EFFECT OF SOIL APPLICATION OF NEMAGON ON INORGANIC LEAF COMPOSITION OF FIELD GROWN BANANA PLANTS

By

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Nemagon Trials on Bananas

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ABSTRACT

An investigation was carried out during the year 1963-1964 at two places on separate dates in South Lebanon, to study the effect of nematocide Namagon on nematode disinfestation and inorganic leaf composition of Dwarf Cavendish bananas Musa nana L. grown under field conditions. Seventy five percent emulsifiable concentrate Nemagon was diluted to the desired concentrations at the time of treatment application. One hundred twenty mls Nemagon at 10% concentration were applied at Zahrani, whereas 120 mls Nemagon at 20% concentration and 240 gms 20% (by weight) granulated Nemagon were tried at Tyre.

Soil samples were collected from each site separately at the time of treatment application to evaluate the density and species of nematodes present. Post treatment soil samples were taken from Tyre 6 months later and from Zahrani 12 months after treatment to assess the nematode population following nematocide application. The leaf samples from Zahrani were collected 2 months after treatment while samples from Tyre were collected 6 months after treatment.

Pre-treatment nematode count of the collected soil samples showed that a fair population of true spiral nematodes existed in the soils of both experiments whereas a high population of reinform nematodes was found to be present only in the plots of Tyre. The post treatment soil samples revealed that liquid Nemagon at either of the two concentrations produced a good control of the true spiral nematodes

while granulated Nemagon was effective only against the reniform nematodes. Furthermore root-knot nematodes were found in all the experimental plots excluding those that were treated with 20% liquid Nemagon.

The study of the data from leaf chemical analysis showed that nematode disinfestation increased the uptake of some essential elements. The elements N, Ca, Mg, Fe and petiole Nitrate-N were found to increase in the leaves of the plants treated with nematocide. The results for other elements, P, Mn, Na, and K and Nitrate-N were either inconsistant or had small variations in both experiments.

The general nutritional level of the banana plants growing in the control plots was sufficiently above the adequacy level for normal growth. However the increase in some nutrients as a result of nematocide treatment suggests that less fertilizers could be used in treated plantations. Thus nematocides could profitably be used as one of the means of improving the nutritional status of the nematode infested bananas.

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INTRODUCTION

The Dwarf Cavendish variety of banana is one of the important fruits of the Middle East (52). The fruit is a good source of vitamins A and C as well as a fair source of vitamins B and G (10). This variety has some cold resistance and can be grown commercially in marginal areas where the temperatures are too low for the growth of most other commercial banana varieties (10,52).

Bananas are grown on the coastal areas of Lebanon where the growing season extends from early April to mid November. During this growing period, the banana tree produces about 15 to 20 leaves. The extensive leaf area demands large amounts of water and nutrients that the root system has to supply during the growing season for maximum growth and production. It is therefore necessary that an efficient root system be maintained at all times.

Reports from the banana producing countries of the world have shown that considerable damage to banana roots is caused by nematodes. The damage is manifested in interference with the uptake of inorganic elements and a reduction in water absorption resulting in losses of yield and fruit quality (1,12,14,31,38,39,49,52).

Limited work has been done in the Middle East to study the effects of controlling nematodes on the nutritional status of the banana tree (1). The investigation reported in this thesis was designed to find the effect of soil application of Nemagon on the soil nematode population and the inorganic leaf composition of field-grown banana plants.

REVIEW OF LITERATURE

Nematode infestation and its interaction with the banana plant.

The plant parasitic nematodes comprise one of the groups of soil inhabiting organisms which influence the growth and productivity of plants. Most soil nematodes can withstand desiccation and, in the dry state, are passively distributed by a variety of agencies over considerable areas (25). According to Leach (30) nematodes cause a great amount of damage in many of the banana plantations of the world and attack all varieties of banana. In Lebanon, Khalidy (27) reported a 94% infestation upon examining up-rooted banana suckers.

Thorne (51) described the genus *Helicotylenchus* (Steiner 1945) as having a spiral body; it includes only 15 known ectoparasitic species. Golden (15,16) demonstrated that the feeding by this nematode was accomplished by inserting the stylet up to five cells deep into the under-ground plant tissue. Cell destruction, injection of saliva and emptying of the cell content were the main injuries. Gerald, Leach and Adams (14) conducted greenhouse experiments with plant parasitic nematodes and observed that *Helicotylenchus annus* (Steiner 1945) contributed to infection and development of bacterial wilt of tomato (*Pseudomonas solanacearum*). Martin and Birchfield (33) and Mai *et el*, (32) gave a very wide host range of 88 plants for the *Helicotylenchus Spp*. Dugain and Vilardebo (12), and Lus and Vilardebo (31) stated that extensive damage was caused by this nematode in West African banana plantations.

Minz (38,39) found the Helicotylenchus nematodes to cause substantial damage to banana plantations of the Cavendish variety on the eastern coast of the Mediterranean sea. Ahmedi (1) has demonstrated the presence of Helicotylenchus nematodes on the roots of pot-grown banana plants in Lebanon.

Limited work has been carried out on the relationship of Rotylenchulus nematodes to the banana; however, there are a number of reports on its relationship with other plants. Ayala (2) reported the Pathogenicity of the Rotylenchulus Spp of nematodes on pigeon pea, tomato, pineapple and Arabica coffee. Their feeding habits produced small necrotic areas, abnormal curvature, and proliferation of roots. Infected plants had a stunted root system, and reduced aerial parts. Martin (34) found the roots of sweet potato grown in soil infested with Rotylenchulus nematode to be sparse, necrotic and discolored with very few feeder roots. According to Jones (25), Peacock showed that reniform nematode eggs hatch freely in water. Martin and Birchfield (33) recovered the reniform nematode from the roots of cotton and tomato. Jones, Newsom and Finley (26) found that the reniform nematode reproduced abundantly on cotton and caused serious injury in all varieties. This nematode increased wilt development on the wilt susceptible varieties of cotton, and under field conditions caused appreciable reduction in the yield of all varieties tested. Birchfield and Jones (7) estimated that 40 to 60% reduction in cotton yield was caused by the Rotylenchulus species. Sasser and Oswaldo (49) isolated Rotylencholus Spp of nematodes from the rhizosphere of banana and other plants. Minz (39) confirmed the occurence of Rotylenchulus nematodes in the rhizosphere of banana plants.

Walker (55) gave a detailed account of the root-knot nematode. According to him the root-knot nematode is most common on outdoor plants in tropical and subtropical climates. The larvae penetrates the meristematic tissue and migrates until the head becomes established in the intercellular space near the endodermis. The parasite feeds within the cell without killing it and stimulates host cells to enlarge and divide, leading to the characteristic gall formation. The larvae and eggs of the said parasite are killed when a 40C to 50C temperature is maintained for a long time. Larvae are transported long distances in planting stock of various types. Minz (39) reported 5 species of root-knot nematodes present on the roots of Dwarf Cavendish bananas grown in the Jordan valley. Ahmedi (1) found *Meloidogyne* to infest the roots of *Musa nana* L. grown in Lebanon.

Effect of nematodes on the nutrition of the host plant.

Raski (47) pointed out that Vanha was amongst the first to determine the inorganic composition of nematode infested plants. He found a relationship between the nematode infestation of sugar beet and the decrease in the content of certain minerals. According to Jones (25), Dropkin and King, applying radioactive Phosphorus to tomato seedlings, observed an interference in the uptake of inorganic elements resulting from the abnormalities caused by root-knot nematodes. They concluded that the main injury produced was the interference of the nematodes with root function. Feldman *et al* (13) observed that leaves from citrus trees infested with *Radopholus similus* were lower in both K and N content than leaves from healthy trees. They further noted that the P content was not influenced by nematode infestation. Maung and Jenkins (35) found that tomato plants infested with *Meloidogyne incognita* var *acrita* (Chitwood 49) caused an accumulation of N, P, and K in roots but not Na. They further reported a lower total accumulation of N, P, K, Na, Mg and Ca in the tops of tomato plants severely infested with nematodes. Heald and Jenkins (20) working with *Pratylenchus penetrans* found significant accumulation of N, K , and Ca occuring in leaves along with an increase of N and a deficiency of P, K and Mg in roots of infested plants of *Ilex crenata*. Their results further showed a low N and high K and Mg in the roots of infested *Ilex rotundifolia*. Kirkpatric *et al* (28), working on the interaction of the nutrition of sour cherry trees and the nematode population, disclosed that the density of the nematodes pertaining to the *Pratylenchus Spp* was directly related with Leaf P content. On the other hand the population of *Helicotylenchus dihystera* and *Tylenchorhynchus Spp* increased with increases in leaf K content. Ahmedi (1) noticed decreased up-take of N, P, Mn and to some extent of K and Mg in Dwarf Cavendish banana plants infested with *Helicotylenchus* and *Meloidogyne* nematodes. However the leaf content of Fe, Na and Ca was unaltered.

Nematocidal activity of Nemagon.

Nemagon is a Shell trade name for the nematocide 1,2-dibromo-3-chloropropane also referred to as DBCP (44). Nemagon is marketed in two forms, the emulsifiable concentrate and the granular form. According to McBeth and Bergeson (36), DBCP is a heavy, straw-colored liquid with a specific gravity of 2.08.

Good and Steele (17) compared different methods of applying DBCP. They found that a good control of root-knot nematode was obtained with both liquid and granular formulations. Aycock and Sasser (4) found a DBCP fertilizer mixture was as effective in nematode control as DBCP alone. Warren (56) obtained control of soil nematodes in Tokay grapes with the application of DBCP in emulsion form diluted in irrigation water. Split applications were found to prolong control. Dugain and Vilardebo (12) controlled nematodes in bananas by applying DBCP in irrigation water just before the onset of the spring season in the Canary Islands. Youngson and Goring (58) found that the basic toxicity of DBCP was relatively unaffected by temperature. Raski (48) applied DBCP in 14 established vine-yeards and reported marked reduction in nematode number. However, nematodes were found to build up again in 3 to 4 months. Ayala (3) got effective control of nematodes in bananas by using 75% emulsifiable concentrate Nemagon. Ahmedi (1) treated banana plants with emulsifiable and granulated forms of Nemagon. He was not able to realize complete eradication of Meloidogyne with the granular form. He further found that the drenching of banana plants growing in 100 litre barrels with 3 mls of 75% emulsifiable concentrate Nemagon (diluted in 6 litres of water) was found to be the most effective minimum dose in producing full control of Meloidogyne and Helicotylenchus nematodes. The above treatment had to be repeated every 6 months.

Hassis, Wells, and Nusbam (18) established effective control of reniform nematodes by injecting DBCP around azalea, boxwood, camellia, holly and rose plants. Plant responses were noticed within 8 to 10 weeks after the injection. Newsom and Jones (42), working with the wilt complex of cotton, obtained satisfactory control of the Rotylenchulus nematodes by soil fumigation using DBCP at the rate of half a gallon per acre.

Luc and Vilardebo (31) obtained excellent control of Helicotylenchus multicinctus and Meloidogyne incognita acrita by soil fumigation during May-June of the year bananas were set out. They used Nemagon at the rate of 40L/ha. It was also found necessary to refumigate the soil in October. In succeeding years fumigating twice a year was effective. Nemagon gave 100% freedom from Helicotylenchus Spp as well as Meloidogyne according to Peachy and Hooper (45). Ahmedi (1) demonstrated complete control of Helicotylenchus Spp and Meloidogyne Spp with the use of Nemagon in the emulsifiable concentrate form on potted banana plants. He further obtained complete eradication of Helicotylenchus Spp by applying granulated Nemagon.

Response of plants to nematocide application.

Milne (37) reported that following fumigation with DBCP, the fertilizer utilization by plants was improved. Raski (5) applied DBCP in established vine-yeards and found an increased vegetative growth of vines as well as an increase in yield. Ayala (3) applied Nemagon 30 days before planting tomatoes in soil infested with reniform nematodes. This resulted in good growth and yield of tomatoes. Peachy and Hooper (45) stated that the development of banana root systems was improved when the sets were treated with Nemagon. Paltmer and Braun (43), working on the apple tree decline, found that after soil drenching with Nemagon the terminal growth of treated trees produced 6.6 boxes of fruit per tree as compared with 2.2 boxes per untreated trees. Warren (56) reported that increased growth and yield followed the application of DBCP in Tokay grapes. Price

(46) improved the growth of Lacatan bananas by applying 3 gallons per acre of 75% emulsifiable concentrate Nemagon diluted in the irrigation water. Luc and Vilardebo (31) reported control of *Helicotylenchus* and *Meloidogyne* nematodes in banana fields and a marked improvement in fruit yield, earliness and size after fumigating the soil with Nemagon. Minz (39) and Ticho (52) found that treating Dwarf Cavendish banana with Nemagon improved the first and second ratoon crop even if the infestation during the planting year was not controlled. Ahmedi (1) reported marked increase in N, P and Mn content and better growth of the banana plant due to complete eradication of nematodes. He also found that high concentrations of this material may cause a temporary toxic effect on the plant.

Leaf sampling and its use as an index to the inorganic nutrition of banana.

Hewitt (21) and Murray (41) established that the third leaf of banana reflects satisfactorily the nutritional state of the whole plant. Hewitt and Osborne (22) fixed the levels of adequacy of leaf nitrogen and phosphorus at 2.6% and 0.20%, respectively. In the presence of adequate nitrogen and phosphorus the weight of the fruit doubled. Bhango, Altman and Karon (6), working with the giant Cavendish banana, found that the nutritional level of the leaf (NPK) was directly correlated with yield. Murray (41) and Hewitt (21) have prepared a provisional table of levels of adequacy and severe deficiency drawn partly from studies on bananas in sand culture. The work was done on the Dwarf Cavendish and Lacatan varieties of banana. The said levels appear in Table 1.

Table 1. Percent nutrients in third leaf of banana plant.

Nutrients	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

Results obtained by Murray (41) showed that Ca efficiency seemed to depress the N content of leaves. Phosphorus deficiency induced an increase in leaf N, K and Ca. Bryzesowsky and Van Biesen (9) concluded that high K had a significant effect on increasing bunch weight, hand weight and number of hands per stem. Crawford, Kennedy and Johnson (11) reported on the work of Nightingale and co-workers who found that a high level of K induced a high NO_3 content of forages. Hanway and Englehorn (19), Kretschmer (29) and Whitehead and Maxon (57) showed that straw contained more NO_3 than the leaves in everglades forages grown under field conditions. Ahmedi (1) working on the nematocide effect on banana found 1.209% Nitrate-N in the petiole of the third leaf of pot-grown bananas as compared with 0.178% in the blade. He further noticed that the slow growth was responsible for the increased accumulation of Nitrate-N in the blades.

MATERIALS AND METHODS

In this study Nemagon was tested under field conditions at 2 sites on the coastal plain of South Lebanon. The banana plantations chosen for this study were newly established and planted to Dwarf Cavendish variety of *Musa nana* L. Irrigation and other cultural operations were similar at both places and were carried out as part of the general practice of the area by the owners concerned. The treatments employed for each site are described in Table 2 and discussed separately. Soil samples collected from both areas just at the time of nematocide treatment, and again on 21st of May 1964 were examined by the Shell Company for the identity and density of nematodes present. The extraction of nematodes from the soil samples was done according to the Baerman method.

The execution of the nematocide treatments at Zahrani including the collection of first soil samples was carried out by the representatives of the Shell Company. The nematocide treatment and soil sampling for the nematode determination of the Tyre experiment was carried out with the assistance of the representatives of the Shell Company. The last soil sample collection was implemented by the author at both experimental sites on the 21st day of the month of May 1964.

Trial at Zahrani.

Two plots of 64 banana plants were chosen adjacent to each other in a recently established commercial banana plantation near Zahrani.

Table 2. Treatments received by experimental banana plants at Zahrani and Tyre during 1963.

Experimental site and date of treatment	Treatments	Organic matter		Fertilizer			
		Goat manure	Farmyard manute	Nitra-phoska	Ammonium sulfate	Super phosphate	Potassium sulfate
Zahrani	Control	5 kgs.	-	1 kg.	-	-	-
Last week of May	120 cc 10% Nemagon solution	5 kgs.	-	1 kg.	-	-	-
Tyre	Control	-	20 kgs.	-	2 kgs.	1 kg.	$\frac{1}{2}$ kg.
21st November	120 cc 10% Nemagon solution	-	20 kgs.	-	2 kgs.	1 kg.	$\frac{1}{2}$ kg.
	240 gms 20% (by wt) granulated Nemagon	-	20 kgs.	-	2 kgs.	1 kg.	$\frac{1}{2}$ kg.

One plot was left untreated for a check while the second received the treatments as shown in Table 2. Nemagon was applied during the last week of May 1963. Two concentric rings with radii of ½ meter and 1 meter were marked out around each plant using the base of the plant as a common centre for both rings. Eight equally spaced injection points were located on the circumference of the inner ring and 16 on the outer ring. Five mls of a 10% solution of Nemagon (diluted from 75% emulsifiable concentrate) was injected 20 cms deep at each injection point with a hand injecter. The fumigant was sealed into the soil by foot pressure after each injection.

From 20 random plants in each plot leaf samples were collected on July 31st, 1963. The third youngest leaf was chosen for tissue analysis counting the last fully opened leaf as leaf number ones. The leaves were normal and free from diseases, malformation or any other disorder.

Trial at Tyre.

The work at Tyre was carried out on a small section of a recently established banana plantation. The soil was of a clay type and deep. The acquired area was divided into 15 plots, each consisting of 6 plants. The plots to receive each of the treatments were chosen at random. This allowed 5 replications (plots) per each of the 3 treatments.

Liquid Nemagon was injected as in the Zahrani experiment except that a 20% solution was used instead of 10%. A granular form of Nemagon concentration, not tested at Zahrani, was included in the experiment. A circular ring having a radius of 70 cms was marked out around the base of each plant. Within a trench 20 cms wide and 20 cms deep, prepared on the circumference of the ring, 240 gms of a 20% (by wight) granular formulation of Nemagon was broadcasted after which the fumigant was covered with soil and trampled. These operations were carried out on 21st of November, 1963.

Due to winter injury the leaf harvest was delayed. The third leaf of each plant under experiment was collected on 21st May, 1964. One leaf per plot from prepared leaves was chosen at random for tissue analysis. Leaves had a little frost injury but were free from diseases. In most cases the harvested leaf was the first harvestable leaf of the season after the winter defoliation.

Chemical analysis.

After collection, leaves from both locations were prepared for analysis. Petioles were separated from the leaf blades. The samples were washed, dried and ground according to methods described by Brown (8) and Toth, et al (53). The ground material was mixed, oven dried at 70°C for about 20 hours and cooled for 2 hours in a desiccator before being subjected to chemical analysis.

Water soluble Nitrate-N was determined in the leaf lamina and petiole by the Phenol-disulphonic acid method in presence of excess chlorides, as described by Ulrich and co-workers (54). For further analysis only the leaf blade was used. Total Nitrogen was determined by the Kjeldahl-method (23). A Beckman model DU flame spectrophotometer was used to analyse the plant material for Calcium, Sodium, and Patassium; Phosphorus, Magnesium, Iron, and Mangenese were read colorimetrically on a Beckman model B spectrophotometer as suggested by Jackson (24) and

Toth _et al_ (53). The results of the chemical analysis were expressed on oven dry weight basis.

The statistical method employed for the data from the Zahrani experiment was the 't' test as described by Snedecor (50); and the method followed in the Tyre test was the completely randomized design 'F' test.

RESULTS AND DISCUSSION

The data obtained in this study are reported in two sections. The effect of nematocide application on nematode population in the soil is dealt with in the first section while the results of the inorganic chemical analysis of banana leaves as affected by the nematocide treatment are reported in the second section. The data are expressed as meas of 20 and 5 plants for the Zahrani and Tyre experiments respectively.

A. Effect of nematocide application on nematode population.

The population of nematodes as affected by the different nematocidal treatments as well as the time elapsed from the date of fumigation and securing of soil samples are reported in Table 3. The experimental plots situated at Zahrani contained 780 *Helicotylenchus* nematodes in a 200 cc. soil sample (All soil nematode counts hereafter are per 200 cc. soil sample), before initiating the treatment. At leaf harvest time on July 31st 1963, no soil samples were taken from the Zahrani experiment for nematode count. Hence the results produced by the nematocide application on the nematode population for the period between the last week of May 1963 to 31st July 1963 were not available. However, the soil samples collected on May 21st, 1964, one year after treatment showed that the plots at Zahrani treated with 10% emulsifiable concentrate Nemagon solution had no *Helicotylenchus* nematodes. The control plots in the same

Table 3. Population and species of nematodes present in 200 cc. soil before and after nematocide application at Zahrani and Tyre experimental sites.

Experimental site and date of nematocide application	Treatments	Nematode species	Number of nematodes per 200 cc of soil: Before treatment	Number of nematodes per 200 cc of soil: After treatment
Zahrani Last week of May 1963	Control	Helicotylenchus Spp	780	53 ††
		Meloidogyne larvae	0	40 ††
	120 cc 10% Nemagon solution	Helicotylenchus Spp	780	0 ††
		Meloidogyne larvae	0	40 ††
Tyre 21st November 1963	Control	Helicotylenchus Spp	624	0 †
		Rotylenchulus	4600	28 †
		Meloidogyne larvae	0	56 †
	120 cc 20% Nemagon solution	Helicotylenchus Spp	624	0 †
		Rotylenchulus Spp	4600	286 †
	240 gms 20% by wt. granulated Nemagon	Helicotylenchus Spp	624	12 †
		Rotylenchulus Spp	4600	0 †
		Meloidogyne larvae	0	60 †

† Nematodes present 6 months after treatment.
†† Nematodes present 12 months after treatment.

area had 53 nematodes of the above species, which is considered to be a low infection. At the time of nematocide application, on November 21st, 1963, the experimental plots located at Tyre contained 624 *Helicotylenchus* nematodes. Soil samples taken at leaf harvest time 6 months after nematocide treatment revealed the absence of *Helicotylenchus* nematodes from the plots treated with 20% emulsifiable concentrate Nemagon solution as well as from the plots that were left as checks. However the nematode density recorded at Tyre during November 1963 was not different from that of Zahrani during May 1963. From the above observations it could be seen that there was no reduction of nematodes by natural factors in the summer of 1963. The higher uptake of certain elements found in the leaf samples collected on July 31st, 1963, from Zahrani could be considered to have been from trees growing in a soil free from *Helicotylenchus* nematodes. Weather conditions prevailing before soil sampling on May 21st, 1964, lack of growth of plants and other unknown soil biological factors could have contributed to the absence of *Helicotylenchus* species from the check plots at Tyre. Though the control and 20% emulsifiable concentrate Nemagon solution treated plots at Tyre showed no *Helicotylenchus* nematodes on May 21st, 1964, the increased uptake of certain elements by treated plants at the above experimental site suggests that the nematocides acted promptly after application. Ahmedi (1) found that complete control of *Helicotylenchus* nematodes could be established with 3 mls of 75% emulsifiable concentrate Nemagon diluted in 6 litres of water and used as a drench per 100 litre barrel. The reports of other workers (32,46) have shown the control of Helicotylenchus nematodes with the use of emulsifiable concentrate Nemagon. It also seems that the elimination of nematodes from the control plots at Tyre was gradual and must have occured during late winter.

Inspite of the fact that there was a general reduction of nematodes, the plots of the Tyre experiment that were treated with 20% granulated Nemagon had 12 Helicotylenchus nematodes. Moreover these plants did not show an increase in mineral uptake, which could be attributed to the lack of nematocidal effect of the granulated Nemagon on Helicotylenchus.

The population of Rotylenchulus nematodes at the time of treatment application was down to zero, 28 and 286 in plots that received 20% granulated Nemagon, control and 20% emulsifiable concentrate Nemagon solution, respectively. The 20% emulsifiable concentrate Nemagon solution was not effective against the Rotylenchulus nematodes while 20% granulated Nemagon seemed to be effective. The 20% granulated Nemagon was buried within a trench 20 cms wide and 20 cms deep with a radii of 70 cms. The stirring and pulverization of the soil caused by late winter cultivation might have released and spread the granulated Nemagon over a wide area of the rhizosphere of the plant. This might have caused death of the Rotylenchulus nematodes present in the rhizosphere that received the above Nemagon treatment.

Furthermore, soil samples taken at the time of nematocide application showed the absence of Meloidogyne nematodes. However on May 21st, 1964, when the soil samples were collected to assess the performance of different treatments, the Meloidogyne larvae were found in all plots except those that were treated with 20% emulsifiable concentrate Nemagon solution. This finding shows that 20% emulsifiable concentrate Nemagon treatment offered protection against the Meloidogyne infestation. The population of Meloidogyne found in plots that received 10% emulsifiable concentrate Nemagon and 20% granulated Nemagon was 40 and 60 larvae respectively. The check plots of Zahrani had 40 Meloidogyne larvae whereas the check plots at Tyre contained 56 larvae.

Ahmedi (1) established complete control of Meloidogyne nematodes with 3 mls of 75% emulsifiable concentrate Nemagon diluted in 6 litres of water when used as a drench per 100 litre barrel. Under the same conditions the use of 40 gms of 20% granulated Nemagon per barrel did not give complete freedom from Meloidogyne. Other workers have shown that Meloidogyne was better controlled with emulsifiable concentrate Nemagon as compared with granulated Nemagon (3,13,48,58).

The population of Helicotylenchus at the time of nematocide application at Zahrani and Tyre was 780 and 624, respectively. Six months later, the numbers of this nematode in the check plots at Zahrani and Tyre was 53 and zero, respectively. This finding shows that there was limited nematocidal effect at the time of securing soil samples.

B. Effect of nematocide application on inorganic leaf composition.

Leaf samples were collected from the two experimental areas for inorganic analysis. From the analytical results the effect of nematocidal treatments on leaf composition were determined. The data of the Zahrani experiment represents the effect of spring nematocide treatments while that of the Tyre experiment represents the effect of winter nematocide treatments. The results obtained for each element from the two experiments are presented separately in 9 tables and discussed individually. Leaf inorganic composition for each element is expressed as mean percent or ppm of oven dried tissue.

1. Water soluble Nitrate-N of the leaf petiole.

The results on Nitrate-N content of banana leaf petioles are reported in Table 4. The data showed a significantly higher Nitrate-N content in leaf petioles of plants at Zahrani that received 10% emulsifiable concentrate Nemagon solution as compared with the control plants. The mean Nitrate-N content of the treated plants was 5295 ppm as compared with the control that had a mean of 4620 ppm. No data is available for nematode count in the soil of the above plots at the time of leaf harvest because the services of a nematologist were not available at that time. However the data obtained on nematode density at the time of treatment application showed the presence of 780 *Helicotylenchus* nematodes in 200 cc of soil. The increased Nitrate-N content in the treated petioles was thought to be due to nematocidal effect of Nemagon on *Helicotylenchus* nematodes, resulting in disinfestation and restoration of the normal function of the banana roots.

The results from the Tyre experiment showed the same trend as that of the Zahrani experiment. The mean Nitrate-N of the plants that received 20% emulsifiable concentrate Nemagon solution, and 20% granulated Nemagon was 3164 ppm and 2894 ppm, respectively as compared with 2645 ppm of the control. The mean Nitrate-N content of the plants that were treated with 20% emulsifiable concentrate Nemagon solution was found

Table 4. Influence of soil application of Nemagon on the Nitrate-N content of banana leaf petiole and blade

Place of experiment	Treatments	ppm Nitrate-N in		Between means of petiole and blade
		Leaf petiole	Leaf blade	Observed "t"
Zahrani	Control †	4620	1150	16.715
	120 cc 10% Nemagon solution †	5295	1364	147.297
Tyre	Control ††	2646	1366	4.091
	120 cc 20% Nemagon solution ††	3164	1542	75.863
	240 gms 20% (by wt.) granulated Nemagon	2894	1582	103.003
Between Treatment means	Observed "t"	2.284	1.306	Theoretical "t" at the 1% level 38 df = 2.712 at the 1% level 8 df = 3.355
	Theoretical "t" 38 df at 5%	2.024	ns	
	L.S.D. at the 5% level	267.5	ns	
	L.S.D. at the 1% level	389.2	ns	

† Concentration expressed as mean of 20 samples.
†† Concentration expressed as mean of 5 samples.

to be significantly higher than the mean of the check at the 1% level as well from the mean of plants treated with 20% granulated Nemagon at the 5% level. There was no significant difference between the means of the control and the plants that were treated with 20% granulated Nemagon.

At the time of leaf collection, there were about 60 Meloidogyne larvae present in the plots that were treated with 20% granulated Nemagon and 56 of the same species in the control as compared with no Meloidogyne larvae in plots treated with 20% emulsifiable concentrate Nemagon solution. The absence of Meloidogyne larvae combined with prompt elimination of Helicotylenchus nematodes might have contributed to the increased efficiency of the roots which resulted in significantly higher uptake of available Nitrate-N or other nitrogenous compounds.

There was great difference in the Nitrate-N content of the plants treated in spring as compared to those treated in winter. The highest mean Nitrate-N content for the plants of the winter experiment was 3164 ppm as compared with the lowest mean of 4620 ppm for the plants of the spring experiment. This might be due to reduced nitrification of N in the soil and reduced uptake by plants because of unfavourable low temperature in winter. Another contributing factor could have been the effect of 2 different locations. Ahmedi (1) is the only investigater who reported on the Nitrate-N content of banana leaf tissue. He noted higher Nitrate-N content in the petioles harvested at the beginning of the growing season as compared with petioles harvested after the peak of the growing season.

2. Water soluble Nitrate-N of the leaf blade.

The data in Table 4 shows that the Nitrate-N content of the plants grown at Zahrani had a slight nonsignificant increase when treated with 10% emulsifiable concentrate Nemagon solution as compared with the control. The nematocide treated plants had a mean Nitrate-N content of 1150 ppm. It should be noted that petiole Nitrate-N content in the plants at Zahrani treated with 10% emulsifiable concentrate Nemagon was 5295 ppm as compared with 4620 ppm in the control plants. This shows a relationship between the Nitrate-N of the leaf blade and petiole.

The results from the plants at Tyre showed the same trend of leaf blade Nitrate-N content as those of Zahrani. The mean Nitrate-N content in the leaf blades for the control, 20% emulsifiable Nemagon solution and 20% granulated Nemagon treated plants was 1366 ppm, 1542 ppm, and 1582 ppm, respectively. There was no significant difference between any two means.

The Nitrate-N content of the petioles and blades for the control plants of the spring experiment was 4620 ppm and 1150 ppm as compared with 2646 ppm and 1366 ppm in the petioles and blades of plants treated in winter. Although there were large quantities of Nitrate-N in the petioles of spring treated plants, the blades had a lower quantity as a result of the enhanced rate of conversion of inorganic Nitrate-N into other forms of Nitrogen towards the biosynthesis of proteins in plant. The slow rate of chemical activity occurring in the leaves during the months of April and May could have allowed the accumulation of Nitrate-N in the leaf blades of the plants treated in winter. The work of Ahmedi (1) on Nitrate-N content of banana leaf showed higher Nitrate-N content both in the blade and petiole tissue during the slow growth period up to June as compared with the fast growth rate ending during the month of September.

From the results recorded in Table 4 it can further be seen that the petioles always contained higher Nitrate-N than leaf blades under all treatments and during each of the season. This could be seen by comparing the control plants at Zahrani that had a mean Nitrate-N content in the petioles of 4620 ppm against 1150 ppm in the blades. The means were significantly different at the 1% level. This was in agreement with the findings of Ahmedi (1) who reported 1.59% Nitrate-N for the petioles as compared with 1780 ppm Nitrate-N for the blades of the third leaf of pot-grown banana plant of variety Dwarf Cavendish. These findings are also in agreement with the findings of Hanway and Englehorn (20), Krestschmer (30) and Whitehead and Maxon (57) who reported the same trend for straw and leaves of the everglades forages under field conditions.

3. Total Nitrogen.

The data acquired in this study on the effect of nematocide application on N content of banana leaf blade is reported in Table 5. The average N content of the plants at Zahrani treated with 10% emulsifiable concentrate Nemagon solution was 3.550% and significantly higher than the controls that contained 3.409%. The N content of the leaves harvested from Tyre showed 3.896%, 3.549%, and 3.598% for the plants treated with 20% granulated Nemagon, 20% emulsifiable concentrate Nemagon and the control, respectively. There was a significant increase in N content of the plants treated with 20% emulsifiable concentrate Nemagon. The increase in N could have been due to prompt nematode disinfestation and restoration of root function. Ahmedi (1) working on the same banana variety found lower N content in the plants grown with a high population of Meloidogyne and Helicotylenchus in the soil.

Table 5. Influence of soil application of Nemagon on the N content of banana leaf blade.

Treatment	Zahrani Mean of 20 plants	Tyre Mean of 5 plants
Control	3.409%	3.549%
120 cc 10% Nemagon solution	3.550%	
120 cc 20% Nemagon solution		3.896%
240 gms 20% (by wt.) granulated Nemagon		3.598%
Between treatment means	Observed "t" = 3.250 Theoretical "t" at the 1% level = 2.712	L.S.D. at the 5% level = 0.263

Reports from the work done elsewhere have shown that there were regular increases in leaf N content of the plants growing in nematode free soil (14,36).

The slow growth rate and reduced translocation of nitrogenous compounds combined with the upward movement of food material for growth at the end of the winter months seemed to be responsible for the tendency of higher N content in the leaf blades of winter treated plants. Ahmedi (1) found the same general tendency.

In this study the lowest N content recorded was 3.409% for the control plants at Zahrani as compared with 2.6% the minimum level of adequacy fixed by Hewitt (21) for normal growth. The density of the species of nematodes present in both experiments could not have exerted a severe harmful effect in reducing N of the host plant. The high level of N could also be attributed to excess N fertilizer applied, and the amount of this element used could be reduced in nematode free soils, thereby reducing the cost of production of bananas. Minz (39) reported that the build up of nematode species as found in this work to have caused failures of second ratoon crop of bananas grown across the southern border of Lebanon. In this study the work was done on new plantations, and similar results as obtained by Minz may prevail in older plantation with limited N supplies.

4. Phosphorus.

The data on the P content of banana leaves are reported in Table 6. The mean P content from the Zahrani plants that received 10% emulsifiable concentrate Nemagon solution was 2446 ppm as compared with 2683 ppm for the control. It was expected that treated plants growing in nematode free soil during spring would have less P content due to increased rate of leaf production and development. The mean P content of the plants from Tyre that received 20% emulsifiable concentrate Nemagon solution, 20% granulated Nemagon and control showed 2303 ppm, 2251 ppm and 2258 ppm, respectively. The difference between any two means was not statistically significant.

The mean P content of the plants that received 10% and 20% emulsifiable concentrate Nemagon solution in spring and winter was 2446 ppm and 2303 ppm, respectively. The mean P content of the control plants from spring growth was 2683 ppm as compared with 2258 ppm of the control plants harvested in winter. It was apparent that there was almost no change in the P level in the treated plants while there was a sharp decline in the P content of control plants in winter. This variation in the P content of the plants of the two seasons as exhibited by the controls might be due to reduced soil biological activity.

Table 6. Influence of soil application of Nemagon on the P content of banana leaf blades

Treatment	Zahrani Mean of 20 plants	Tyre Mean of 5 plants
Control	2683 ppm	2258 ppm
120 cc 10% Nemagon solution	2446 ppm	
120 cc 20% Nemagon solution		2303 ppm
240 gms 20% (by wt.) granulated Nemagon		2251 ppm
Between treatment means	Observed "t" = 3.250 Theoretical "t" at the 1% level = 2.712	

Ahmedi (1) found increased P content in the leaves of banana plants that were free from Nematodes. As per report of Jones (25), Dropkin and King applied radio-active P to tomato seedlings and observed interference with the uptake of P in plants infested with *Meloidogyne*. Maung and Jenkins (35) reported a decrease in P content of the tops of tomato plants infested with root-knot nematode. The author found no reduction of P in plants that were infested with nematodes. This could have been due to the low density of nematode species present and the delayed infestation under the conditions of this experiment.

Hewitt and Osborne (22) fixed the level of adequacy of P content of banana leaves at 2000 ppm, above which plants made normal growth. The minimum level of P recorded in this study was 2251 ppm for the plants treated with 20% granulated Nemagon. This figure was above the adequacy level which indicates no nutritional problem with P.

5. Potassium.

The results of the chemical analysis for the leaf K content are presented in Table 7. The mean of the plants from Zahrani that received 10% emulsifiable concentrate Nemagon solution was 3.872% as compared with 3.850% for the control. There was no significant difference between the means of treated and non-treated plants. No data is available for K from the plants at Tyre. This was due to a breakdown of the Flame Photometer.

Ahmedi (1) observed a slight increase in leaf K concentration of the treated plants, especially those plants that received liquid Nemagon treatment. Increase in leaf K content of the plants growing in nematode free soil has been reported by many workers (13,35). On the other hand there are reports (20,28) showing increases in leaf K of plants infested with nematodes. This investigation revealed no effect of nematocide application on the K content of the leaf blade tissue of banana plant. This could be attributed to the low density of nematodes since it was found that the only species present was the Helicotylenchus that did not seem to have affected the K uptake when the K level in the soil is relatively high as in Lebanon.

Table 7. Influence of soil application of Nemagon on the K content of banana leaf blade.

Treatment	Zahrani Mean of 20 plants	Tyre ≠ Mean of 5 plants
Control	3.850%	Nil
120 cc 10% Nemagon solution	3.872%	
120 cc 20% Nemagon solution		Nil
240 gms 20% (by wt.) granulated Nemagon		Nil
Between treatment means	Observed "t" = 0.186 Nonsignificant	

≠ No data available.

The K content of all the plants under this study was more than 2.6%, the level of adequacy fixed by Hewitt (21). The yield of banana plants has been reported to be directly correlated with the K content of the plant (6). Since the K content of the plants in the control and treated plots was above the adequacy level it is evident that with the high K content of the soils of Lebanon the nematodes present did not affect the uptake of K by banana plants.

6. Calcium.

The data on the Ca content of banana leaves are presented in Table 8. The mean Ca content from the Zahrani plants that received 10% emulsifiable concentrate Nemagon solution was about the same as the control. The mean Ca content of the plants from Tyre receiving 20% emulsifiable concentrate Nemagon, 20% granulated Nemagon and the control were 1.551%, 1.428% and 1.438%, respectively. The results revealed a significantly higher Ca content in the leaves of plants that received 20% emulsifiable concentrate Nemagon as compared with plants that received 20% granulated Nemagon or the control. There was no significant difference between the means of plants that were treated with 20% granulated Nemagon and the control. The increases in Ca of the plants that were treated with 20% emulsifiable concentrate Nemagon solution indicates that roots free from nematode infestation could absorb Ca at an enhanced rate. The effect of nematocides on Ca uptake by the plants is not fully understood. Heald and Jenkins (20) found *Pratylenchus penetrans* to be responsible for the accumulation of Ca in the leaves of *Ilex crenata*. On the other hand Ahmedi (1) found that *Meloidogyne* and *Helicotylenchus* nematodes could not influence the Ca content of banana leaves.

The maximum amount of leaf Ca recorded for the plants during spring was 1.441% as compared with 1.551% during winter. Increased Ca content in winter was thought to be due to slow growth rate or attainment of maturity and Ca accumulation in the leaf. Battikhah and Khalidy (5), Mirza and Khalidy (40) and Ahmedi (1) showed increased Ca in old leaves as compared with young leaves.

Murray (41) fixed the adequacy level for Ca at the 1% of oven dry tissue above which bananas made normal growth. In this study treated and non-treated plants had a Ca content above 1%, showing that Ca was not a limiting factor for the production of banana fruit in Lebanon. It has to be borne in mind that in Lebanon irrigation water is high in $CaCO_3$ and so are the soils.

Table 8. Influence of soil application of Nemagon on the Calcium content of Banana leaf blade.

Treatments	Zahrani Mean of 20 plants	Tyre Mean of 5 plants
Control	1.349%	1.438%
120 cc 10% Nemagon solution	1.441%	
120 cc 20% Nemagon solution		1.551%
240 gms 20% (by wt.) granulated Nemagon		1.428%
Between treatment means	Observed "t" = 1.147 Nonsignificant	L.S.D. at the 5% level = 0.103

7. Sodium.

The data collected in this study on Na content of banana leaves are reported in Table 9. The Na content from the Zahrani plants that were treated with 10% emulsifiable concentrate Nemagon solution was 486 ppm and significantly higher than the control that contained 309 ppm. The mean Na content of the plants at Tyre receiving 20% emulsifiable concentrate Nemagon solution, 20% granulated Nemagon and control were 247 ppm, 262 ppm and 280 ppm, respectively. There was no significant difference between any two means. Maung and Jenkins (35) found that *Meloidogyne incognita* did not cause accumulation of Na in tomato roots. Ahmedi (1) working with barrel-grown bananas established that *Meloidogyne* and *Helicotylenchus* nematodes did not affect the uptake of Na.

Table 9. Influence of soil application of Nemagon on the Sodium content of banana leaf blade.

Treatments	Zahrani Mean of 20 plants	Tyre Mean of 5 plants
Control	309 ppm	280 ppm
120 cc 10% Nemagon solution	486 ppm	
120 cc 20% Nemagon solution		247 ppm
240 gms 20% (by wt.) granulated Nemagon		262 ppm
Between treatment means	Observed "t" = 2.675 Theoretical "t" at the 5% level = 2.024	Nonsignificant

The maximum Na content of the plants treated during spring was 486 ppm as compared with 280 ppm in winter treated plants. The corresponding figures for Ca were 1.441% and 1.551%. The mean Na content of the winter growth was low as compared with the spring growth. This might be due to a depressing effect of Ca on Na. At Zahrani, the mean Na content for the check plants was 309 ppm as compared with 1.349% Ca whereas the corresponding figures for treated plants were 486 ppm Na and 1.441% Ca. This shows that high amounts of Na could coexist with high amounts of Ca without significant antagonism during the season of rapid growth.

8. Magnesium.

Table 10 shows the Mg level found in banana leaf blades. The mean leaf Mg content of the Zahrani plants that received 10% emulsifiable concentrate Nemagon solution was 1.164%, as compared with 0.989% for the control. The significant increase of Mg in the tissue of treated plants was thought to be due to nematode disinfestation of banana roots. The mean leaf Mg content of the plants at Tyre that received 20% emulsifiable concentrate Nemagon, 20% granulated Nemagon and control was 1.097%, 1.038% and 1.036%, respectively. The results were significantly different in favour of the plants that were treated with 20% emulsifiable concentrate Nemagon solution.

The response to Mg uptake shown by the plants that were treated with either concentration of liquid Nemagon was similar to the finding of Ahmedi (1). He found an increased Mg content in the leaves of banana plants that were treated with emulsifiable concentrate Nemagon solution. Maung and Jenkins (35) also found increases of Mg content in tomato plants growing in nematode free soil.

According to Murray (41) the minimum level of Mg needed by a banana plant for normal growth was 0.36%. In this study all plants Whether treated with nematocides or not had sufficient if not excess amounts of Mg. It seams that the occurence of nematodes in the experimental plantations did not reduce Mg uptake sufficiently to cause a deficiency problem.

Table 10. Influence of soil application of Nemagon on the Magnesium content of banana leaf blade.

Treatment	Zahrani Mean of 20 plants	Tyre Mean of 5 plants
Control	0.989%	1.036%
120 cc 10% Nemagon solution	1.164%	
120 cc 20% Nemagon solution		1.097%
240 gms 20% (by wt.) granulated Nemagon		1.038%
Between treatment means	Observed "t" = 7.326 Theoretical "t" at the 1% level = 2.712	L.S.D. at the 5% level = 0.049

9. Iron.

The results of the analysis of Fe content of banana leaf blade are recorded in Table 11. The mean Fe content of the plants at Zahrani treated with 10% emulsifiable concentrate Nemagon solution was 69 ppm as compared with 60 ppm for the control. There was a significant increase in Fe content of the treated plants. The mean Fe content of the plants under study at Tyre that received 20% emulsifiable concentrate Nemagon solution, 20% granulated Nemagon and the control were 112.6 ppm, 104.4 ppm and 97.2 ppm, respectively. There were highly significant differences between every 2 means. The 10% and 20% emulsifiable Nemagon solution as well as 20% granulated Nemagon were effective in increasing the Fe content of bananas. Ahmedi (1) working with nematode control and its effect on banana nutrition found a tendency of increased uptake of Fe by the plants treated with liquid or granulated Nemagon.

Table 11. Influence of soil application of Nemagon on the Iron content of banana leaf blade.

Treatments	Zahrani Mean of 20 plants	Tyre Mean of 5 plants
Control	60 ppm	97.2 ppm
120 cc 10% Nemagon solution	69 ppm	
120 cc 20% Nemagon solution		112.6 ppm
240 gms 20% (by wt.) granulated Nemagon		104.4 ppm
Between treatment means	Observed "t" = 2.343 Theoretical "t" at the 5% level = 2.024	L.S.D. at the 1% level = 7.04

The response of the increased uptake of Fe by the plants that were treated with nematocides in both spring and winter shows that Fe uptake is not influenced by seasonal growth. The maximum level of Fe achieved in the control plants of both spring and winter experiments was 60 ppm and 97.2 ppm, respectively, which shows a lower Fe content in spring. This finding was also true of Nemagon treated plants. The increased rate of leaf production was thought to create a dilution of the Fe content in banana plants during spring.

10. Manganese.

The data on leaf blade Mn content are reported in Table 12. From the table it is seen that the mean Mn content for the plants at Zahrani that received 10% emulsifiable concentrate Nemagon solution was 82 ppm as compared with 125 ppm for the control. The Mn content for the plants at Tyre showed 204 ppm, 237 ppm and 214 ppm for the plants treated with 20% emulsifiable concentrate Nemagon solution, 20% granulated Nemagon, and the control, respectively. There was a highly significant decrease in the leaf Mn content for the plants at Zahrani that were treated with 10% emulsifiable concentrate Nemagon as compared with control. However, the plants at Tyre showed no significant difference in their Mn content.

Table 12. Influence of soil application of Nemagon on the Manganese content of banana leaf blade.

Treatment	Zahrani Mean of 20 plants	Tyre Mean of 5 plants
Control	125 ppm	214 ppm
120 cc 10% Nemagon solution	82 ppm	
120 cc 20% Nemagon solution		204 ppm
240 gms 20% (by wt.) granulated Nemagon		237 ppm
Between treatment means	Observed "t" = 4.614 Theoretical "t" at the 1% level = 2.712	Nonsignificant

During spring the Mn content for check plants was 125 ppm as compared with 214 ppm during winter. The seasonal change of Mn in the leaf blades of bananas was regarded to be due to dilution as a result of production and development of leaves at an increased rate during the spring season. This was in accordance with the findings of Ahmedi (1) who claimed that Mn uptake by bananas remained unaltered round the year whereas the leaf concentration was negatively correlated with growth rate and leaf production.

SUMMARY AND CONCLUSION

Research for one year was carried out on newly established plantation of the banana, Musa nana L. to study the effect of Nemagon (a nematocide) application on nematode control and its influence on chemical composition of leaves in two locations. The first experiment was conducted at Zahrani and consisted of treating bananas with 120mls of a 10% concentration liquid Nemagon during May 1963. The second experiment included 120 mls of 20% concentration liquid Nemagon and 240 gms of 20% (by wt.) granulated Nemagon per plant employed at Tyre during November 1963. At fumigation time 1 kilogram of nitrophoska and 5 kilograms of goat manure were added to each plant at Zahrani, whereas 20 kgs of farmyard manure, 2 kgs ammonium sulfate, 1 kgs superphosphate and ½ kg of potassium sulfate were given to each plant at Tyre.

The soil samples collected from both sites before treatment with nematocides revealed the presence of a fair number of the true spiral nematodes and a heavy population of reniform nematodes but no root-knot nematodes were found. Liquid Nemagon was found to be effective in destroying the true spiral nematodes but not the reniform nematode, whereas granulated Nemagon controlled the reniform nematodes. The 10% emulsifiable concentrate Nemagon and 20% granulated Nemagon did not prevent the appearance of the root-knot nematodes, whereas these nematodes did not develop in the plots treated with the 20% emulsifiable concentrate Nemagon. It was further observed that physical and climatic conditions prevailing in winter reduced the nematode population.

The third leaf of each experimental plant was collected for chemical analysis. The leaf harvest date for Zahrani was July 31st, 1963, and for Tyre May 21st, 1964. The application of Nemagon to these plants was found to increase the uptake of certain inorganic elements. Petiole Nitrate-N was found to increase significantly in plants treated with either concentration of liquid Nemagon whereas blade Nitrate-N showed nonsignificant increases. Petioles always contained more Nitrate-N than blades. Liquid Nemagon at the concentrations used induced increased uptake of N, Ca, Mg, Fe while the Mn and P content was inconsistent. Potassium remained unaffected while Na was found to be high in spring and low in winter. The low Na content of the leaf is thought to be due to the depressing effect of leaf Ca build up in winter. The general nutritional status of the plants in non-treated plots was shown to be above the optimal requirements of banana plants found necessary by Hewitt (21) and Murray (41) for normal growth. However analysis of leaf blades showed increased uptake of nutrients by plants treated with liquid Nemagon. Rate of growth, season and antagonism between elements were also found to influence the uptake of minerals. Research is needed to determine the amount of fertilizer required for optimum growth and yield of bananas in plantations in which nematodes are controlled by nematocides.

It is recommended that areas planted with bananas be treated with effective nematocides to achieve an over all control of nematodes. Increased yields due to increased uptake of minerals should increase net returns. The savings accruing from reduced fertilizer requirements should pay for the nematocide and can be applied to reduce the cost of production. Regular applications at 6 month intervals are essential to check the build up of nematodes.

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