UPTAKE OF PHOSPHORUS AND MAGNESIUM AND THE INTERACTION OF PHOSPHORUS WITH OTHER INORGANIC NUTRIENTS IN THE BANANA

BY

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P AND Mg UPTAKE IN BANANA

Mirza

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ABSTRACT

Studies on some phases of nutrition of the Cavendish variety of banana were conducted during 1962-63 on the university campus in Beirut to determine the effect of five levels of phosphorus fertilization on leaf inorganic composition and leaf area and to study the uptake of magnesium from foliar spray. The treatments of the first experiment consisted of zero, 200, 400, 600 and 1000 grams of superphosphate fertilizer applied at the time of planting. Each plant also received 200 grams of ammonium nitrate and 200 grams of potassium sulphate. Leaf samples were taken after eight months and analysed for phosphorus, nitrogen, potassium, calcium, manganese, sodium and iron. Data involving leaf area was also recorded. In the second trial plants were treated with foliar spray of 33.50 grams of magnesium sulphate. Leaf samples taken ten days after spray were analysed for magnesium content.

Statistical analysis of the data revealed

that phosphorus fertilizer applications affected the inorganic composition of the leaves. There was an increase of phosphorus and a tendency of increased manganese. Nitrogen, sodium and calcium were decreased while potassium and iron remained unaffected. It was also found that leaf inorganic composition was influenced by age of leaf in some instances. Calcium and manganese increased with age while phosphorus, nitrogen and potassium decreased with maturity. Iron was not affected by the age of the leaf. It was also revealed that the control plants had sufficient phosphorus and the leaves of different ages had about the same amount of the said element. Under the conditions of this study use of phosphorus fertilizer did not seem to be necessary for securing a nutritional balance in the plant. However, to obtain an increase in leaf area a high amount of superphosphate had to be used. In the second trial it was revealed that foliar sprays of magnesium sulphate tended to increase the magnesium content of the leaf. Also magnesium nitrate spray caused excessive burning to the leaves.

INTRODUCTION

The banana, with its close relative, the plantain, constitutes an important source of food for large number of people in the tropics and other parts of the world (27).

The fruit is highly nutritious being a rich source of minerals and a good source of vitamins with about 20 per cent of the ripe fruit consisting of sugars (9, 10, 18, 20).

World banana covers an area of one million hectars producing 20 million tons of fruit (30). Lebanon grows dwarf Cavendish type variety only which is locally known as "moz hindi" (18). Khalidy and Piquer (18) estimate the area under bananas in Lebanon to be about 2,800 hectars with an annual production of 28,500 tons.

The growth of the banana is rapid and it therefore makes a high demand on nutrients (30). From a survey conducted on banana cultivation in Lebanon (18), it was found that there is a great difference between the amount of phosphorus fertilizer applied by different growers in the same region. Battikhah (3) found that banana grown for his work on nitrogen nutrition showed phosphorus deficiency, and suggested further work using this element for bananas. He also found that his plants were magnesium deficient.

This study was therefore undertaken to find the effect of phosphorus fertilization and foliar sprays of magnesium on the leaf organic composition of the banana as well as the effect of phosphorus on leaf area.

REVIEW OF THE LITERATURE

A limited amount of research has been done on the banana plant compared to other crops. However, some research has been published on a number of phases of the banana (4).

Fertilizer applications and their effect on growth and yield received attention by a number of workers. According to Butler (8) Croucher and Mitchell in 1940 found out that addition of phosphorus to Gros Michel variety in Jamaica failed to produce a response. Hewitt in 1955 (14) investigating the effect of fertilizer on leaf composition found out that with the increase of phosphorus there was no corresponding increase in the phosphorus content of the leaf. In 1960 Butler (8) reviewed experimental results obtained for several years on research conducted at different locations in Honduras and Jamaica. The results showed that the use of phosphorus alone or in combination with potassium and nitrogen did not induce a growth response of economic importance in bananas. The soil phosphorus content of the areas where the said research was conducted was high and varied from 100-600 p.p.m. On the other hand, Simmonds (30) suggested that bananas growing in soils with 10-20 p.p.m. of phosphorus respond to the application of phosphorus fertilizers. The experiments at Honduras also showed that when the growth rate of banana was measured the applications of phosphorus did not cause any significant differences. The addition of phosphorus to the nitrogen fertilizer did not increase bunch weight, it also had no effect on the reduction of the incidence of the Panama disease nor did it reduce the effect of damage due to wind. The soils of the coastal strip of Lebanon where most of the banana is grown were found to be deficient in phosphorus (19). Battikhah in 1962 (3) reported a low level of 1.221 p.p.m. of P_2O_5 in the soil he used for his experiment on bananas on the campus of the American University of Beirut, and results of his leaf analysis showed that the highest level of phosphorus attained was below the level of adequacy set by Hewitt (14). Khalidy and Piquer (18) in their survey of banana plantations on the coastal strips of Lebanon found out that up to 450 grams of pure P_2O_5 per plant was applied by many growers. From reviewing the literature it seems that work on phosphorus uptake and effects is of great importance for the banana industry of Lebanon.

Phosphorus Effects

Phosphorus is essential to plant growth. Bananas in phosphorus deficient soils grow to a certain stage, after which growth stops this might be followed by death of the plant. The cessation of growth is accompanied by loss in leaf color coupled with severe marginal scorching and shrinkage of older leaves, poor root development and the rotting of the base of the corms (30). Frieberg (13) reported that an improper balance of phosphorus in banana tissue caused a very pronounced shrinkage of the developing fruits and the entire suppression of elongation growth and enlargement of leaves.

In general phosphorus deficiency in plants results in restricted top and root growth. Leaves are smaller, shoots are short and thin, the leaves are of dull bluish color coupled with tints of bronze and purple, both blossoming and fruiting are reduced, and the quality of fruit may also suffer. Extreme phosphorus deficiency may result in some leaf yellowing similar to nitrogen deficiency (5, 9, 10, 29).

As regards interaction of phosphorus with other inorganic elements in banana tissue, investigations of Hewitt (14) showed that the content of nitrogen and potassium was significantly lowered by phosphorus application. Murray (24) in 1960 reported that with phosphorus deficiency some accumulation of nitrogen occurred in the young leaves and also a considerable increase in calcium and potassium occurred.

Magnesium Effects

Magnesium is essential for plant growth as it is a constituent of chlorophyl and produces a definite effect on the role of photosynthesis, it is also an activator of many enzymes (9, 23, 26, 29). In general deficiency of magnesium in plants causes chlorosis, and may also cause intervienal and marginal necrosis and a fast rate of abscission of the leaf (10).

In bananas temporary deficiencies of magnesium are thought to cause transient yellow leaf symptoms (2). Magnesium deficiency of banana is characterized by blue-tinged blotching and striation of the petiole and mid-rib (30). According to Simmonds (30) work done in 1953 by Brun and Champion in French Guinea describes magnesium deficiency, which was corrected by application of 2.5 lbs. per plant of magnesium limestone or 0.25 lbs.

per plant of magnesium sulphate.

Due to the fact that little work was done on magnesium uptake in the banana, it was felt that reports on other crops be reviewed. Boynton in 1945 (6) and Southwick in 1946 (32) working on apples reported that leaf magnesium increased after epsom salt spray and the deficiency symptoms were reduced, while Fisher et.al. in 1958 (12) studying apple nutrition in New York showed that addition of epsom salt did not affect magnesium content of the leaf significantly. Lott in 1948 (21) working on muscadine grapes found out that soil and spray applications of magnesium sulphate have generally been ineffective in correcting chlorosis due to magnesium deficiency while Scott and Scott in 1952 (28) working on bunch grapes reported that 0.4 lbs. of magnesium sulphate per gallon of water corrected the chlorotic condition in the grape vineyards and increased magnesium content of the leaves. Embleton in 1959 (11) demonstrated foliage spray of magnesium nitrate to be a promising method for correcting magnesium deficiency of oranges in California. McLung in 1953 (22) reported that abnormalities due to magnesium deficiency in peaches were corrected by application of magnesium.

The workers cited above used many sources of magnesium such as magnesium nitrate, magnesium sulphate, magnesium chloride, magnesium oxide, magnesium acetate and chelated magnesium, although they disagree on the quantity and the method of magnesium application it can however be generalized that magnesium sulphate as a soil fertilizer or foliar spray seemed to be the most promising source of magnesium to overcome magnesium deficiencies in horticultural crops.

Leaf Sampling and Leaf Composition of Banana

Tissue analysis has made a major contribution to agriculture by revealing nutritional problems in the field where none are suspected to exist, this being the only method to apply when lack of response to applied elements may actually be a lack of absorption or utilization (31). The leaf being the site of major chemical activity during the plant's life, analysis of this part of the plant appears to be the most likely indicator of its nutritional status (14).

Most of the work done so far on the banana has been on the first seven leaves (1). Hewitt (14) and Murray (24) have established that the third leaf of the banana plant indicates best the nutritional condition of the whole plant. However for the nutrients that tend to accumulate with the age of the leaf such as calcium, analysis of an older leaf would be preferable (24).

Hewitt in 1955 (14) worked out ranges of values for nitrogen, phosphorus and potassium for optimal growth in bananas and Murray (24) in 1960 worked out the ranges for calcium and magnesium. These ranges appear in Table I below.

TABLE I

PER CENT NUTRIENTS IN THIRD LEAF OF BANANA

	N	P	K	Ca	Mg
Adequacy	2.60	0.20	2.64	1.00	0.36
Severe deficiency	1.50	0.09	2.00	0.54	0.12

Investigations of Hewitt (14) showed that the phosphorus content of the leaf was directly related to the age of the leaf. Battikhah and Khalidy (4) also found that the older the leaf is the less phosphorus it contains (14). They also reported that the third leaf of the banana had 0.26 per cent magnesium which is low as compared to 0.36 per cent magnesium established by Murray (24) to be the critical level for sufficiency.

MATERIALS AND METHODS

This study consists of two experiments both of which were conducted on the campus of the American University of Beirut. In both cases banana plants of the Cavendish variety *Musa nana* were used.

Experiment No. 1

Uptake of phosphorus and its interaction with other inorganic elements

Twenty-five uniform suckers of three to four months of age were purchased from Damour. The roots on examination were observed to be slightly infested by nematodes, this being typical of all bananas grown in Lebanon (17). All unfolded leaves were removed and the suckers planted on the third of December 1961 in 100 litre asbestos cement barrels filled with soil.

For the fertilizer treatments, the plants were divided at random into five groups with five plants in each group. All plants received the same amount of nitrogen and potassium. However, phosphorus was varied to establish its effect on the plant performance. The fertilizer treatments employed in this work were as follows.

Ammonium nitrate:

200 grams per plant in five equal applications of 40 grams each at intervals of 6 weeks.

Potassium sulphate:

200 grams per plant in two equal applications of 100 grams each at intervals of 16 weeks.

Super-phosphate:

Applied in a single dose to plants immediately after planting in varying amounts as seen hereunder:

First group of five plants	zero grams per plant
Second group of five plants	200 grams per plant
Third group of five plants	400 grams per plant
Fourth group of five plants	600 grams per plant
Fifth group of five plants	1000 grams per plant

The superphosphate fertilizer showed upon analysis to contain a total of 16.25 per cent P_2O_5.

To calculate and compare the leaf area and to study the nutritional condition of the whole plant, leaves number one, three, and five were cut and removed on the fifth and sixth of September 1962. Although the trend among investigators is to use leaf number one, three, five and seven (1). The seventh leaf could not be included in this study as half of the plants did not have a seventh leaf. The area of each leaf was acquired by tracing the boundaries of the leaf on a sheet of paper. The weight of a known area of the same paper sheet was determined and the surface area of each leaf calculated.

Experiment No. 2

Uptake of magnesium by banana leaf

Twenty-five uniform plants of three to four months of age were selected and were planted in 100 litre asbestos cement barrels on the sixth of September 1962. No fertilization was done and the plants were allowed to establish themselves. On the 14th of November 1962 magnesium was sprayed on the leaves in the form of magnesium sulphate and magnesium nitrate. The levels of the nutrients sprayed were as follows:

Source	Fertilizer grams/plant	Total magnesium grams/plant
Magnesium Nitrate	12	3.35
Magnesium Nitrate	24	6.70
Magnesium Sulphate	16.75	3.35
Magnesium Sulphate	33.50	6.70

Within a week of the spray all the plants sprayed with magnesium nitrate showed extensive burning damage to the leaves up to an extent of 40 per cent of the total leaf surface. Both the high and the low concentrations caused injury. Leaves sprayed with magnesium sulphate and those that did not receive any nutritional spray continued to grow normally without any damage to the leaves. Due to the fact that magnesium nitrate caused extensive damage, this source of magnesium was excluded from the final trial. In the final trial to supply magnesium through foliar spray to the plants only magnesium sulphate at the rate of 33.50 grams per plant diluted in 500 ml. of distilled water was employed. This amount of magnesium sulphate supplied each plant with 6.7 grams of magnesium. For this study uniform plants of ten to twelve months of age were chosen. They were divided into two groups of five plants each. One group of five plants was sprayed on the 20th of June 1963, the second group of five plants was left as check. On the 1st of July 1963 leaf number three from all the plants in both the groups were cut and removed.

In both the experiments leaves collected were removed to the laboratory, where they were washed, dried and ground according to methods described by Brown (7) and Toth et.al. (33).

The method of analysis for determining the inorganic composition varied for the different elements. Nitrogen content was determined by the Kjeldahl method (15). Manganese, iron, phosphorus, and magnesium were determined colorimetrically with a Beckman Model B Spectrophotometer, while potassium, calcium and sodium were determined spectrophotometrically with a Beckman flame attachment to the Beckman Model DU Spectrophotometer according to methods described by Jackson (16) and Toth et.al. (33). Magnesium determination of the leaves from the first experiment could not be done due to prolonged technical disorder of the Spectrophotometer.

The data obtained are calculated on the dry weight basis and are presented in the tables as percentages.

The method employed in the statistical analysis was the analysis of variance for split plot design in case of the first experiment. Differences in the second experiment were compared on the basis of t test. Both methods are described by Panse and Sukhatme (25). The results and discussion in this study are based on the mean of five replications.

RESULTS AND DISCUSSION

The data acquired during this study are reported separately in two sections. The first section deals with the effect of phosphorus fertilizer on the inorganic leaf composition of the banana, and its effect on leaf area. The second section brings forth the results of the work on the uptake of magnesium through foliar spray.

I. Phosphorus Fertilization

A. Effect on Inorganic Leaf Composition

1. Phosphorus: The result of leaf analysis shows that a significant increase in leaf phosphorus content was achieved in plants receiving phosphorus fertilizer as seen in Table II. Plants treated with 200, 400, and 600 grams superphosphate did not show significant difference among themselves in their phosphorus content. However, the phosphorus content of said plants was significantly higher than plants receiving no phosphorus. The plants that did not receive any phosphorus fertilizer had a mean phosphorus content of 0.23 per cent.

TABLE II

VARIATION IN THE AVERAGE LEAF PHOSPHORUS CONTENT OF THE BANANA AS INFLUENCED BY LEAF AGE AND PHOSPHORUS FERTILIZER TREATMENT

Leaf number / Phosphorus fertilizer (grams)	1	3	5	Mean of treatments
	Percent phosphorus			
0	0.23	0.23	0.22	0.23
200	0.56	0.44	0.22	0.41
400	0.52	0.40	0.22	0.38
600	0.59	0.45	0.46	0.50
1000	0.76	0.66	0.57	0.66
Mean of leaves	0.53	0.44	0.34	

L.S.D. Between means at the 5% level

Treatment = 0.13

Leaf number = 0.09

Hewitt (14) reported that 0.20 per cent leaf phosphorus in the third leaf is an indication of phosphorus sufficiency in banana. This level of sufficiency was achieved in this study with plants receiving no phosphorus fertilizer. From the findings it was established that no phosphorus fertilizer is required under the conditions of this experiment as a sufficiency level was achieved in the leaves of the plants that did not receive any phosphorus fertilizer treatment. Table II further shows that the plants receiving the 1000 grams superphosphate treatment were significantly higher in their leaf phosphorus content than plants receiving the lower amounts of said fertilizer, such plants accumulated in their leaves a mean of 0.66 per cent phosphorus.

When studying the phosphorus content in leaves of different ages, it was found that there was a significant decrease in leaf phosphorus with increase in leaf age. This result is in agreement with the findings of Murray (24), Hewitt (14) and Battikhah and Khalidy (4). It was also established that at zero level of phosphorus application all the three leaves studied had about the same amount of phosphorus. Such phosphorus accumulation in leaves of different ages of the same plant may be used as an indication of phosphorus sufficiency.

2. Nitrogen: Table III shows that all the plants treated with 400 grams or more of superphosphate had a significantly lower nitrogen content than untreated plants, while the plants treated with the lowest concentration, namely 200 grams did not show significant depression in nitrogen content of the leaves. The results are in agreement with the findings of Butler (8) Hewitt (14) and Murray (24). Previously it was brought out under the section of phosphorus that the use of phosphorus fertilizer was not necessary. Also the use of phosphorus fertilizer was found to cause a depression of nitrogen, this element being required in high amounts by the banana. On further examination of Table III it can be seen that none of the treatments depressed the nitrogen level of the third leaf to less than 2.60 per cent the level of adequacy set by Hewitt (14). The distribution of nitrogen in the three leaves studied showed that as the leaves advanced

TABLE III

VARIATION IN THE AVERAGE LEAF NITROGEN CONTENT OF THE BANANA AS INFLUENCED BY LEAF AGE AND PHOSPHORUS FERTILIZER TREATMENT

Leaf number / Phosphorus fertilizer (grams)	1	3	5	Mean of treatments
	Percent nitrogen			
0	3.95	3.34	2.95	3.41
200	3.62	3.15	3.01	3.26
400	3.60	3.03	2.78	3.14
600	3.33	2.67	2.95	2.98
1000	3.45	2.92	2.25	2.87
Mean of leaves	3.59	3.02	2.79	

L.S.D. Between means at the 1% level

Treatment = 0.24

Leaf number = 0.20

in age their nitrogen content decreased significantly. The nitrogen content in leaf one was 3.59 per cent, 3.02 per cent in leaf three and 2.79 per cent in leaf five.

3. Potassium: The application of phosphorus had no effect on the potassium content of the leaf. This can be seen from data presented in Table IV. All the banana plants under this study had in their third leaf more than 2.60 per cent potassium, the level of adequacy set by Hewitt (14). The leaf potassium content was found to decrease rapidly with leaf age. There was a highly significant difference between leaves one, three and five. The amount of potassium found in leaf one was 5.23 per cent while leaf three had 4.47 per cent and leaf five had 3.68 per cent. This is in accordance with the findings of Battikhah and Khalidy (4).

4. Calcium: *The data dealing with calcium in the* leaf tissue of banana are reported in Table V. Calcium in the leaf tended to be supressed when phosphorus fertilizer was applied. Significant results were obtained only in the case of plants receiving 400 grams of superphosphate where calcium was depressed to 0.66 per cent as compared to 1.18 per cent for the

TABLE IV

VARIATION IN THE AVERAGE LEAF POTASSIUM CONTENT OF THE BANANA AS INFLUENCED BY LEAF AGE AND PHOSPHORUS FERTILIZER TREATMENT

Leaf number / Phosphorus fertilizer (grams)	1	3	5	Mean of treatments
	Percent potassium			
0	4.52	5.71	3.63	4.62
200	6.10	4.58	4.01	4.90
400	5.45	3.83	3.62	4.30
600	4.70	4.32	3.75	4.26
1000	5.36	3.92	3.40	4.23
Mean of leaves	5.23	4.47	3.68	

L.S.D. Between means at the		1%	5% level
Treatment	=	N.S.	N.S.
Leaf number	=	0.73	-

TABLE V

VARIATION IN THE AVERAGE LEAF CALCIUM CONTENT OF THE BANANA AS INFLUENCED BY LEAF AGE AND PHOSPHORUS FERTILIZER TREATMENT

Leaf number	1	3	5	Mean of treatments
Phosphorus fertilizer (grams)	Percent calcium			
0	0.60	1.13	1.80	1.18
200	0.50	0.56	2.02	1.03
400	0.71	0.56	0.72	0.66
600	0.53	1.04	1.65	1.07
1000	0.56	1.15	1.45	1.05
Mean of leaves	0.58	0.89	1.53	

L.S.D. Between means at the 5% level

Treatment = 0.30

Leaf number = 0.31

control. This finding is in accord with the results obtained by Murray (24). The data also shows that the application of phosphorus fertilizers was not desirable as this might depress calcium. In the light of this finding, the author wishes to stress once more the fact that the most desirable nutritional balance in the leaves was obtained in the control plants. The data in Table V, also shows that calcium content of the leaves increased significantly with age. The increase was from 0.58 per cent mean of the first leaves to 1.53 per cent mean of the fifth leaves with the third leaves having a mean of 0.89 per cent. This finding agrees with those of Murray (24) and Battikhah and Khalidy (4).

The third leaves of both the plants receiving 200 and 400 grams of phosphorus fertilizer had a calcium content of 0.56 per cent. This very nearly approaches the level of severe deficiency set by Murray (24). However, the control plants and the plants receiving 600 and 1000 grams of phosphorus fertilizer accumulated more than 1 per cent calcium in their third leaves which is given by Murray (24) as the level of adequacy for optimal growth. Battikhah (3) found in his work under similar conditions that only plants deficient in nitrogen were low in calcium. This could further indicate that the phosphorus treatments may have had an effect on calcium although this could not be definitely established.

5. Manganese: The data presented in Table VI shows a definite trend towards increase in the manganese content of the leaf when phosphorus was applied. However, significant results were only obtained when 400 grams of superphosphate was applied. This treatment induced 0.0111 per cent manganese as compared to 0.0060 per cent manganese in the check. The results obtained also revealed that there was a significant increase of this element in the older leaves as compared with the younger leaves. The mean manganese in leaf one was 0.0039 per cent, 0.0087 per cent in leaf three and 0.0149 per cent in leaf five. This clearly shows a significant build up of manganese as the leaf advanced in age, similar cases being reported in the literature (4).

6. Sodium: No work has so far been done on sodium in banana leaf tissue. The data collected from this study on sodium content of banana leaves

TABLE VI

VARIATION IN THE AVERAGE LEAF MANGANESE CONTENT OF THE BANANA AS INFLUENCED BY LEAF AGE AND PHOSPHORUS FERTILIZER TREATMENT

Leaf number / Phosphorus fertilizer (grams)	1	3	5	Mean of treatments
	Percent manganese			
0	0.0040	0.0047	0.0094	0.0060
200	0.0036	0.0069	0.0105	0.0070
400	0.0040	0.0105	0.0187	0.0111
600	0.0042	0.0136	0.0490	0.0109
1000	0.0036	0.0076	0.0208	0.0107
Mean of leaves	0.0039	0.0087	0.0149	

L.S.D. Between means at the 5% level

Treatment = 0.0051

Leaf number = 0.0039

are presented in Table VII. Phosphorus application caused a significant depression of sodium in the leaves. The check plants had a sodium content of 0.1207 per cent while the sodium content of the plants receiving 200 grams superphosphate significantly dropped to 0.1078 per cent. A further reduction to 0.0949 per cent was induced by application of 400 grams of superphosphate per plant. Further depression to 0.0842 per cent occurred in leaves of the plants treated with 600 grams of superphosphate. The sodium content reached the lowest level of 0.0801 per cent when 1000 grams superphosphate per plant was used. Although the sodium content decreased significantly in all the cases when compared to the checks, the decrease between plants receiving 400, 600 and 1000 grams of superphosphate was not significant. However, there seemed to be a trend of a decrease in sodium as the phosphorus fertilizer increased. It was also established that the oldest leaf studied i.e. leaf number five had the highest amount of sodium followed by leaf numbers one and three, respectively.

7. Iron: Phosphorus fertilizer did not influence the iron content in banana leaf tissue. Also, the iron

TABLE VII

VARIATION IN THE AVERAGE LEAF SODIUM CONTENT OF THE BANANA AS INFLUENCED BY LEAF AGE AND PHOSPHORUS FERTILIZER TREATMENT

Leaf number / Phosphorus fertilizer (grams)	1	3	5	Mean of treatments
	Percent sodium			
0	0.1064	0.1187	0.1560	0.1270
200	0.1213	0.0991	0.1030	0.1078
400	0.1028	0.0837	0.0983	0.0949
600	0.0781	0.0809	0.0937	0.0842
1000	0.0789	0.0770	0.0844	0.0801
Mean of leaves	0.0975	0.0919	0.1071	

L.S.D. Between means at the 5% level

Treatment = 0.0150

Leaf number = 0.0480

content of the leaves of various age groups did not differ significantly. These findings are reported in Table VIII.

TABLE VIII

VARIATION IN THE AVERAGE LEAF IRON CONTENT OF THE BANANA AS INFLUENCED BY LEAF NUMBER AND PHOSPHORUS FERTILIZER TREATMENT

Leaf number / Phosphorus fertilizer (grams)	1	3	5	Mean of treatments
	Percent iron			
0	0.0072	0.0096	0.0093	0.0087
200	0.0112	0.0082	0.0092	0.0095
400	0.0066	0.0089	0.0057	0.0071
600	0.0142	0.0112	0.0082	0.0112
1000	0.0103	0.0079	0.0061	0.0081
Mean of leaves	0.0099	0.0092	0.0072	

L.S.D. Between means at the 5% level

Treatment = N.S.

Leaf number = N.S.

B. Effect on Leaf Area

Plants treated with high amounts of phosphorus fertilizer resulted in significantly greater leaf surface area than both the control and the plants treated with low levels of superphosphate. Data reported in Table IX shows that 600 and 1000 grams of superphosphate resulted in 2392 and 2349 square centimeters of mean leaf surface area, respectively. Both of these areas do not differ significantly among themselves. Plants receiving zero, 200 and 400 grams of superphosphate produced almost equal mean leaf surface area of 1994, 1995, and 1992 square centimeters, respectively. This clearly reveals that at least 600 grams of superphosphate were necessary under the conditions of this study to increase leaf area. Referring again to Tables II, III and V we find that the control plants had adequate amounts of phosphorus without a depression of nitrogen and calcium in the leaves, however the results in Table IX indicate the need for 600 grams or more of superphosphate to obtain an increase in leaf area. Moreover, since the banana plant depends to a great extent on leaf area for a number of its functions, therefore, an increase in the leaf area may in turn

TABLE IX

VARIATION IN THE AVERAGE LEAF AREA OF THE BANANA AS INFLUENCED BY LEAF AGE AND PHOSPHORUS FERTILIZER TREATMENT

Leaf number / Phosphorus fertilizer (grams)	1	3	5	Mean of treatment
	Area in square centimeters			
0	1788	2055	2138	1994
200	2111	1850	2025	1995
400	2153	2028	1796	1992
600	2288	2592	2297	2392
1000	2545	2452	2049	2349
Mean of leaves	2177	2195	2061	

L.S.D. Between means at the 1% level

Treatment = 227

Leaf number = N.S.

mean a greater degree of performance by the plant. This necessitates a further study of the problem of nutrition of the banana taking into consideration the performance of the plant as to growth and yield to be able to find if growers should increase leaf area by applying greater amounts of phosphorus fertilizer. Table IX also shows that leaf numbers, one, three and five did not differ among themselves as to surface area.

II. Uptake of Magnesium Through Foliar Spray

Foliar spray containing 6.7 grams magnesium in the form of magnesium sulphate in 500 mls. of distilled water per plant did not significantly increase the magnesium content in banana leaves. However, a definite trend towards increase in magnesium content is apparent as seen from Table X, where sprayed plants contained 0.365 per cent mean magnesium in their third leaf as compared to 0.291 per cent mean magnesium in the third leaf of the checks. According to Murray (24) the level of adequacy of magnesium in the third leaf is 0.36 per cent and less than 0.09 per cent indicates a severe

TABLE X

VARIATION IN THE AVERAGE CONTENT OF MAGNESIUM IN BANANA LEAVES AS INFLUENCED BY FOLIAR SPRAY OF MAGNESIUM

Treatment	Per cent magnesium in third leaf
Sprayed with 33.50 grams of magnesium sulphate	0.365
No spray	0.291

Theoretical t = 2.306

Observed t = 1.626

D.F. = 8

deficiency. The plants receiving the foliar spray containing magnesium sulphate showed an increase in their leaf magnesium content. This increase attained the level of sufficiency previously mentioned. However, this increase was not found to be significant when compared to the controls. When magnesium nitrate was employed as a source of magnesium even at the low concentration of twelve grams of magnesium nitrate in 500 mls. of distilled water, it produced leaf burning of up to 40 per cent of the total leaf area. Because of the extensive burning magnesium nitrate was dropped out of the trials.

SUMMARY AND CONCLUSION

The study reported in this thesis was undertaken to determine the effect of phosphorus fertilization on leaf inorganic composition and leaf area in the banana plant. The uptake of magnesium from foliar sprays was also evaluated in this study.

I. Inorganic leaf composition as influenced by the age of the leaf and the phosphorus fertilizer treatment revealed the following results:

a. Phosphorus: The older the banana leaves the less phosphorus they contained. However, in case of sufficiency when no phosphorus fertilizer was applied, all the leaves irrespective of age had about the same amount of phosphorus. Leaf phosphorus was found to increase with the application of phosphorus fertilizer. Phosphorus sufficiency was achieved in the third leaf in all plants receiving no superphosphate fertilizer.

b. Nitrogen: As the leaves became mature their nitrogen content decreased. Medium and high amounts of superphosphate depressed the nitrogen content of the leaves. However, zero and 200 grams of superphosphate did not significantly depress the nitrogen. The no fertilizer treatment was previously found to be the most economical to use and it also does not interfere with the nitrogen content of the leaves.

c. Potassium: The leaf potassium content decreased rapidly with leaf age. Applications of superphosphate did not influence the potassium leaf content.

d. Calcium: An increase in calcium content of the leaves was found as they became older in age. Medium amounts of phosphorus fertilizer significantly depressed the calcium in the banana leaves, while the application of superphosphate in low or high amounts did not significantly depress calcium. The finding that no application of superphosphate fertilizer to the plant does not depress calcium in the banana leaves is a further indication of the desirability not to use phosphorus fertilizer under the conditions of this experiment.

e. Sodium: The oldest leaf had the highest amount of sodium followed by leaf one and leaf three, respectively. Sodium content of the leaves was depressed by application of phosphorus fertilizer.

f. Iron: Age of the leaf and phosphorus fertilizer both did not affect the iron content of the leaves.

g. Leaf area: High amount of superphosphate fertilizer resulted in a significant increase in leaf area. Leaves of different ages were found to have the same leaf area.

II. Foliar sprays of magnesium sulphate as influencing the magnesium of the leaf produced the following results:

Foliar spray of 33.50 grams of magnesium sulphate (6.70 grams of magnesium) diluted in 500 mls. of distilled water indicated a tendency to increase the magnesium content of the leaf. Also magnesium nitrate when used as a spray caused severe burning of the leaves.

By varying the amount of phosphorus fertilizer to banana plants with sufficient nitrogen and potassium it was revealed that no application of superphosphate produced the most desirable effect as to leaf inorganic composition. These plants had sufficient amount of phosphorus in the leaf and produced no ill effects on the other elements analyzed for.

From the findings of this study it is not possible to conclude that bananas should not be fertilized with high amounts of phosphorus, because although the control produced the most desirable effects on the leaf composition in the experimental plants it did not induce a larger leaf area. Further work through harvest is required to be able to determine the extent of the importance of leaf area on production. The foliar spray of magnesium sulphate induced a tendency towards an increased magnesium content in the leaves, however this was not significant.

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