Nitrogen requirements of bananas in South Africa.

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NITROGEN REQUIREMENTS OF BANANAS IN SOUTH AFRICA.
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ABSTRACT - Results of previous fertilizer experiments indicated that the nitrogen requirements of bananas under a subtropical climate are not as high as generally accepted. To prove this point, three experiments were conducted with the sole purpose of determining the optimum N requirements. Five levels of nitrogen were compared in three randomised block experiments. Two were with Dwarf Cavendish, one on a reasonably heavy soil, and one on a light sandy soil. The third, with Williams, was conducted on a heavy soil. In one of the experiments, only the plant crop and ist ratoon crop were analysed and in the other experiments the 2nd ratoon crop was also harvested. The yield in all three experiments were very similar, indicating that the optimum economical quantity of nitrogen required annually is between 56 and 67 g of N/mat. Higher applications were shown to be uneconomical. The optimum yields corresponded with leaf lamina N contents in the sufficiency range of 2,5 to 3 %.

BESOINS DU BANANIER EN AZOTE AU SUD AFRIQUE.
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RESUME - Des résultats d'expérimentations antérieures sur les engrais ont montré que les besoins en azote du bananier en climat subtropical ne sont pas aussi élevés qu'on l'admet généralement. Pour le confirmer trois Essais ont été conduits avec comme objectif la détermination de besoins optimums en N. Cinq niveaux de cet élément ont été comparés sur 3 blocs : deux avec la Dwarf Cavendish, l'un sur sol assez lourd, l'autre sur sol sableux et le troisième bloc avec la variété Williams sur terrain lourd. Dans l'un des essais seul a été suivi le premier cycle et dans les autres la deuxième récolte également a été observée. Les rendements obtenus dans les trois expérimentations étaient très semblables, montrant que la quantité économique optimum de N se situait entre 56 et 67 g de N par plant ; des applications plus importantes n'étaient pas économiques ; les récoltes optimales correspondaient à une teneur en N dans le limbe foliaire de 2,5 à 3 p. 100.

INTRODUCTION

Much research has been done and many papers published on the nitrogen nutrition of the banana. According to Lahav (1980) 21 % of the more than 800 papers on banana nutrition have a bearing on nitrogen. Of these there are only a limited number where large positive effects on yield were obtained with heavy nitrogen applications per se. Holder and Gumbs (1983) in an irrigation and nitrogen experiment found irrigation to be important, but the higher N rates were not significantly better than the lower N x irrigation combinations. Their recommended rate was 280 kg/ha/year. This would be approximately 169 g N/mat/year with 1 666 plants/ha. Melin (1970) obtained an interaction between potassium and nitrogen , but mentioned no direct effect of N. The lowest level of N he used was 160 g N/mat/year.

The most noteworthy response to nitrogen reported in the literature is that of Warner and Fox (1977). In their experiment with «Williams Hybrid» bananas in Hawaii, yields were increased from 30 to about 100 ton/ha/year with increased levels of nitrogen. However, the nitrogen applications were adjusted to maintain the leaf N status of the N4 treatment at a level of about 2,6 %. Although reasonably heavy dressings were made during the first year, the applications in the latter three years were not excessively high. Maximum yields were obtained with applications of 115 to 161 kg N/ha/year with a corresponding leaf N of 2,8 %. These results were obtained on soil reasonably, but not entirely, free of weeds. Therefore taking a plant population of 1 666 mats/ha, this is equivalent to between 69 and 97 g of N/mat/year. This corresponds well with the results of Hernandes, Robaina and Garcia (1981) who found 100 g of N/mat/year to be the best rate for «Giant Cavendish».

In practice, however, the quantities of N applied is usually much higher. Lahav and Turner (1983) estimate it between 250 and 600 kg of N/ha/year (150 to 360 g N/mat/year).

In South Africa applications of 170 g of N/mat or higher are not uncommon, although Du Plessis, Langeneg-

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ger, Koen, Kuhne and Smart (1977) found very little difference in yield between no nitrogen and 136 g N/mat/year, while the fruit in the latter case was slightly smaller in all three years recorded.

In a continious function experimental design with seven levels each of N and K. Langenegger (1982) found that yields in the plant and 1st ratoon crops were improved considerably by potash, but nitrogen applications had no significant effect and excessive nitrogen even tended to reduce yields.

To clear up these conflicting opinions regarding the nitrogen requirements of bananas, it was decided to establish three experiments with the sole purpose of determining the optimum and most economic rates of nitrogen to apply as well as the corresponding optimum leaf N content.

MATERIALS AND METHODS

The following randomised block experiments were planted : on the South Coast of Natal (SC), on a very sandy soil, five levels of nitrogen (0, 56, 112, 168 and 224 g of N/plant/year) were compared. Bananas have been planted on these soils for the previous six seasons. Five Dwarf Cavendish plants were used per plot with guard plants surrounding each plot and there were seven replications. Sufficient phosphate and potassium were applied and nitrogen was given in four dressings during the summer.

At the Burgershall Experimental Station (BH) two identical experiments were planted, the one with Dwarf Cavendish and the other with Williams. These spils have been planted to bananas for the past eight years. The soil in this case is a heavy red soil (> 50 % clay). The five levels of nitrogen were 0, 67,2, 124,4, 181,6 and 248,8 g of N/plant/year. In these experiments four plants were used per plot ; each plot was surrounded by guard trees and each treatment replicated six times. Data taken, were cycle lengths and bunch mass. On the sandy soil (SC) plant height and stem circumference at flowering were also measured. In the other two experiments on the heavy soil (BH) the following data were taken for the 3rd hand of every bunch : mass, number of fingers and mean mass/finger. Leaf lamina samples were taken from the 3rd youngest leaf, i.e. the two half portions on both sides of the midrib in the middle of the leaf, after flowering.

Yield is given in ton/ha and is calculated on a basis of the plant population x total bunch mass including the stalk, and taking 70 % of the total as marketable. The plant populations were 1 666 for the heavy soil (BH) and 2 250 for the sandy soil (SC).

In one of the experiments, only the plant and 1st ratoon crops were analysed while in the experiments with Cavendish and Williams on the heavy soil (BH) the 2nd ratoon crop was also harvested.

The determine how much nitrogen was actually removed, a reasonably large Cavendish bunch of 35 kg, from the 67,2 g N treatment, was dissected, the individual parts weighed, samples taken, dried and analysed.

RESULTS AND DISCUSSIONS

Production.

The yields obtained in the three experiments are given respectively in Tables 1, 2 and 3. It is evident from these results that the response of bananas to nitrogen applications under the conditions of these experiments is not very imposing.

The experiment with Cavendish at Burgershall only showed a significant reduction in yield due to a lack of nitrogen in the plant crop. This effect disappeared for the 1st and 2nd ratoon crops and the total of the three crops were not significantly different. In the adjacent experiment with Williams only a non-significant tendency for lower yields were found where no nitrogen was applied. The average value of the carbon content was 0,14 % C, which can be regarded as just above average. On the South Coast, where a response to nitrogen was really expected, due to the sandiness of the soil, nitrogen significantly increased yields to some extent, but when the total of two crops are considered the effect was not as large as was expected. In this case the control treatment was delayed considerably in its cycling time, but remarkably the growth, as measured by pseudostem height and circumference, was not inhibited by a lack of nitrogen at flowering.

To determine the profitability of nitrogen fertilization, the gross income for each treatment is given in Table 4. From the gross income the cost of the nitrogen applied over the particular period was substracted and the profit due to nitrogen applications calculated on an annual basis. It is obvious that in all three the experiments the lowest level of nitrogen applied gives a reasonable return and it is not economically feasible to apply more than 56 to 67 g of N/mat/annum. It is also clear that under subtropical conditions in South Africa, the increase in gross income that can be expected from applied nitrogen is not likely to be more than 10 %.

The amount of nitrogen removed by a reasonable Cavendish bunch (35 kg) was found to be 64 g.

Leaf analyses.

The nitrogen contents of the lamina samples collected in the various treatments of the two experiments at Burgershall are given in Table 5. The relatively high N values in the control treatments account for the small response obtained by applying nitrogen. The leaf N status of 2,8 % as reported by Warner and Fox (1977) seems to be quite acceptable for the Williams. However, in the case of the Dwarf Cavendish the value seem to be about 10 % higher than for the Williams and a small response was obtained. For the Cavendish, a value between 2,8 and 3 % could be closer to the optimum, although the leaves of the Cavendish do not seem to be as sensitive to increase N application compared to the Williams (Table 5).

It is also evident from Table 6 that by increasing the nitrogen, the potassium content of the leaves is reduced. It is therefore important that applications of the less important plant nutrient, nitrogen (Langenegger, 1982), should not be overdone, as this could have an antagonistic

TABLE 1 - The effect of increased nitrogen applications on the production of Dwarf Cavendish bananas in t/ha (Burgershall).

g N/mat/yr	Plant crop	1st ratoon	2nd ratoon	Total
0	24,6 b	33,5	37,2	95,3
67,2	27,9 a	35,0	38,2	101,1
124,4	27,9 a	34,9	37,8	100,6
181,6	28,9 a	36,2	38,7	103,8
248,8	29,0 a	35,1	37,5	101,6
Mean	27,7	34,8	37,9	100,6
LSD P = 0,05	2,6	NS	NS	NS
P = 0,01	3,5	NS	NS	NS
CV (%)	7,8	12,2	13,1	8,9

TABLE 2 - The effect of increased nitrogen applications on the production of Williams banana in t/ha (Burgershall)

g N/mat/yr	Plant crop	1st ratoon	2nd ratoon	Total
0	28,6	37,8	34,7	101,1 b
67,2	30,9	40,8	35,6	107,3 ab
124,4	30,8	41,3	36,6	108,7 ab
181,6	31,6	44,8	36,5	112,9 ab
248,8	31,9	39,4	38,1	109,4 ab
Mean	30,8	40,8	36,4	107,9
LSD P = 0,05	NS	NS	NS	3,639 (3,62)
P = 0,01	NS	NS	NS	NS
CV (%)	7,2	12,4	6,5	3,87 (3,9)

TABLE 3 - The effect of increased nitrogen applications on the production of Dwarf Cavendish banana in t/ha (South Coast).

g N/mat/yr	Plant crop	1st ratoon	Total
0	19,0 b	25,5 c	44,5 b
56	22,0 a	28,8 b	50,8 a
112	22,1 a	29,2 ab	51,3 a
168	23,5 a	31,6 a	55,1 a
224	22,4 a	29,9 ab	52,3 a
Mean	21,8	29,0	50,6
LSD P = 0,05	2,9	2,7	5,0
P = 0,01	NS	3,6	6,8
CV (%)	12,1	8,3	8,9

effect on the uptake of the more important nutrient for bananas, namely potassium.

CONCLUSIONS

The previous results of fertilizer experiments, which have shown that nitrogen is not as important for the production of bananas under subtropical conditions, have been substantiated. It is clear that nitrogen is only required as a plant nutrient in relatively small quantities. Applications in excess pf 70 g N/mat/year could be uneconomical, and even detrimental, in that it could have an antagonistic effect on the absorption of potassium. The banana also seems to be a very efficient user of soil nitrogen as the quantity removed by a bunch of 35 kg namely 64 g, is very close to the quantity of between 56 and 67 g of N required per plant per annum. It would seem that a booster appli-

TABLE 4 - Profitability of nitrogen fertilization for bananas.

Cavendish (BH-3 1/2 yrs)	kg N applied/ha	Yield t/ha	Gross income (R/ha)	Cost of N (R/ha)	Annual profit due to N (R/ha) *
	0	94,6	30 177	0	-
	382	101,1	32 251	504	R449
	725	99,8	31 836	1 008	R186
	1 059	103,9	33 144	1 512	R415
	1 451	103,5	33 016	2 016	R235
Williams (BH 3 1/2 yrs)	0	101,1	32 250	0	-
	392	107,3	34 229	504	R421
	725	108,7	34 675	1 008	R405
	1 059	112,9	36 015	1 512	R644
	1 451	109,4	35 058	2 016	R226
Cavendish (SC-3 yrs)	0	44,5	14 196	0	-
	378	50,8	16 205	486	R508
	756	51,3	16 365	972	R399
	1 134	55,1	17 577	1 458	R641
	1 512	52,3	16 684	1 944	R181

* - In march 1988 R2,20 = 1 US dollar

TABLE 5 - The effect of increasing levels of N on N content of the lamina (Burgershall).

(a) Cavendish g N/mat/yr	Plant crop	1st ratoon	2nd ratoon	(b) Williams Plant crop	1st ratoon	2nd ratoon
0	2,87 c	2,76	2,96	2,62 c	2,46 c	2,45 c
67,2	2,90 c	2,83	3,10	2,65 bc	2,63 b	2,62 bc
124,4	2,94 bc	2,87	3,10	2,76 a	2,64 b	2,76 ab
181,6	3,10 ab	2,87	3,23	2,75 ab	2,67 b	2,94 a
248,8	3,11 a	2,97	3,19	2,85 a	2,84 a	2,91 a
Mean	2,98	2,86	3,11	2,72	2,65	2,74
LSD P = 0,05	0,166	NS	NS	0,11	0,12	0,18
P = 0,01	NS	NS	NS	0,15	0,17	0,24
CV (%)	4,6	6,4	5,0	3,4	3,8	5,4

TABLE 6 - The effect of increased nitrogen applications on the K content of the lamina 2nd ratoon Burgershall.

g N/mat/yr	Cavendish % K	Williams % K
0	3,53 a	3, 44 ab
67,2	3,45 a	3,54 a
124,4	3,23 ab	3,51 a
181,6	3,19 ab	3,19 bc
248,8	2,93 b	3,05 c
Mean	3,27	3,35
LSD P = 0,05	0,41	0,34
P = 0,01	NS	NS
CV (%)	10,5	8,5

cation of nitrogen, in an organic form such as manure, before planting could be followed by only small annual maintenance applications. However, this quantity is difficult to determine as it could be influenced by various factors such as soil and climate. Therefore the optimum application can only effectively be established by means of regular leaf analysis.

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STICKSTOFFBEDARF DER BANANENPFLANZE IN SÜDAFRIKA.

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KURZFASSUNG - Aus früheren Versuchsergebnissen mit Düngemitteln ist bekannt, dass der Stickstoffbedarf der Bananenpflanze im subtropischen Klima nicht so gross ist wie generell angenommen wird. Zur Bestätigung dieser Erkenntnis wurden drei Versuche mit dem Ziel gefahren, den optimalen N-Bedarf zu bestimmen. Fünf Stickstoffgaben wurden anhand von drei Blöcken miteinander verglichen: zwei mit Dwarf Cavendish, wovon eine auf ziemlich schwerem Boden und die andere auf Sandboden, und der dritte Block mit Williams auf schwerem Boden. Im Verlauf eines Versuchs wurde lediglich der erste Zyklus verfolgt, während bei den beiden anderen auch die zweite Ernte beobachtet worden ist. Die Ernteerträge aller drei Versuche waren sich ziemlich ähnlich und ergaben, dass die wirtschaftlich optimale Stickstoffgabe zwischen 56 und 67 g N je Pflanze liegt, umfangreichere Gaben unwirtschaftlich sind und die optimale Ernteleistung einem N-Anteil in der Blattspreite von 2,5 bis 3 % entspricht.

NECESIDADES DEL BANANO EN NITROGENO EN AFRICA DEL SUR.

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RESUMEN - Resultados de experimentaciones anteriores sobre los abonos han mostrado que las necesidades en nitrógeno del banano en clima subtropical no son tan elevadas como generalmente se admite. Para confirmarlo se han llevado a cabo tres ensayos que tienen como objetivo la determinación de las necesidades óptimas en N. Se han comparado cinco niveles de este elemento sobre 3 bloques : dos con la Dwarf Cavendish, uno sobre suelo bastante pesado, otro sobre suelo arenoso y el tercer bloque con la variedad Williams sobre terreno pesado. En uno de los ensayos sólo se ha seguido el primer ciclo y en los otros también se ha observado la segunda cosecha. Los rendimientos obtenidos en las tres experimentaciones eran muy semejantes, mostrando que la cantidad económica óptima de N se situaba entre 56 y 67 g de N por planta ; aplicaciones más importantes no eran económicas ; las cosechas óptimas correspondían a un contenido en N en el limbo foliar de 2,5 a 3 por 100.