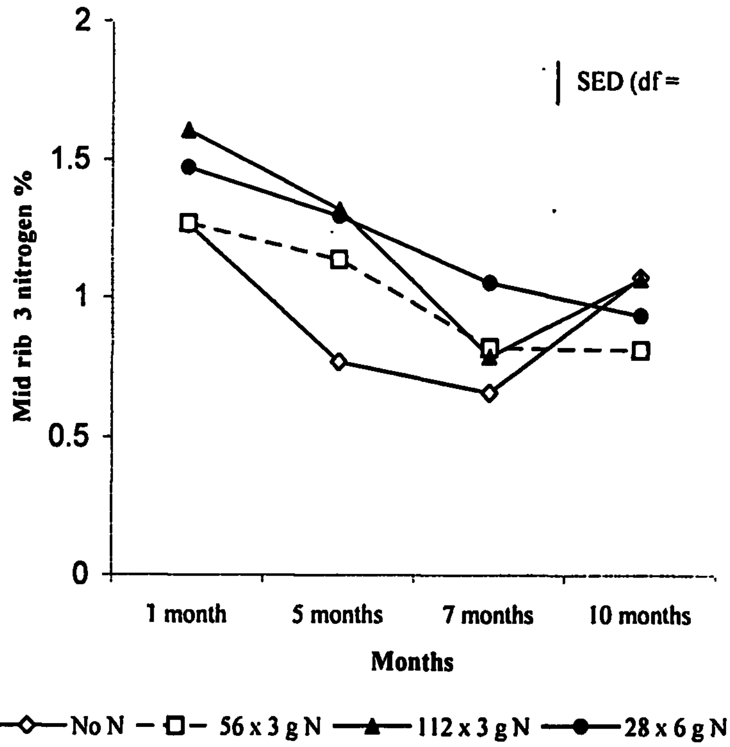

Figure 2. Changes in midrib-3 nitrogen contents as affected by different nitrogen fertilizer treatments (SED – Standard error of the difference).

Crop yield as affected by the tissue nitrogen content

Figure 3 illustrates the changes in bunch yield as affected by the N content in lamina-3 at various stages of the growth. A higher content of nitrogen in the lamina-3 was maintained at 5 months after planting (MAP) in "Kolikuttu" banana when compared to 1, 7 and 10 (MAP). Figure 3 further shows that it is desirable to have > 3.5% nitrogen in lamina-3 at 5 months to obtain a higher yield from "Kolikuttu" banana. However, at the other stages of growth, the N content in lamina-3 should be maintained > 3.0% (figure 3).

Hewitt (1955) reported that 2.6% N in leaf is adequate for banana while Murray (1962) showed that < 1.5% nitrogen is deficient for banana. Bhangoo *et al.* (1962) obtained the highest yield in Giant Cavendish banana grown in Honduras with 2.8% nitrogen in lamina. Mithra and Dhua (1988), too, reported that at 5 month of age, lamina-3 should have a minimum of 3% nitrogen. Figure 4 illustrates the associations of the N content in midrib-3 with the crop yield. Unlike in the case of lamina-3, higher nitrogen contents in midrib–3 were observed at early vegetative stage (1 month) than later (5 months). Figure 4 also shows that the nitrogen content in the midrib-3 should be > 1.3% at very young growth stages (< 1 month) more than 1.0% at 5 months to obtain higher "Kolikuttu" yields.

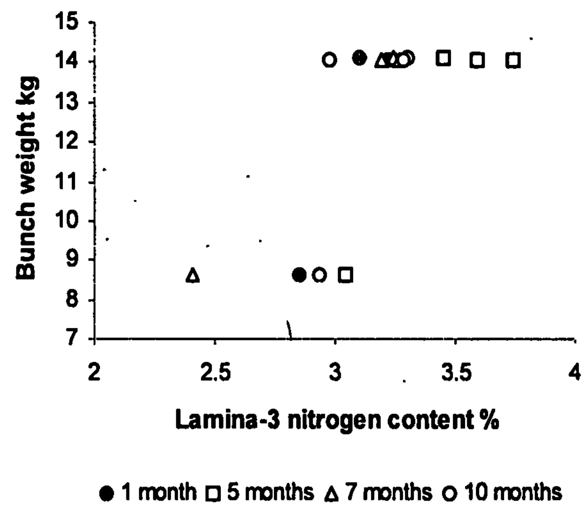

Figure 3. Bunch yield of "Kolikuttu" banana as affected by the nitrogen content in lamina-3.

The optimum leaf nitrogen content recorded in the present study is in agreement with the values reported for banana by other authors (Arunachalam *et al.*, 1976; Lahave, 1995). However, the results showed that the optimum levels of nitrogen in lamina-3 and midrib-3 to be maintained in banana varieties vary with the crop age. This aspect should be taken into account in leaf analysis-based nutrient recommendation programs for banana.

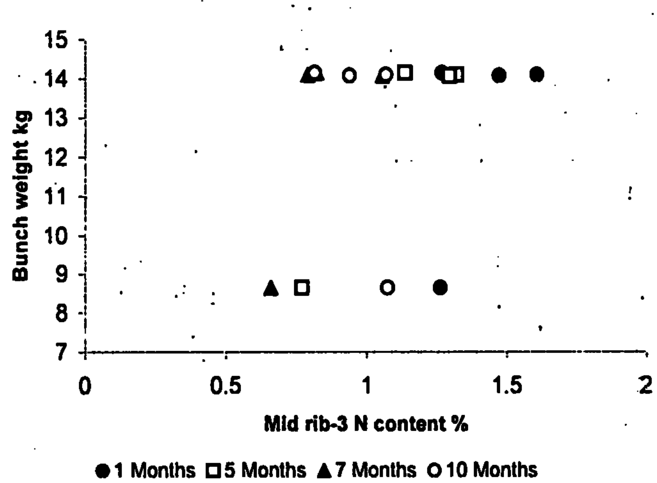

Figure 4. Bunch yield of "Kolikuttu" banana as affected by the nitrogen content in midrib-3.

CONCLUSIONS

Application of nitrogen fertilizer significantly improved the bunch yield and the bunch characteristics of "Kolikuttu" banana. However, application of nitrogen fertilizer at higher dosages (> 336 g N per plant) in three splits reduced the bunch weight. Lower quantities of nitrogen fertilizer (168 g N) applied in more splits, too, produced similar bunch weight in "Kolikuttu" banana indicating that nitrogen should be supplied at the optimum rate to meet the plant demand. Although nitrogen applied at higher number of splits did not increase the bunch yield, it helped to maintain higher leaf nitrogen content and a desirable finger weight. Results showed the necessity to maintain the nitrogen content of the third youngest leaf (lamina-3) at 3.5% at five months of age (early vegetative stage) and at 3.0% during the rest of the growth cycle in order to obtain higher yields form "Kolikuttu" banana.

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