The value of KNO_3, organic manure and poly-feed in a banana plantation under drip irrigation.

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LA VALEUR DE KNO_3, DE LA FUMURE ORGANIQUE ET DU POLY-FEED EN BANANERAIE IRRIGUEE GOUTTE A GOUTTE

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RESUME - On a comparé sur quatre ans le nitrate de potasse KNO_3,le poly-feed et la fumure organique en conditions d'irrigation goutte à goutte. La fumure organique est la plus efficace lorsqu'elle est appliquée conjointement au KNO_3, alors qu'appliquée en même temps que 2.000 kg/ha de poly-feed elle ne parvient à provoquer aucune augmentation supplémentaire de rendement. Le poly-feed utilisé seul s'est montré sans intérêt. On ne peut parvenir au rendement optimal avec une époque de floraison souhaitable qu'en utilisant à la fois le fumier et l'engrais. Ainsi, la fumure organique se montre essentielle en conditions d'irrigation goutte à goutte aussi.

La dose optimale de nitrate de potassium est de 1.000 kg/ha pour les parcelles n'ayant pas reçu de fumier, de 2.000 kg/ha pour les parcelles en ayant reçu.

La culture de plants sains de bananier et l'obtention de rendements optimaux en conditions d'irrigation goutte à goutte paraît réclamer une fertilisation phosphorée régulière. L'engrais appliqué au cours de l'année préparatoire suffit seulement pour les deux premières années de la bananeraie. Ensuite, il faut poursuivre une fertilisation régulière, soit à l'aide d'engrais P solubles fournis par l'intermédiaire du système d'irrigation, soit à l'aide de superphosphates appliqués durant l'hiver.

INTRODUCTION

The drip irrigation system has become common practice in Israeli banana plantations. The main advantages of this technique lie in advancing flowering, shortening the flowering-to-maturation period, and in saving water, all factors of prime importance in the production and marketing of the fruit.

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Drip irrigation is capable of providing the sucker not only with its water requirements but also with nutrients. It has already been shown that this method is likely to give rise to serious nutritional problems, due to the leaching of soluble salts and nutrients from the root zone (3). To assure an optimum level of nutrients in the root zone, a high frequency application rate seems essential. The objective of this work was to determine the optimal nutritional regime under drip irrigation conditions, while endeavouring to reduce fertilizer amounts.

The value of organic manure for banana plantations has long since been established (2). Although under sprinkler irrigation, heavy fertilizing replaced manuring to some extent, the highest yields are always achieved when fertilizers are combined with manure. Moreover, experiments carried out in the coastal plain of Israel, as well as in the Jordan

Valley, showed nitrogen to be more effective if applied together with organic manure (2, 4).

The transition from sprinkler to drip irrigation was not accompanied by a change in the generally accepted manuring practices. The growers continued manuring the whole area, though only part of it was wetted ; consequently, some of the organic manure was not being utilized, which resulted in nutritional deficiencies.

The high cost of organic manure and the amount of manual labor involved in spreading it, together with the change from sprinkler to drip irrigation, raised again, even more acutely, the question of necessity of organic manure application, and the feasibility of its replacement by chemical fertilizers.

Organic manure is thought to improve soil structure by increasing soil aggregation due to the gradual release of certain organic compounds. This effect is restricted to organic manures which are difficult to replace. On the other hand, the contribution of manure to the gradual release of trace elements can be tested by substituting manure by poly-feed fertilizer.

The present work consisted of two experiments ; one was aimed at determining the influence of potassium nitrate (the fertilizers were contributed by Haifa Chemicals Ltd), the effectiveness of which has already been demonstrated in banana plantations under sprinkler irrigation (4). Potassium fixation in the soil and the high K requirement of the banana sucker determined our choice of this fertilizer (KNO_3), known for its high potassium concentration, optimal N/K ratio (1:3.5) and high solubility (1).

The second experiment was aimed at testing the influence of poly-feed (24-0-24) providing N and K together with trace elements, in a balanced available form (chelates).

METHODS

The experiments were carried out in a banana plantation in the northern coastal plain of Israel, during the years 1972-1977. The soil at the site is a brown grumusol with a low lime content. The suckers were planted in the spring of 1972. Planting distances were 2.85 x 3.20 m. The drip irrigation method was employed, with two irrigation lines per row. The dripper discharge was 4 l/h. and the distance between drippers was 1 m.

During the preparatory year the area was treated with 100 m^3/ha farmyard manure, 1000 kg/ha KCl and 1000 kg/ha superphosphate. Subsequently, 45 m^3/ha/year of chicken manure was applied on the soil surface along-side the drippers, in February, to assure its penetration by means of rain action as well as by the drip irrigation.

Fertilizer treatments were given once weekly via the irrigation system. In the first experiment, rates of 0, 500, 1000 and 2000 kg of KNO_3/ha/year were compared.In the second experiment, conducted simultaneously in the same manner, similar levels of poly-feed were tested. This fertilizer contained the following additional minerals (in %) : Mg - 1.0, SO_4 - 1.71, Mn - 0.145, Fe - 0.1, Cu - 0.011, Zn - 0.042, B - 0.076, and Mo - 0.008. All fertilizer treatments were given either with or without manure. The experiments thus included 14 treatments in five randomized block replications. Each plot comprised ten stools arranged in two rows. A single border row served to separate between manure treatments, while two rows separated fertilizer treatments.

TABLE 1 - Effect of KNO_3 level, with and without manure, on banana sucker height (average of years 1972-1976) and on the number of green leaves in spring 1973.

TABLEAU 1 - Effet de la dose de KNO_3, avec et sans fumier, sur la hauteur du plant de bananier (moyenne des années 1972-1976) et sur le nombre de feuilles vertes au printemps 1973.

CUADRO 1 - Efecto de la dosis de KNO_3, con o sin estiércol, sobre la altura de la planta de plátano (promedio de los años 1972-1976) y sobre el número de hojas verdes en la primavera 1973.

KNO_3 (kg/ha/yr) (kg/ha/an) (kg/ha/año)	Height of sucker (cm) Hauteur de la plante (cm) Altura de la planta (cm)		Number of green leaves Nombre de feuilles vertes Número de hojas verdes	
	with manure avec fumier con estiércol	without manure sans fumier sin estiércol	with manure avec fumier con estiércol	without manure sans fumier sin estiércol
0	163 d	159 d	5.6 c	5.2 c
500	181 bc	176 c	6.8 ab	6.0 bc
1000	186 ab	184 ab	7.9 a	7.1 ab
2000	191 a	186 ab	7.9 a	6.9 ab
S.E.	2.6		0.5	

TABLE 2 - Effect of KNO_3 level, with and without manure, on the average banana bunch weight, the number of bunches and the yield per hectare (averages of years 1972/73-1976/77).

TABLEAU 2 - Effet de la dose de KNO_3, avec et sans fumier, sur le poids moyen du régime, le nombre de régimes et le rendement par hectare (moyenne des années 1972/73-1976/77).

CUADRO 2 - Efecto de la dosis de KNO_3, con o sin estiércol, sobre el peso promedio del racimo, el número de racimos y el rendimiento por hectarea (promedio de los años 1972/73-1976/77).

KNO_3 (kg/ha/yr) (kg/ha/an) (kg/ha/año)	Bunch weight (kg) Poids du régime (kg) Peso del racimo (kg)		Number of bunches/ha Nombre de régimes/ha Número de racimos/ha		Yield (t/ha) Rendement (t/ha) Rendimiento (t/ha)	
	with manure avec fumier con estiércol	without manure sans fumier sin estiércol	with manure avec fumier con estiércol	without manure sans fumier sin estiércol	with manure avec fumier con estiércol	without manure sans fumier sin estiércol
0	23.9 b	23.3 b	1720 c	1650 c	39.7d	37.2 d
500	26.0 a	26.2 a	2060 ab	1910 b	49.7 bc	47.2 c
1000	26.3 a	27.2 a	2110 a	2000 ab	53.0 ab	50.5 abc
2000	27.4 a	26.4 a	2150 a	2140 a	55.1 a	51.5 abc
S.E.	0.57		62		1.48	

TABLE 3 - Effect of KNO_3, with and without manure, on banana flowering dates and fruit maturation period (1973-1976).

TABLEAU 3 - Effet de KNO_3, avec et sans fumier, sur la date de floraison du bananier et le temps de maturation du fruit.

CUADRO 3 - Efecto de KNO_3, con o sin estiércol, sobre la fecha de floración del plátano y el plazo de maduración del fruto.

KNO_3 (kg/ha/yr) (kg/ha/an) (kg/ha/año)	Average flowering date Date moyenne de floraison Fecha promedia de floración		Flowering-to-maturation period (days) Intervalle floraison-maturation (jours) Intervalo floración-maduración (días)	
	with manure avec fumier con estiércol	without manure sans fumier sin estiércol	with manure avec fumier con estiércol	without manure sans fumier sin estiércol
0	13/VIIIb	22/VIIIc	125	131
500	10/VIII ab	15/VIII bc	132	131
1000	29/VII a	9/VIII ab	130	129
2000	1/VIII a	9/VIII ab	133	131
S.E. (days)	4		4.4	

The following parameters were recorded yearly, throughout the experiment :

a. pseudo-stem height of followers, measured in the autumn
b. flowering date of each sucker
c. yield, calculated according to bunch weight and number of bunches per hectare
d. flowering-to-maturation period ; and
e. count of green leaves, made in the spring of 1973.

RESULTS

Fertilization with KNO_3.

Increasing the amount of fertilizer and the addition of organic manure brought about a general improvement in the appearance of suckers, which was expressed by their height and by the number of green leaves in spring 1973 (table 1). KNO_3 showed the greatest influence up to 1000 kg/ha.

Fertilizing with 2000 kg/ha induced almost no more imprc vement. As in former experiments (2), the effect on the number of bunches per hectare was greater than on other yield components (table 2).

Manuring showed no effect on the average bunch weight. Conversely, there was an increase in bunch weight in all fertilizer treatments, as compared with unfertilized control plots. However, increasing the fertilizer rate from 500 to 2000 kg/ha KNO_3 with or without manure did not show any additional significant rise in bunch weight.

Notwithstanding the increasing yield following increased fertilization rates, analysis shows that the yield increment lessened when 2000 kg/ha was applied. The influence of manure was constant with all treatments, giving an increased yield of about 2500 kg/ha.

Fertilizing and manuring advanced flowering date. Increased fertilization was effective only up to a rate of 1000 kg/ha KNO_3, 2000 kg/ha failed to induce additional advancement.

Flowering-to-maturation period was uniform in all treatments with the exception of suckers which had received only manure. In that case, the flowering-to-maturation period was advanced by 5 days (non-significant) compared with other treatments (table 3).

Fertilization with poly-feed.

While testing the postulation which attributes the contribution of organic manure to its microelements content, suckers fertilized with poly-feed were found inferior in size and yield to those fertilized with KNO_3. Only when poly-feed was applied at a rate of 2000 kg/ha, were yields and flowering dates equal to those treated with KNO_3 in addition to manure (table 4).

DISCUSSION

The importance of fertilization and manuring on the successful cultivation of banana plantations was again demonstrated. In fact, at the end of the experiment the untreated plots were destined for uprooting ! Practically all recorded parameters were favorably influenced by fertilizing and manuring, although increased fertilizer rates evinced only a relatively minor effect, especially on yields.

Raising the fertilizer and manure levels produced an increase in the number of bunches per unit area, and in the number of green leaves. The large number of suckers and leaves reduced light penetration, and probably the temperature within the plantation. Reduction of light and heat could be expected to cause a delay in flowering and a prolongation of the bunch maturation period. However, while the organic manure and increased fertilizer rates advanced the flowering date, they did not affect the maturation period. A similar influence of fertilization and manuring, *i.e.*, an increased effect of nitrogenous fertilizer on the background of manure, was observed in plantations under sprinkler irrigation (2). It should be noted that under the experimental conditions obtaining, it was not quite clear if N alone was responsible for accelerating plant development, or the combined action of N and K.

The inferiority of suckers treated with poly-feed *vs.* KNO_3 is attributed to the K_2O:N ratio, which is most important to the banana plant (6). The 1:1 ratio found in the poly-feed is considered to be less favorable to the banana

TABLE 4 - Effect of poly-feed (24-0-24+microelements), with and without manure, on average yield and flowering dates of banana (1972-1976).

TABLEAU 4- Effet du poly-feed (24-0-24+ oligo éléments), avec et sans fumier, sur le rendement moyen et la date de floraison du bananier.

CUADRO 4 - Efecto del poly-feed (24-0-24+ microelementos), con o sin estiércol, sobre el rendimiento promedio y la fecha de floración del plátano.

Poly-feed (kg/ha/yr) (kg/ha/an) (kg/ha/año)	Yield (ton/ha) Rendement (t/ha) Rendimiento (t/ha)		Average flowering date Date moyenne de floraison Fecha promedia de floración	
	with manure avec fumier con estiércol	without manure sans fumier sin estiércol	with manure avec fumier con estiércol	without manure sans fumier sin estiércol
500	49.9 ab	46.1 bc	6/VIII bc	13/VIII c
1000	46.2 bc	44.8 c	26/VII ab	3/VIII abc
2000	52.0 a	51.5 a	25/VII a	25/VII a
S.E.	1.5		4 days	

plant than the 3.5:1 ratio in KNO_3 (4).

KNO_3 fertilizer could not replace manure, the importance of which was evident even when 2000 kg/ha fertilizer was supplied. However, in spite of the inferiority of the poly-feed, as pointed out above, its effect, when applied at a rate of 2000 kg/ha, was the same when applied with or without manure. The high cost of this fertilizer, however, renders its substitution for manure, at 2000 kg/ha, unprofitable.

The influence of organic manure cannot be explained merely by the contribution of the N and K contained therein. Manure supplied 240 kg/ha N yearly, which represents 46% of the total N supplied to the suckers receiving 2000 kg/ha KNO_3 and 12 kg/ha K (12 % of total). On the other hand, manure was the sole source of supply of P (280 kg/P_2O_5/ha/yr). This mineral was supplied to the soil only in the preparatory year. In consequence of its utilization by the banana plant, the P content in both the soil and leaves appeared to verge on deficiency ; as shown in both cases by analyses (5). It should be noted that the lack of influence of the poly-feed (24-0-24) may likewise be connected with P deficiency. It has already been established that drip irrigation in banana plantations reduces considerably the P content in the petiole (3), and that organic manure is an important source of this element (4).

The main influence of manure consists in enriching the soil with P and in lowering P fixation. Manure seems to have an effect also on trace elements, but no estimation of this effect has yet been made. The design of the experiment did not enable the determination of which mineral exerts the greatest influence on the banana plant. This problem requires further investigation.

SUMMARY

1. Manure showed the best advantage when applied together with KNO_3. Manuring failed to bring about any additional yield increase, when used together with 2000 kg/ha of poly-feed. Poly-feed, when used alone was found to be unprofitable. Optimal yield with desirable flowering time can be achieved only by using manure together with the fertilizer. Manuring was thus shown to be essential also under drip irrigation conditions.

2. Fertilizer rates were determined within limits of 1000 kg/ha KNO_3 as optimum for plots to which manure was not applied, and up to 2000 kg/ha for manured plots.

3. Cultivation of healthy banana suckers and production of optimal yields under drip irrigation would seem to demand regular P fertilization. Fertilization applied in the preparatory year suffices only for the first two years of orchard life. Thereafter, regular fertilization should be adhered to, either with soluble P fertilizers supplied through the irrigation system or by super-phosphate in winter.

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