The effect of different NPK levels on growth and nutrient uptake of 'Dwarf Cavendish' bananas.

S.F. DU PLESSIS*

EFFET DE DIFFERENTS NIVEAUX DE N, P ET K SUR LA CROISSANCE ET LE PRELEVEMENT D'ELEMENTS MINERAUX PAR LE BANANIER 'PETITE NAINE'

S.F. DU PLESSIS.

Fruits, Jan. 1987, vol. 42, n° 1, p. 53-58.

RESUME - Pour déterminer le rôle de NPK sur la croissance et l'absorption minérale du bananier, 12 grands pots contenant chacun 3 000 kg de sol vierge ont été installés dans une bananeraie et ont reçu toutes les combinaisons possibles de 2 niveaux de N et P et 3 niveaux de K. On a mesuré régulièrement la croissance et, à la récolte, analysé séparément les souches, pseudo-troncs, feuilles et régimes.
La croissance optimum ne fut obtenue qu'en présence simultanée de N, de P et de K. L'apport excessif de N en présence de P et K réduisit la croissance, alors que l'excès de K ne la réduisit pas. Les apports de N ont augmenté le prélèvement de N, P, K et Zn mais diminué celui de Fe, Mn et B. Les apports de K ont augmenté le prélèvement de la plupart des éléments nutritifs. Le potassium s'est montré l'élément le plus important pour la culture bananière, suivi en ordre décroissant de N, Ca, Mg et P.

INTRODUCTION

The object of this pot experiment was to determine the role played by nitrogen, phosphorus and potassium in the growth of the banana plant. For this purpose growth measurements were made at regular intervals; finally the plants were completely harvested and the different plant parts analysed separately to determine nutrient uptake and accumulation.

The role of P and K in banana production could not be determined in field experiments (DU PLESSIS, LANGENEGGER, KOEN, KUHNE and SMART, 1977 and KOEN, SMART and KRUGER, 1976) due mainly to the fact that these experiments were done on «old» banana soil with relatively high P and K status. Furthermore, virgin soil with a low P and K status was not available for field experiments. Therefore, it was decided to do a pot experiment with a soil low in P- and K- status.

* - Citrus and Subtropical Fruit Research Institute, Nelspruit.

Communication présentée au 3e Séminaire international sur la Nutrition du Bananier, Nelspruit, Afrique du Sud, août 1982.

By using large pots in the banana plantation, field conditions could be maintained throughout the growing cycle of the plants. Furthermore, all inputs were controlled and leachate collected which enabled a complete nutrient balance sheet to be drawn up.

METHODS OF INVESTIGATION

Twelve large pots with a capacity of 2 300 l and a diameter of 0,9 m were used and placed in the plantation, protruding 100-150 mm above the ground level. Each pot was filled with approximately 3 000 kg of a virgin, red, clayey soil with a low P and K status (Table 1). Adequate drainage was assured and the drainpipes at the bottom of each pot connected to a bottle where all leachate could be measured and sampled.

Treatments were combined in a 2 x 2 x 3 factorial with no replicates as follows :

Urea	N_1 = 115 g N/pot
	N_2 = 230 g N/pot
Super phosphate	P_0 = none
	P_1 = 30 g P/pot

TABLE 1 - Characteristics of the soil used in this pot experiment.

Characteristics	Analysis data
pH (1+1 water)	6,0
P (mg/kg)	0,8
K (mg/kg)	102
Clay (%)	40

Potassium chloride K_0 = none
K_1 = 175 g K/pot
K_2 = 350 g K/pot

All fertilizers were applied on the soil. Corms were used as planting material and planted at the same time as the surrounding field.

Pseudostem circumference was measured monthly and leaf samples taken (3rd youngest leaf) for analysis. Soil samples were taken from three depths (0-300 ; 300-600 and 600-900 mm) after harvesting; the plants were then removed completely, divided into four parts (stem, corm, leaves and bunch) which were analysed separately.

RESULTS

Growth curves.

Fig. 1 and 2 indicate the pseudostem growth over a period of 21 months as affected by the different treatments. Stem circumference is increased to a certain extent when either P or K is added to the nitrogen treatment. When both P and K are applied however, the stem circumference increased considerably. The fact that $N_1P_0K_1$ was better than $N_1P_1K_0$ probably indicates that K was in shorter supply than P for this particular soil. The P status was very low at 0,8 mg resin extractable P/kg of airdry soil whereas the K status of 102 mg/kg is probably also in the deficient range for optimum growth.

At the P_0K_0 level, increase in N applications had no effect on growth (Fig. 2). At the P_1K_1 level, however, additional N was detrimental to growth. An increase in K-application at the $K_1P_1K_1$ level was neither beneficial nor harmful to plant growth.

Distribution of nutritional elements in different plant parts.

Table 2 illustrates the average uptake of nutrients by the different plant parts. Notably, potassium is present in the highest quantities in all plant parts and more than twice

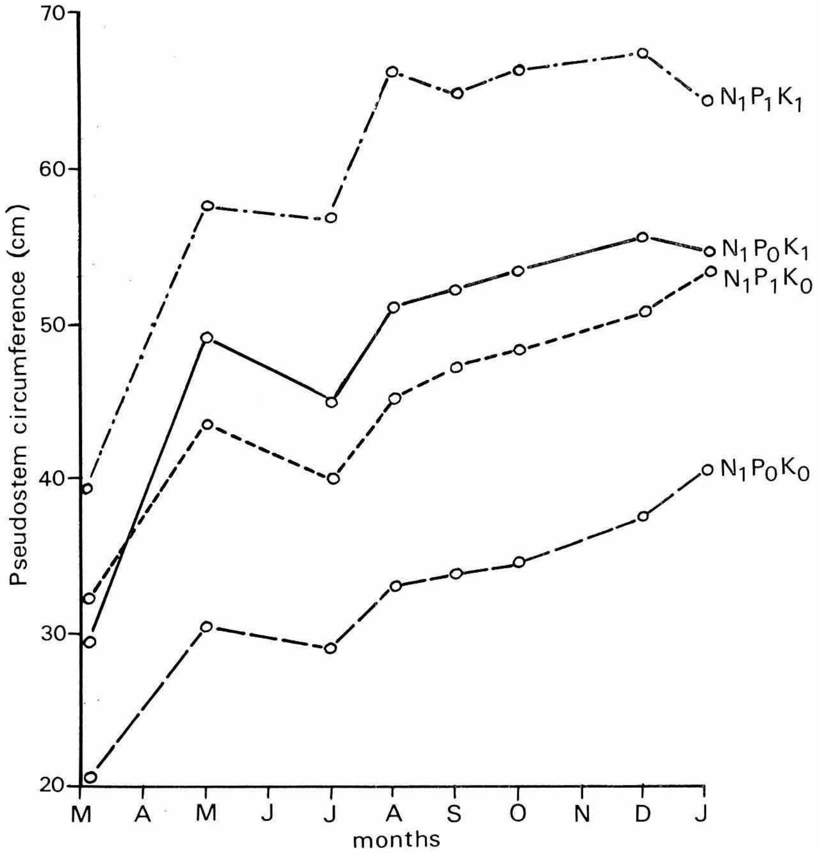

Figure 1 • The effect of different N-P-K levels on stem growth.

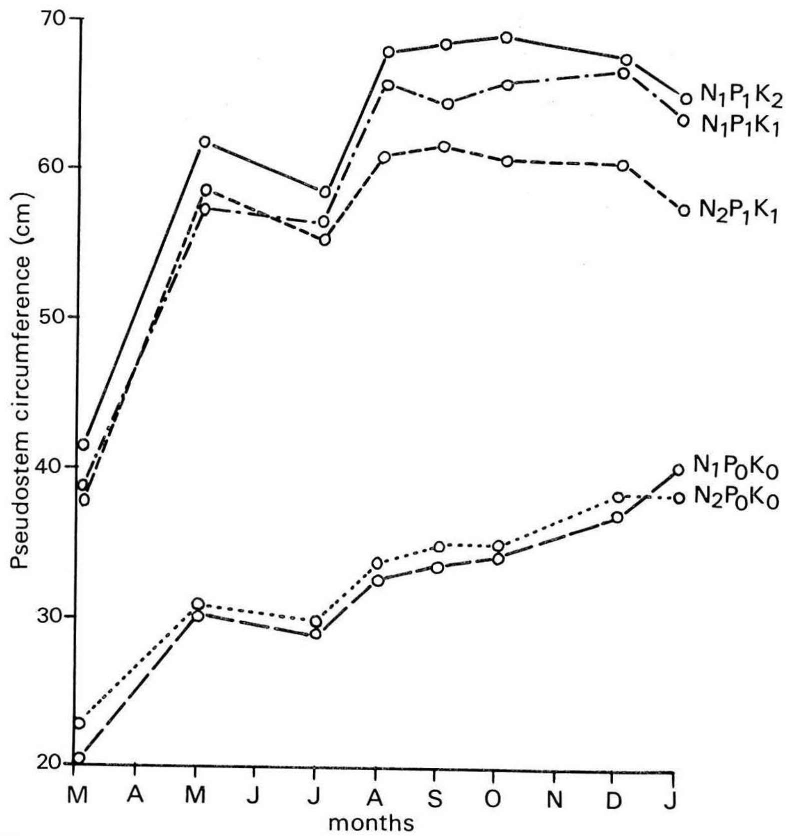

Figure 2 • The effect of (a) different N-levels at constant P and K and (b) different K-levels at the N_1P_1 level on stem growth.

the level of nitrogen, the second most abundant element in these plants. The elements can be ranked in order of total content as follows :

K > N > Ca > Mg > P > Fe > Mn > B > Cu > Zn.

In the case of leaves, K and Ca are present in about equal amounts. Nitrogen is fairly equally distributed between the four plant parts, whereas potassium is present in the largest concentration in the fruit and corm. The high potassium content of the fruit indicates that about one-third of the potassium present in the plant will be removed by harvesting the bunches.

The corm is higher in magnesium content than calcium, whereas the leaves contain about four times as much calcium as magnesium.

As far as the micro-elements are concerned Mn accumulates mainly in the leaves, copper and boron in the corm, and zinc is evenly distributed throughout the plant.

TABLE 2 - Distribution of nutritional elements in the different plant parts, expressed in g/pot.

Element	Plant part			
	Corm	Pseudostem	Leaves	Fruit
N	9,6	7,4	8,1	9,4
P	0,5	0,5	0,5	0,9
K	23,3	17,6	11,8	24,9
Ca	4,8	7,5	11,9	2,6
Mg	5,3	4,3	2,9	1,4
Fe	0,57	0,32	0,24	0,21
Mn	0,11	0,16	0,47	0,05
Cu	0,18	0,02	0,01	0,01
Zn	0,02	0,02	0,01	0,02
B	0,15	0,05	0,05	0,03

TABLE 3 - Effect of increased N-application at the P_1K_1 level on the uptake of different elements.

Treatment	Macro elements (g/pot)					Micro elements (mg/pot)				
	N	P	K	Ca	Mg	Fe	Mn	Cu	Zn	B
$N_1P_1K_1$	50,1	5,0	133,9	46,5	22,5	2087	1191	86	101	408
$N_2P_1K_1$	67,2	4,1	121,6	46,7	22,9	2313	1311	83	88	530
Diff (a)*	17,1	- 0,9	- 12,3	0,2	0,4	226	120	- 3	- 13	122
(b) %	34	- 18	- 9	0	2	11	10	- 3	- 13	30

* - Difference between N_2 and N_1 (a) in g or mg/pot and (b) as percentage ($^a/N_1$ x 100)

The effect on N- and K-applications on the uptake of different elements.

• N-application.

Table 3 shows the effect of increased N-applications on element uptake by the plants. The increased N-uptake with increased N-application can be expected but the decrease in P-, K- and Zn-uptake are noteworthy. Calcium, magnesium and copper remained unchanged, whereas Fe, Mn, and especially B are increased fairly significantly despite a decrease in growth.

• Potassium applications.

Although increased K-applications at the N_1P_1 level had virtually no effect on plant growth, the effect on nutrient uptake is considerable (Table 4). The uptake of N, P, Fe, Mn, Cu, Zn, and B increased sharply (by more than 50%), Ca was increased by 18%, whereas Mg remained almost constant.

At the N_2P_1 level, increased K-applications improved growth and improved the uptake of all elements including Mg. These improvements in element uptake were comparable to those obtained at the lower N-level (N_1P_1).

Midrib analyses.

The whole midrib of the third youngest leaf was analysed periodically during the growing cycle of the plants. From the data (Table 5) it is evident that Mg, Ca and P show very little variation in concentration from about 10 months prior to flowering to flowering ; potassium levels vary considerably but tend to decrease over the period. Nitrogen levels vary less but tend to increase especially during the first 4 months of the 10 month period.

Soil studies.

• Leaching of the P and K in the soil profile.

In Table 6 the effect of the increased N-, P- and K-applications on the movement of P and K in the soil profile are indicated. The increased K-applications have increased the soil K-levels considerably in both the top - and subsoil. High K-levels even occurred at 600-900 mm depth, which is notable keeping in mind the relatively high clay content of this soil (40% clay). Very little movement of phosphorus occurred. The pH was lowered slightly by N-applications.

• Leaching of elements from the pots.

Analysis of the leachate indicates that very little leaching of nutritional elements from the pots occurred (Table

TABLE 4 - Effect of increased K-applications at the N_1P_1 and N_2P_1 levels on uptake of different elements.

Treatment	Macro elements (g/pot)					Micro elements (mg/pot)				
	N	P	K	Ca	Mg	Fe	Mn	Cu	Zn	B
$N_1P_1K_1$	50,1	5,0	133,9	46,5	22,5	2087	1191	86	101	408
$N_1P_1K_2$	79,7	7,7	238,5	55,0	23,2	3901	1890	133	190	906
* Diff (a)	29,6	2,7	104,6	8,5	0,7	1814	699	47	89	498
(b) %	59	54	78	18	3	87	59	55	88	122
$N_2P_1K_1$	67,2	4,1	121,6	46,7	22,9	2313	1311	83	88	530
$N_2P_1K_2$	95,9	6,9	242,6	50,7	25,0	3540	2239	113	165	744
* Diff (a)	28,7	2,8	121	4,0	2,1	1227	928	30	77	214
(b) %	43	68	100	9	9	53	71	36	88	40

* - Difference between K_2 and K_1 (a) in g or mg/pot and (b) in percentage ($^a/K_1$ x 100)

TABLE 5 - Analysis of the midrib of the third youngest leaf sampled during the growth cycle (average for 12 pots).

Month	Macro elements (g/pot)					Micro elements (mg/pot)			
	N	P	K	Ca	Mg	Fe	Cu	Zn	Mn
February	15,4	1,19	46,5	16,3	4,9	248	16	24	262
May	29,0	1,38	27,1	16,1	5,3	105	12	14	586
June	33,4	1,62	38,2	16,3	5,0	126	16	16	844
August	27,1	1,67	24,5	14,3	4,6	167	17	19	818
September	29,2	1,40	31,6	13,6	5,0	155	18	16	511
October	32,9	1,65	31,8	14,2	4,6	221	19	18	505
December	32,2	1,48	26,1	18,6	4,9	193	15	17	916
Mean	28,5	1,48	32,3	15,6	4,9	174	16	18	635

TABLE 6 - The effect of the P- and K-treatments on the leaching of P and K in the soil.

Element (mg/kg soil)	Treatment	Depth of sample (mm)		
		0 - 300	300 - 600	600 - 900
K	K0	102	85	74
	K1	324	159	107
	K2	991	342	235
P	P0	0,8	0,4	0,4
	P1	7,6	0,8	0,5

TABLE 7 - The effect of N- and K-applications on the leaching of macro elements and zinc from the pots.

Treatment	Macro elements (g/pot)				Zinc (mg/pot)
	N	K	Ca	Mg	
N1	1,21	2,65	66,6	19,7	200
N2	0,96	4,92	108,0	30,8	186
K0	1,84	2,30	69,2	19,0	20
K1	0,45	2,92	71,6	18,8	112
K2	0,97	6,71	121,2	38,1	446

7). Increased K-applications, especially at the K_2 level, caused a sharp increase in K-, Ca- and Mg-concentration in the leachate. The amount of zinc leached from the soil with high applications of K is notable; no other micro-elements were leached from these pots.

DISCUSSION AND CONCLUSIONS

Plant growth.

The effect of potassium on growth of the banana plant has been indicated by several researchers e.g. JAMBULINGAM, RAMASWAMY and MUTHUKRISHNAN (1975), and TURNER and BARKUS (1980). In the present investigation it was shown that K influenced the pseudostem growth but that optimum growth only occurs in the presence of adequate amounts of N and P (Fig. 1). Furthermore, an increase of K above the optimum level (Fig. 2) had no effect on growth. With too high a level of N (230 g), on the other hand, a reduction in growth occurred, stressing the importance of maintaining optimum nitrogen levels in the plant. This concurs with the observation made by RAMASWAMY and MUTHUKRISHNAN (1974) that production is lowered when the plant received more than 150 g of N per cycle.

Nutrient uptake.

Quite remarkable effects of applied N and K on the uptake of the other elements were observed. K-applications increased the uptake of most nutritional elements, whereas N-applications increased N, P, K and Zn uptake but decreased Fe, Mn, and B uptake. This is in contrast to the claim by RANDHAWA, SHARMA, KOHLI and CHACKO (1973) that P and K applications did not influence the N and P content in the leaves. DU PLESSIS *et al.* (1977) stressed the point that no reaction to P and K applications can be expected if a particular soil contains fairly large amounts of these elements. It is evident from Table 1 that the soil used in the present experiment was very low in both P and K.

MURRAY (1980) claimed that lower N-levels increased the P content of the plants, whereas lower K-levels tend to decrease both P and Ca content. This is in agreement with the present observations.

Leaching.

It was demonstrated that potassium movement in the soil can be fairly significant despite the relatively high clay content of the soil. Phosphorus on the other hand showed very little (if any) downward movement. This implies that, if necessary, deep placement of phosphate before planting is very important, but that K-applications can be done after planting as a topdressing. GODEFROY, MULLER and ROOSE (1970) even recommended that N and K applications should be made more than once a year to reduce the possibility of leaching to a minimum.

REFERENCES

DU PLESSIS (S.F.), LANGENEGGER (W.), KOEN (T.K.), KUHNE (F.A.) and SMART (G.). 1977.
Bemestingsproef met piesangs ('Dwarf Cavendish') in die Burgershall-area.
Citrus and Subtrop. Fruit J., 521, 5-8.

GODEFROY (J.), MULLER (M.) et ROOSE (E.). 1970.
Estimation des pertes par lixiviation des éléments fertilisants dans un sol de bananeraie de Basse Côte d'Ivoire.
Fruits, 25, 403-423.

JAMBULINGAM (A.R.), RAMASWAMY (N.) and MUTHUKRISHNAN (C.R.). 1975.
Studies on the effect of potassium on Robusta banana.
Potash Review, Subject 27, no. 4.

KOEN (T.J.)., SMART (G.) and KRUGER (J.J.). 1976.
Bemestingsproef met piesangs ('Dwarf Cavendish') in die Levubu-area.
Citrus and Subtrop. Fruit J., 515, 5-7.

MURRAY (D.B.). 1960.
The effect of deficiencies of the major nutrients on growth and leaf analysis of the banana.
Trop. Agric., 37, 97-106.

RAMASWAMY (N.) and MUTHUKRISHNAN (C.R.). 1974.
Correlation studies in the nutrition of 'Robusta' banana.
Indian J. Hort., 31, 145-147.

RANDHAWA (G.S.), SHARMA (C.B.), KOHLI (R.R.) and CHACKO (E.K.). 1973.
Studies on nutrient concentration in leaf tissue and fruit yield with varying planting distance and nutritional levels in 'Robusta' banana.
Indian J. Hort., 30, 467-474.

TURNER (D.W.) and BARKUS (B.). 1981.
Some factors affecting the apparent root transfer coefficient of banana plants (CV. ,Williams').
Fruits, 36, 607-613.

NOTE DE LA REDACTION

Les effets prononcés de la fumure potassique sur le bananier 'Petite Naine' ont été démontrés longtemps avant les travaux cités dans l'article, notamment par l'IRFA en Guinée (PELEGRIN, 1953). Par ailleurs les bilans totaux réalisés sur des bananiers 'Petite Naine' de dimensions moyennes, en conditions normales de culture, montrent généralement des prélèvements de N, P, K un peu plus élevés que ceux présentés ici (cf. notamment MARTIN-PREVEL et TISSEAU, 1962).

***

Strong effects of potassium fertilizing on 'Dwarf Cavendish' bananas have been shown long before the cited references, in particular by IRFA in Guinea (PELEGRIN, 1953). On the other hand, total balance sheets conducted on average sized 'Dwarf Cavendish' bananas in normal growing conditions generally reveal N, P and K uptakes somewhat higher than the presented figures (see for instance MARTIN-PREVEL and TISSEAU, 1962).

***

PELEGRIN (P.). 1953.
L'utilisation des engrais en culture bananière.
Fruits, 8 (9), p. 453-458.

MARTIN-PREVEL (P.) et TISSEAU (Renée). 1962.
Les éléments minéraux dans le bananier et dans son régime.
Fruits, 17 (3), 123-128. (English, spanish and portuguese translations in : *Fertilité*, nº 22).