THE EFFECTS OF SOIL FUMIGATION, APPLIED FERTILIZERS AND CLIMATE ON THE GROWTH AND NUTRIENT LEVELS OF CAYENNE PINEAPPLES UNDER FIELD CONDITIONS.

VOLUME I

Text.

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I N D E X

VOLUME I*

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TRIAL 1.

A C K N O W L E D G E M E N T S.

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CHAPTER I.

INTRODUCTION AND RELEVANT LITERATURE.

1. INTRODUCTION.

The pineapple producing area of the Eastern Cape lies between 33°S and 34°S latitude. It is the most distant area from the equator in which pineapples are grown commercially, most other areas lying between latitudes 25°N and 25°S (Collins, 1960). The prevailing climatic conditions may be considered as being adverse to the growth of a plant which originated in the tropics. Girton, (1962) considers the area to be unsuitable for commercial production because of the cold weather experienced during winter. Seasonal fluctuations in growth and nutrient levels of the plant have been referred to by van Lelyveld, (1964), but these have never been studied locally. Because of the profound effect of temperature on the growth and nutrient requirements of any plant, it was deemed necessary to investigate the effects of the cooler conditions on the growth and nutrient levels of the pineapple plant, the results of which may give some indications of seasonal nutrient requirements.

The nutrient requirements of the pineapple plant have been established for commercial production in many countries (Teiwes and Grüneberg, 1963). The methods of application, uptake and utilization of nutrients have been studied in detail particularly by Nightingale (1942 (a) and 1942 (b)); Sideris, Young and Krauss (1943); Sideris and Young (1945; 1946 (a); 1946 (b) and 1956) and Sanford (1964). In South Africa basic fertilizer requirements of nitrogen, phosphorus and potassium applied to the basal leaves of the plant in the dry form have been determined (van Lelyveld, 1964; Nyenhuis, 1967). The results of these findings became available only after initiation of this study.

According to Ayala, Gonzalez-Tejera and Irizarry (1969) pineapples, wherever grown, are attacked by soil inhabiting plant parasitic nematodes. Their control was limited to small confined

areas until the discovery of the mixture known as D-D (1,2- dichloropropane and 1,3- dichloropropene) by Carter in 1940 (Carter, 1953). This discovery started a new era in which nematodes in pineapple fields could be effectively and economically controlled on a field scale. Although nematodes were known to occur in pineapple fields in the Eastern Cape, their effect was largely overlooked until recently. Some of the first replicated field trials for the control of nematodes were started by the author in 1963. Outstanding responses in plant growth and yield led to the commercial application of soil fumigants by 1965. The need for further investigation in this field had become obvious and additional trials were conducted to establish more effective control measures.

Since soil inhabiting nematodes attack the roots of plants they must directly affect the uptake of nutrients by the roots. The severe stunting of plant growth and reduction of yields encountered in infested soils is thus to a high degree due to nutrient starvation as a result of root damage. The effects of applying certain soil fumigants on the uptake of certain nutrients has been studied by Smith (1963) in the Hawaiin Islands. The findings of such studies have indicated not only effects on absorption but also on the utilization of nutrients within the plant (Sanford, 1964). The extent to which nematodes affect the uptake of available and applied nutrients under local conditions was not known. Attempts were made to determine these effects under field conditions as they would be of significant economic importance in the production of pineapples, particularly if nutritional requirements were found to vary with nematode control.

2. RELEVANT LITERATURE.

i) Soil requirements.

The pineapple plant is not particularly fastidious in its soil requirements provided that the drainage is adequate and the soil reaction not alkaline. Malan (1954), Collins (1960) and Teiwes et al (1963) refer to the tremendous variety of soils upon which pineapples are successfully cultivated. Since a study of soil types does not concern this thesis, it is only necessary

to mention that the optimum soil type would be a medium to heavy loam, rich in humus and nutrients and having a soil reaction of between pH 5,5 and 6,2 (Teiwes et al, 1963).

ii) Temperature and growth.

Temperature is one of the most important climatic factors influencing the growth of plants. It is a decisive factor which limits pineapples to definite geographical areas (Collins, 1960). The climatic requirements of pineapples are characterised by their sensitivity to frost and to intense insolation (Teiwes et al, 1963). The optimum and limiting temperatures for growth have been referred to in a number of publications which are not always consistent. According to Malan (1954), the optimum temperatures as given by Clark lie between 23,9°C and 29,4°C and by Johnson as being between 15,6°C and 32,2°C. According to Collins (1960) growth largely ceases when the soil temperature drops below 20°C and very little root growth takes place below 22,5°C or above 41,2°C. Temperatures rising above 35°C cause sunscald, especially when the relative humidity is low (Malan, 1954). Sanford (1964) maintains that the minimum temperature for root and leaf growth is 20°C and the optimum is 32°C. From graphed findings by C.A. Farden in 1950 on the effect of temperature on leaf elongation, and by S. Watanabe in 1932 in Japan on root elongation as presented by Sanford (1961), the optimum growth of leaves and roots occur at 36,2°C and 33,1°C respectively. These graphs as presented by Sanford (1961) indicate some growth above 8,1°C and substantial growth only above 23,7°C. Sanford (1961) states that at temperatures above 36,2°C and below 23,7°C, the growth rate is reduced and also that the application of fertilizers would be of little value at temperatures below 23,7°C.

According to Sanford (1964), studies by Burr in 1961 on sugar cane indicate that not only nutrient absorption, but also the plant nutrient requirements are affected by temperature. He maintains that although this work has not been done specifically on pineapple plants, it may be assumed that it would hold good for the pineapple as well.

Malan (1954) compared temperatures prevailing in Hawaii

and Malaya with those of the pineapple growing areas of South Africa, the relevant figures being reproduced in Table I. The figures for Bathurst, East London, Port Shepstone and Nelspruit are means for the period 1930 - 1945 as supplied by the Weather Bureau while those for Honolulu and Malaya are according to Gaiguaux. It is very evident from Table I that the temperatures for Bathurst and East London which fall in the Eastern Cape region, are far below those of Hawaii and Malaya.

The cool winter conditions which prevail in this region during winter prompted van Lelyveld (1964) to refer to a "prolonged dormant season preceeding flower differentiation" and Girton (1962) to state that no significant growth could be expected to take place during the months of June, July and August. As far as can be ascertained, no actual growth measurements were made to substantiate such statements, although it was common knowledge that little or no growth took place during the winter months.

In experiments with different types of planting material planted at different times of the year Sanford (1961) found that the growth of pineapple plants in Hawaii was continuous over a 13 to 15 month period to flower differentiation. The eventual weights of the plants varied from one to 4,5 kg depending on the time of planting and the type of planting material. Summer planting (June) resulted in the largest plants being produced while winter planting (February), resulted in the plants remaining small. Similar findings in Australia are reported by Mitchell (1962). Growth under local conditions is much slower and spring plantings (September) differentiate in 20 to 30 months depending on climatic conditions and the type of planting material. The growth pattern under cooler conditions can thus be expected to be quite different from that found in warmer climates. The relative growth rate (RGR) of a plant being the increase in growth by unit of time is determined by the formula

$$\frac{\log_e W_2 - \log_e W_1}{t_2 - t_1}$$ (Blackman, 1968)

and has been used to determine the RGR of a number of plant species. Using total leaf weight Tay and Tan (1971) determined the RGR of

pineapple plants in Malaya. They found that the RGR increased steeply to a peak between the sixth and seventh month from planting after which it declined gradually to the tenth month. The same authors found the nett assimilation rate (NAR) to follow a similar pattern to the RGR. The two factors are inter-related by way of the fact that the NAR is the nett dry weight increase per unit area of leaf upon which the growth of a plant is dependent.

iii) Nutrient requirements.

A comprehensive review of literature concerning this subject has been compiled by Teiwes et al (1963). The amounts of fertilizer required by the plant vary considerably with soil conditions and climatic conditions such as sunlight, temperature and rainfall (Sanford, 1964). For example, Nightingale (1942 (a)) reports that the nitrogen requirements of the pineapple plant, to give the same yields, may vary by as much as 75% in different seasons in the same locality. Nevertheless, standard fertilizer programmes have been determined for different conditions by field experimentation.

In Hawaii, concentrations of phosphorus, potassium, calcium and magnesium in the soil are used to determine the fertilizer requirements at the time of planting and during the early stages of growth. They serve as indicators of nutrient reserves in the soil and are not necessarily the amount which is available to the plant, for several physiological and environmental factors influence nutrient absorption. The determination of soil nitrogen has not proved to be a reliable indicator of nitrogen availability because the nitrogen content of the soil is too variable and no sound relationship between the amount of soil nitrogen and early growth has been found. Leaf analysis and visual deficiency symptoms are used for the determination of nutrient requirements during the growth of the plant (Sanford, 1961).

It has been found generally, that nitrogen is required in relatively large quantities for good growth and yields of pineapples (Nightingale, 1942 (a); Sideris et al, 1946 (b); Samuels, Landrau and Olivencia, 1955; Py, Tisseau, Oury and Ahamad, 1957; van Lelyveld, 1964). The recommended applications of nitrogen up to plant crop vary from none on bush soils in Zululand (Nyenhuis, 1967), to 672 kilograms nitrogen per hectare (kg N/ha)

in Hawaii (Collins, 1960). Samuels et al (1955), obtained the highest yields by applying 186 kg N/ha in Puerto Rico while Marr (1966) reports that some plantations in Hawaii applied 532 kg N/ha and that Pineapple Research Institute of Hawaii recommendations for optimum yields were applications of 560 to 672 kg N/ha. Work by van Lelyveld (1964), showed that 600 kg $(NH_4)_2SO_4$ per 10000 plants (i.e. between 542 and 723 kg N/ha depending on the number of plants which varied in his trials from 36084 to 48100 plants per hectare) gave the highest plant crop yields under Eastern Cape conditions.

It has been found that NH_4 - N is more readily available to the plant than NO_3 - N (Sanford, 1961) and that sulphate of ammonia was particularly good on sandy soils (Py et al, 1957). As a foliar spray nitrogen is applied in the form of urea (Sanford, 1959). Nitrogen applied after flower bud emergence has not been found to increase the plant crop yield and is thus not recommended (Nightingale, 1942 (a); Sanford, 1961). The nitrogen requirements for the first ratoon crop are relatively low and given by Sanford (1961) as being one fifth to two fifths of the plant crop requirements. This would mean applications of between 112 and 269 kg N/ha based on the recommendations of the Pineapple Research Institute of Hawaii.

Potassium is applied in the sulphate form either as pre-planting, basal leaf or foliar spray applications (Samuels et al, 1955; Py et al, 1957; Sanford, 1959). The quantity of potassium applied to plant crop is given by Collins (1960) as between 220 and 260 kg K/ha, the amounts depending on available soil reserves. Potassium is not normally applied to the ratoon crop as such applications have seldom been found to result in yield increases (Sanford, 1961).

The application of phosphates has given varied results. Py et al (1957) report that they found no response to phosphorus in most soils and a depressing effect in some. Montenegro, Torres and da Silva (1967) found no response to phosphorus when applied at 44 kg P/ha and a significant depressing effect at 88 kg P/ha. Samuels, Landrau and Alers Alers (1956) recorded none to some response at 28 kg P/ha, and a decreased yield at

41 kg P/ha, while Nyenhuis (1967) recorded yield increases with applications of up to 93 kg P/ha. According to Collins (1960), the rates of application in Hawaii vary between 75 and 123 kg P/ha. Some plantations in Hawaii apply about 168 kg P/ha using Diamone (18% N : 46% P_2O_5) as a preplanting application followed by foliar sprays of 56 kg diammonium phosphate (21% N : 53% P_2O_5)/ha when leaf-P falls below 0,24% (Marr, 1966). The depressing effect often encountered could be caused by the suppressing effect of applied phosphorus on nitrogen absorption as found by Nightingale (1942 (b)).

The needs for calcium and magnesium are determined by soil analysis and are corrected by applying lime and magnesium sulphate (Sanford, 1961).

The most commonly applied trace elements are iron and zinc. Iron is applied as foliar sprays of ferrous sulphate. The rates and frequency of application vary from 5,6 to 9 kg $FeSO_4$/ha applied every two to four weeks, depending on visual defiency symptoms (Sanford, 1959). Zinc is applied as zinc sulphate, either mixed with other fertilizers and applied to the basal leaves in the dry form or as foliar sprays (Lewcock, 1956; Teiwes et al, 1963; Sanford, 1959). The amounts vary from 20 to 40 kg $ZnSO_4$/ha in dry mixtures and approximately one kg/ha in foliar applications given at two to four weekly intervals as and when required.

Sulphur is applied in abundance as the sulphate forms of fertilizers are used. Copper, boron, manganese and molybdenum are seldom applied and where leaf analysis indicate deficiencies, blanket applications of very low amounts are made (Sanford, 1961).

Information from Girton (1966) on the findings of research workers in the Hawaiian Islands regarding the levels of soil nutrients at which responses to applied fertilizers could be expected is given in Table 2. High, critical and low levels of nutrients in the leaves, expressed on a dry weight basis, obtained from the same source are presented in Table 3. These figures are used as indicators of nutrient requirements of the pineapple plant in Hawaii.

In a review of experiments on the methods of fertilizer application during the period 1916 - 1959 in Hawaii by numerous scientists, Sanford (1959) concluded that ferrous sulphate and zinc sulphate applied as foliar sprays were far better than soil applications. He also concluded that foliar sprays of nitrogen, phosphorus and potassium were advantageous over dry side dressings. His reasons for this conclusion were not because of yield differences but rather that foliar sprays afforded alternative paths of entry of the nutrients into the plant and that these nutrients could be applied together with iron and zinc which were beneficially applied as foliar sprays. No significant yield differences were encountered in either the plant or ratoon crops nor was there any significant effect on the numbers of slips and suckers produced. The main disadvantage of side dressings in Hawaii was the high labour costs involved in applying the nutrients, compared with the relatively cheap mechanised application of foliar sprays.

Sanford (1959) also concluded that there were no differences when low (<561,7 litres per hectare (l/ha)), medium (561,7 to 2808,3 l/ha) or high (>2808,3 l/ha) volumes of water were used when applying nutrients as foliar applications provided that the concentration of nutrients was below such level as would cause leaf injury. Low volume sprays were considered advantageous when $FeSO_4$, $ZnSO_4$ and phosphorus compounds were applied as there was better uptake of these nutrients through the leaves. High volumes result in run off which would tend to reduce the efficiency of such sprays. Nutrients which are taken up just as readily by soil or leaf applications could be applied in high volume sprays. The relatively low solubility of K_2SO_4 requires the application of higher volumes. Experiments with different concentrations of nutrients indicated leaf injury when applied under sunny conditions. The findings were as follows : $(NH_4)_2SO_4$ considerable injury at 8% concentration ; $(NH_2)_2CO$ only slight injury at 10% concentration; K_2SO_4 only slight injury at 6% concentration and $FeSO_4$ moderate injury at 4% concentration.

While $(NH_2)_2CO$, K_2SO_4, $MgSO_4$ and $FeSO_4$ could all be

safely mixed in the same sprays, $Ca(NO_3)_2$ would precipitate as $CaSO_4$ and phosphorus compounds would react with the iron to precipitate as Fe-phosphate compounds on the leaf surface according to Sanford (1959). He also states that the incorporation of herbicides, insecticides and flower inducing hormones in nutrient sprays could not be generally recommended.

Experiments in which the volumes of nutrient solutions applied at constant concentrations were varied indicated that smaller plants were unable to utilize large amounts of nutrients. They also indicated that the plants required greater amounts of nutrients applied in higher volumes as they increased in size (Sanford, 1959).

iv) Nematode infestations.

Plant parasitic nematodes have been found to attack tropical plants throughout the world and can result in yield losses without obvious symptoms of their presence (Wallace, 1963). The conditions under which nematodes are found vary widely, and they appear to be independent of soil type, their existence and activities being more dependent on soil moisture and temperature than other factors (Wallace, 1963). Variations in the population density of different genera may be found in different soil types. Ayala (1961) for instance found more root knot nematodes in the sandy soils than in the clay soils of Puerto Rico while the populations of spiral nematodes were about the same in both soil types. Nematode counts in soil samples can be expected to vary considerably, depending on the prevailing conditions at the time of sampling. Nevertheless, nematode counts have been found to give important indications of their eventual effects on plant growth and yield. According to Wallace (1963), the subsequent damage by nematodes is clearly influenced by the initial density of the populations in the soil.

Since the discovery of D-D, the fumigation of pineapple soils has become standard practice in most countries where pineapples are grown commercially (Carter, 1953; Collins, 1960; Ayala, 1961; Sanford, 1964). The use of soil fumigants in the Eastern Cape has been very recent and even today, many small plantations do not apply them. As recently as 1967, local research workers were still hesitant in recommending their use

as a general practice, mainly because of lack of information regarding the economics of application (Heyns, 1967).

While Meloidogyne sp. probably cause the greatest damage to crops in Hawaii, Rotylenchulus sp. have also been found to be important. Ayala (1961) found the most frequently occuring genera in Puerto Rico to be Rotylenchulus and Helicotylenchus with Pratylenchus, Paratylenchus, Aphelenchoides, Dorylaimus, Ditylenchus and Meloidogyne also occuring in substantial numbers. Meloidogyne sp. were not widely distributed and were found only in the Northern regions (Ayala, 1961). In an initial survey of the local pineapple growing area, ten parasitic genera were isolated. They were Helicotylenchus, Scutellonema, Rotylenchus, Meloidogyne, Xiphinema, Longidorus, Rotylenchulus, Paratylenchus, Criconemoides and Trichodorus according to Heyns (1967). The most commonly occuring of these were the spirals (Helicotylenchus) and to a lesser extent the root knot nematodes (Meloidogyne) (Heyns, 1967).

The most widely used soil fumigant in the pineapple growing areas of the world is D-D, while ethylene dibromide (EDB) is used to a lesser extent and mainly in high rainfall areas because its effectiveness is dependent on soil moisture and it is ineffective under dry soil conditions (Carter, 1953). The chemical, 1,2-dibromo-3-dichloropropane (DBCP) which is not phytotoxic to the growing plant is used in a preplanting mixture with D-D or as a post planting application (Carter, 1953; Collins, 1960; Bannister, 1961; Smith, 1963; Marr, 1966; Mc Beth, 1957; Ayala et al, 1969). The quantities of fumigants applied in Hawaii vary with local conditions, but in general, are given as 181-272 kg D-D/acre or approximately 275-560 l/ha by Collins (1960), and mixture of 40 U.S. gal. D-D + 3 U.S. gal. DBCP (373 l D-D + 28 l DBCP/ha) and EDB 18 U.S. gal. (225 l/ha approx.) by Marr (1966).

Some experiments with soil fumigants have resulted in increases in plant crop yield, others only in increases in ratoon crop yield and still others in yield increases in both crops (Carter, 1954). With a relatively heavy application of D-D (over 800 l/ha), Ayala et al (1969) report that yields were more than doubled, while treatments which included less effective

fumigants resulted in increases in plant crop yields and crop failures in the ratoons. The latter results may have been due to the observed rapid build up of nematode populations following treatments which did not reduce the populations sufficiently (Ayala et al, 1969).

The applications of soil fumigants not only control nematodes but also kill off a large number of other parasites and pathogens which indirectly lead to an increase in the uptake of nutrients (Smith, 1963). The application of D-D, for example, suppresses the activities of nitrifying bacteria for a period of up to 24 weeks. The resulting build up of NH_4-N which is more readily assimilated by the plant than NO_3-N, leads to an initial increase in the rate of plant growth (Tamm, 1945; Carter, 1953; Smith, 1963; Sanford, 1964). Smith (1963) found that soil fumigation sometimes increased and sometimes decreased the quantity of iron which may be extracted from the soil. It appeared to improve the utilisation of iron within the plant but not the uptake of iron by the plant. He also reported that the availability of manganese was increased in the soil due to the killing off of manganese oxidizing micro-organisms. The increased availability of manganese led to an increased uptake as indicated by the leaf-Mn level. Although fumigation increased the availability of phosphorus in the soil as indicated by soil analysis, it resulted in a decrease in leaf-P in the initial stages of growth. The addition of superphosphate to the soil did not overcome the suppressing effect of fumigation and whether or not the leaf-P level would eventually equal or surpass that of unfumigated plants would depend upon the relative root health status of the plants (Smith, 1963). It has been suggested that this suppressing effect may be tied up with the inhibition of manganese oxidation, but the exact interaction is not known (Smith, 1963). Sanford (1964) reports that leaf-P is reduced in the early stages of growth following the application of D-D and EDB, but that this effect was later reversed and also that the application of D-D, EDB and DBCP all resulted in increased availability and absorption of manganese. Fumigation was also found to increase leaf-K because of an improved root system (Sanford, 1964). According to Sanford (1964), the primary effects of fumigants become more obvious in the later stages of growth,

indicating that these effects are brought about by the improvement in the size and quality of the roots following the control of nematodes.

According to Brown (undated) samples for nematode counts should be taken from the top 9-12" (22,9 - 30,5 cm) of soil. Several samples should be taken over the suspect area, at least ten 50 g samples per acre. These should be mixed thoroughly to give a composite sample. The use of polyethylene bags for storing the samples is recommended by both Brown (undated) and Hooper (1969 (a)).

A number of methods for the extraction of nematodes from the soil have been described (Chapman, 1958; Hooper, 1969 (a)). Chapman (1958) found that while the Sieving Baermann-funnel and the Baermann-funnel methods were satisfactory, the Inverted Flask method provided the greatest yield and least variability in the numbers of nematodes.

Details of identification of plant parasitic nematodes are given by Hooper (1969 (b)), while Brown (undated) describes some of the more obvious facets which facilitate general identification of the more important genera.

v) Leaf samples for analysis.

It has been generally accepted that the D-leaves, recognised as the longest and most active leaves on the plant, give the best indications of the nutritional status of the pineapple plant (Nightingale, 1942 (a); Steyn, 1957; Sanford, 1961). The basal white tissue has been used for the quantitative determination of all elements by Nightingale (1942 (a)); Steyn (1957) and others, while Sanford (1961), reports that phosphorus, potassium, calcium and magnesium are determined in the basal white tissue and nitrogen, iron and chlorophyll are determined in the middle third of the green tissue in crop logging of plantations in Hawaii. Zinc is also determined in the white tissue except where deficiency levels are to be determined, in which case the apical meristem, which has the highest concentration of zinc, is used (Pineapple Research Institute of Hawaii, 1961).

The concentration of an element is usually expressed as a percentage or p.p.m. on a dry weight basis (Steyn, 1957), but can

also be expressed on a fresh weight basis as the moisture content of the basal white tissue is not expected to vary more than 1 to 1,5% according to Sanford (1961).

Nightingale (1942 (a)), sampled leaves between 8 a.m. and 4 p.m. while Steyn (1957) found variations in the nutrient status during the day and recommended the taking of samples between 8 a.m. and 10 a.m. on calm sunny days. In order to minimise the loss of soluble constituents, Steyn (1957), recommends the trimming of the basal white tissue after washing and the use of the middle third for analysis.

Steyn (1957) found adequate cleansing of samples by washing in water with 0,1% Teepol added, sponging with cotton wool, rinsing twice in distilled water and finally, rinsing in deionised water.

The most satisfactory temperatures for drying of samples were found by Steyn (1957) to be an initial drying at 50°C for 72 hours, followed by grinding and then a further drying at 65°C for 24 hours.

3. INTRODUCTORY DISCUSSION ON EXPERIMENTATION.

To gain some knowledge of the effect of applied nutrients, plant parasitic nematodes and the cooler climatic conditions experienced in the Eastern Cape on the growth and nutritional status of the pineapple plant a series of experiments was conducted.

Two fertilizer trials were included in the study to give some indication of the responses to fertilizers under local conditions. When the first experiment was begun, the knowledge concerning the nutrient requirements of pineapples in South Africa was limited. A number of trials involving levels of nitrogen, phosphorus and potassium had either just been completed or were underway at the Government Research Stations at East London and Bathurst. A study of the nitrogen requirements by van Lelyveld (1964) was well under way and the need for duplication of work from which the results were not yet available was considered unnecessary. Instead of trials involving levels of applied nutrients, a comparison was made in the first trial of the standard

practices used locally and those used in Hawaii. The main differences between these practices at that time were that nutrients were applied in the dry form to the basal leaves locally, and as preplanting and foliar spray applications in Hawaii. In local programmes neither iron nor zinc was applied but in certain instances and on the recommendations of Lewcock (1956) both copper and zinc were added to fertilizer mixtures. In Hawaii on the other hand it was standard practice to add both iron and zinc to fertilizer mixtures applied as foliar sprays. In the trial more or less basic practices were thus compared.

Although experiments had been conducted at the Government Research Stations at East London and Bathurst in which different forms of nitrogen were applied as band, basal leaf and foliar applications, the application of iron and zinc had not been included. Since both iron and zinc deficiency symptoms were prevalent in the area and because there had been indications of responses to applied iron and zinc in some trials, it was decided that further work was necessary regarding the placement of fertilizer (for details see p. 33). There are three main methods in which fertilizers can be applied, namely as preplanting, basal leaf or foliar spray applications. Sanford (1959) indicates that there are advantages and disadvantages in the different methods of fertilizer application. Application of iron and zinc as foliar sprays were found to be superior to soil applications, while spray applications of nitrogen and potassium were found to be equal to dry side dressings of the same materials when applied at the same rate by Sanford (1959). Similar results were found with the applications of phosphorus, calcium and magnesium provided that certain precautions involving compatibility were observed (Sanford, 1959). In view of the above findings together with knowledge of the findings of other research workers in Hawaii (Marr, 1966) a second trial was designed to compare fertilizer placement under local conditions and also to confirm that the methods used in the Fertilizer/Fumigation trial (see p. 51) were suitable.

Local knowledge regarding the control of plant parasitic nematodes being limited at the time prompted the laying out of

soil fumigation trials. The treatments included in the initial trial were suggested by Girton (1963) who had had experience in the production of pineapples in Hawaii. The treatments included in the trial were thus based on knowledge of control measures used in Hawaii at that time. A second trial, which included some of the most promising treatments used in the first trial, was begun before completion of the first trial in order to save time. Some of the treatments involving fumigant mixtures in the second trial were at different economic levels of treatment, rather than different dosage rates, the main purpose of the trial nevertheless being an attempt to obtain effective control of nematodes.

A trial involving soil fumigation and applied nutrients was conducted to gain some knowledge of the effect of nematodes on the growth and nutrient content of plants under field conditions. Although some knowledge regarding the effects of fumigation on uptake of nutrients and growth was available (Smith, 1963; Sanford, 1964) it was necessary to determine these effects under local field conditions for better understanding of nutrient requirements as affected by soil fumigation. Indications of the treatments to be used in the trial were obtained from available literature and the results of the preliminary trials described earlier. The rate of soil fumigation was to be such that effective control of nematodes would result without serious phytotoxic effects of treatment. In the trial the interactions of five applied nutrients and soil fumigation were investigated. Their effects on certain aspects of plant growth, fruit quality, yields and nutrient status of the plant were determined.

Climatic conditions under which pineapples are grown commercially in the Eastern Cape being considered by many as being adverse to growth led to a preliminary study of the effects of these conditions, particularly temperature, on the rate of growth and the nutritional status of the pineapple plants under field conditions. Three commercial plantations were selected for sampling, from which plants were weighed and the leaves analysed to determine the nutrient status. The seasonal growth rates and nutrient levels recorded were then compared with prevailing temperatures.

The purpose of this study was, therefore, to evaluate some of the effects of temperature, nutrition and nematodes on the growth and nutritional status of the Cayenne cultivar of Ananas comosus (L) Merr. under field conditions in the Eastern Cape.

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CHAPTER II.

MATERIALS AND METHODS.

1. LOCATION AND CLIMATE.

All field experiments were conducted on the farm "Whitney Estate" in the Alexandria district of the Eastern Cape. The farm lies between five and eight kilometers from the Indian Ocean and has an average elevation of about 120 meters. It lies approximately 33° 30'S latitude and 26° 30'E longitude.

The general soil type is a sandy loam derived from calciferous deposits of the Uitenhage series. It varies from reddish to grey in colour depending on aspect and exposure to prevailing winds. It overlies limestone and contains about 20% clay and 75% sand and has a low base exchange capacity of less than 20 m.e./100g.

The climate is variable as the area lies between the summer and winter rainfall areas of the coastal belt. The annual rainfall averages 691 mm with more rain falling during the summer than the winter months, the heaviest falls generally being recorded at the equinoxes (Table 4). During the winter, antarctic cold fronts periodically sweep across the area reducing temperatures to near zero. Hot berg wind conditions are also experienced, these extreme conditions being interspersed with mild weather. The mid-summer months are usually hot and dry with variable winds. Rain during this period falls mainly as thunder showers.

Mean temperatures for Bathurst which has a third order weather station and is situated 30 kilometers east of "Whitney Estate" are presented in Tables 5 and 6. The mean temperatures for Molokai, Hawaii presented in Table 7 are after Girton (1962). When the mean temperatures for Molokai are compared with those for Bathurst, it can be clearly seen how much lower the local temperatures are. The mean minimum temperature for Molokai is higher than the mean temperature for Bathurst throughout the comparative seasonal twelve months period (Fig. I). Similarly the mean temperature for Molokai is above the mean maximum temperature for Bathurst.

2. MATERIALS.

i) Fertilizers.

All nutrients applied to the plants were commercially available preparations of fertilizers in the following formulations:

(a) Phosphorus.

Granular superphosphate (8,3%P).

$Ca\ H_4\ (PO_4)_2$ water soluble.

$NH_4\ H_2\ PO_4$ water soluble.

$Ca_2\ H_2\ (PO_4)_2$ citric acid soluble.

$Ca_3\ (PO_4)_2$ insoluble.

(b) Nitrogen.

Sulphate of ammonia $(NH_4)_2\ SO_4$ (21,0%N).

Urea $(NH_2)_2\ CO$ (46,0%N) low biuret 0,3%.

(c) Potassium.

Sulphate of potash $K_2\ SO_4$ (40,0% K).

(d) Iron.

Ferrous sulphate $Fe\ SO_4\ :\ 7\ H_2O$ (20,0% Fe).

(e) Zinc.

Zinc sulphate $Zn\ SO_4\ :\ 7\ H_2O$ (22,0% Zn).

ii) Soil fumigants.

The soil fumigants used included:

(a) 1,3 - dichloropropene : 1,2 dichloropropane 100% formulation (D-D).

(b) 1,2 - dibromo - 3 - chloropropane 80% E.C. formulation (DBCP).

(c) Ethylene dibromide 92% E.C. formulation (EDB).

3. METHODS OF APPLICATION.

i) Fertilizers.

Certain factors based on the findings of others as described by Sanford (1959; 1961) were considered when fertilizer treatments and programmes were decided. Nutrients were not applied between flower differentiation for the plant crop and harvesting of the plant crop; phosphorus and potassium were not applied after flower differentiation for the plant crop; increasing amounts of some nutrients were applied as the plants increased in size and 'medium volume' sprays were used when foliar applications were made.

In preplanting applications the fertilizer was applied to the soil surface in the solid form and worked into the top 15 cm.

The solid form was also used for the basal leaf applications where fertilizers were applied by hand using cone shaped copper spoons, graduated to give the correct amounts. The first application, usually given when the plants were still small, was applied next to the plant while subsequent applications were made to the axils of the lower leaves of the plant. When this method was used for the ratoon crop the fertilizer was applied to the basal leaves of the ratoon suckers. In foliar applications, the fertilizers were dissolved in water and applied by knapsack sprayers at a rate of 1123,3 and 2246,6 l/ha. Details regarding the rates of application of nutrients are given when the treatments of the trials involved are presented. The pH of the water used in the foliar sprays was adjusted to 5,8 by the addition of citric acid to prevent the precipitation of ferrous sulphate.

ii) Soil fumigants.

Soil fumigants were applied by soil injector guns graduated to give the correct applications, details of which are given when treatments of the trials involved are presented. The holes left by the injector guns were closed immediately to prevent any loss by evaporation.

4. FIELD TRIAL LAYOUT.

Details concerning the layout of field plots are shown diagramatically in Figures II and III. The first diagram shows how

border rows and guard plants at the ends of the data rows were included in the treated area but not used for sampling. The second diagram indicates the layout used in split plot trials.

5. TAKING OF DATA.

i) Soil samples for chemical analysis.

A garden trowel was used to take samples at random from the area which was to be planted to the particular field trial. The sample was taken from the top 20 cm of soil at five different locations to make up about 1 kg of soil. The sample was then thoroughly mixed and placed in a plastic bag, labelled and sent off for analysis.

Where samples were taken from individual experimental plots, the procedure was as above except that the five samples were taken at random within a plot and between the growing plants. The methods used for determining the amounts of available nutrients were those recommended by the Fertilizer Society of South Africa (Annexure A).

ii) Soil samples for nematode counts.

A home made soil auger capable of taking out 1,5 cm diameter cores of soil was used. Sampling consisted of taking twenty cores at random from the top 20 cm of soil from the root zone of the plants in each plot. The cores were then thoroughly mixed, placed in a plastic bag, labelled and sent off for analysis. Sampling was done when the soil was moist, but not wet, usually three or four days after a rainfall in excess of 15 mm. The method of extraction of nematodes was a modification of the Baermann Funnel Method as described by Brown (undated) (Annexure B).

iii) Root weights.

The roots were cut off plants which had been carefully lifted for this purpose. The roots were then washed in water to remove all soil particles and weighed.

iv) Plant weights.

Plants were carefully lifted so as to recover as many roots as possible. Soil was washed from the roots and the whole plant then weighed.

v) D-leaf weights.

The D-leaves are the leaves from the fourth whorl and are recognised as the longest leaves on the plant (van Lelyveld, 1964). These leaves are actively growing, indicative of the size of the plant and also the nutrient status of the plant (Sanford, 1964). The D-leaves were pulled from the plants lifted for plant weight records as well as from growing plants. Where plants had been lifted, four D-leaves were removed from each plant, otherwise one leaf was pulled from each growing plant in the data area of each plot. The number of leaves sampled at any particular time from one plot were weighed together and constituted one sample.

vi) Sucker and slip counts.

The suckers were counted in the spring following the harvesting of the plant crop, i.e. four to six months after harvesting. In this way the total number of suckers for each plot was established. The slips were removed from the plants at the time of sucker counting and the number produced in each plot established.

vii) Fruit weights.

The fruit was allowed to mature on the plant and was harvested at the stage of maturity normally accepted at the canning factories. Harvesting was done each week, the tops were removed and the fruit from each plot weighed individually.

viii) Fruit juice extractions for T.S.S., acid and sugar determinations.

Juice was extracted from mature fruit harvested on the same day from all plots, using a stainless steel fruit juice

press. Fruit samples were taken during mid season harvesting of the plant crop, at a time when there was fruit on all the plots of all treatments. The juice samples were placed in 100 ml screw top glass bottles, sealed, labelled and sent in for analysis. Sugar was determined by refractometer giving the percentage Brix. Acidity was determined by titrating the sample against 0,1N NaOH. Total soluble solids were determined by evaporating to dryness at 65°C.

ix) Fruit density.

Five fruits from each plot at the same stage of maturity were weighed and their volume determined by immersing in water and weighing the water displaced. The fruit density was then calculated from

$$\frac{\text{wt. of fruit}}{\text{wt. of water displaced.}}$$

x) Fruiting period.

The pineapple plant bears over a long period, the plant crop for instance may be harvested over a period of six months or longer in each treatment. In an effort to get some arbitrary figure by which the period from planting to harvesting could be compared for different treatments, the following formula was used:

$$\frac{\Sigma(\text{wt. of fruit harvested each month X No. of months from planting})}{\text{Total wt. of fruit harvested}}$$

This resulted in a figure of 'X' months for each treatment which may be considered as an "average fruiting period" from planting to harvesting.

6. RELATIVE GROWTH RATE.

The relative growth rate of plants growing under field conditions was determined from the weights of plants sampled monthly in three plantations, using the formula

$$\frac{\log_e W_2 - \log_e W_1}{t_2 - t_1}$$ (Blackman, 1968).

The RGR was also determined by applying the above formula to

mean D-leaf weights taken from the sample plants referred to above.

7. PREPARATION OF LEAF SAMPLES FOR CHEMICAL ANALYSIS.

All D-leaves which were to be used for leaf analysis, were pulled on bright sunny days between 8 a.m. and 10 a.m. in order to eliminate variations in amounts of nutrients which might occur at different times of the day (Steyn, 1957). After weighing the D-leaves, the white basal portion was cut off with a stainless steel knife and prepared for analysis. The cleansing method used was similar to that described by Steyn (1957) and van Lelyveld (1964). The leaf material was washed in rain water, to which about 0,1% by volume Teepol was added, to remove visible surface dirt. Each leaf portion was scrubbed lightly with a nylon brush until all marks and stains had disappeared. This was followed by rinsing in deionised distilled water, to which 0,1% Teepol had been added, and swabbing with clean cotton wool. The samples were then rinsed in two consecutive dishes containing deionised distilled water and then placed on a clean muslin cloth to drain. Plastic containers were used throughout.

The middle third of the basal white tissue was cut out with stainless steel scissors, placed in a muslin bag and labelled. The samples were then dried in a forced draught oven for 24 hours at 65°C, after which they were ground in a Casella mill and stored for chemical analysis, details of which are given in Annexure C.

8. ANALYTICAL PROCEDURE.

Nitrogen determination was done by the standard micro-kjeldahl method. The technique used was essentially the same as that described by Steyn (1957) with the exception of slightly different amounts of leaf material and reagents being used (Annexure C).

Phosphorus was determined colorimetrically by the vanado-molybdo-phosphate method as described by Jackson (1958) (Annexure C).

Analysis for the elements Ca, Cu, Fe, K, Mg, Na, Mn and Zn was by atomic absorption spectrophotometer using a Techtron AA4 instrument, details of procedure are given in Annexure C.

9. STATISTICAL ANALYSIS.

For randomised blocks experiments the standard analysis of variance methods were used. The data from the 2^6 and 3^3 factorial experiments was analysed by computer. The standard levels of significance accepted in agricultural research were used throughout. Differences which showed significance at the 5% level are referred to as significant and those which showed significance at the 1% level as being highly significant.

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CHAPTER III.

FIELD TRIALS.

A. FERTILIZER TRIALS.

TRIAL 1.

The first trial was planted in October, 1963, to compare local fertilizer programmes with those generally used in Hawaii.

The treatments included the general standard practices used locally and in Hawaii, together with differences in levels of phosphorus and potassium because of the low values of these nutrients in the soil.

1. TREATMENTS.

Details of the nutrients applied for the plant crop were as follows:

Treatments	N	P	K	$FeSO_4$	$ZnSO_4$
A Preplanting Basal leaf Foliar spray	556	74	191		
Total	556	74	191		
B Preplanting Basal leaf Foliar spray	556		191	124	10
Total	556		191	124	10
C Preplanting		74			
Basal leaf Foliar spray	556		191	124	10
Total	556	74	191	124	10

Treatments		N	P	K	$FeSO_4$	$ZnSO_4$
D	Preplanting		74	117		
	Basal leaf	331		191		
	Foliar spray	225			72	8
	Total	556	74	308	72	8
E	Preplanting		74			
	Basal leaf	331		191		
	Foliar spray	225			72	8
	Total	556	74	191	72	8
F	Preplanting		74	117		
	Basal leaf					
	Foliar spray	556		191	124	10
	Total	556	74	308	124	10
G	Preplanting		37			
	Basal leaf					
	Foliar spray	556		191	124	10
	Total	556	37	191	124	10

X No fertilizer

Details of application of nutrients to the plant crop were :

(i) Preplanting applications.

Phosphorus Treatment G : 37 kg P November (445,8 kg superphosphate)

Treatments C D E F : 74 kg P November (891,6 kg superphosphate)

Potassium Treatments D F : 117 kg K November (292,5 kg potassium sulphate)

(ii) Basal leaf applications.

Nitrogen Treatment A : 111,2 kg N in five applications Jan., March, Sept., Dec., Feb. (529,5 kg ammonium sulphate per application)

Treatments D E : 66,2 kg N in five applications Jan., March, Sept., Dec., Feb. (313,2 kg ammonium sulphate per application)

Potassium Treatment A : 38,2 kg K in five applications Jan., March, Sept., Dec., Feb. (95,5 kg potassium sulphate per application)

Treatments D E : 38,2 kg K in five applications Jan., March, Sept., Dec., Feb. (95,5 kg potassium sulphate per application)

(iii) Foliar spray applications.

The amounts of nutrients given below were applied in 1123,3 l water/ha per application.

Nitrogen, Iron and Zinc. Treatments D E :

18,7 kg N; 8,8 kg $FeSO_4$; 1,0 kg $ZnSO_4$ every two months Jan., March, May, June.
(40,6 kg Urea per application)

37,5 kg N; 8,8 kg $FeSO_4$; 1,0 kg $ZnSO_4$ every two months Aug., Oct., Dec., Feb.
(81,2 kg Urea per application)

Nitrogen, Potassium, Iron and Zinc. Treatments B C F G :

23,2 kg N; 8,0 kg K; 7,8 kg $FeSO_4$; 0,6 kg $ZnSO_4$ monthly Dec., Jan., Feb., March, April, May, June, July.
(50,4 kg Urea; 20 kg potassium sulphate per application)

46,4 kg N; 16,0 kg K; 7,8 kg $FeSO_4$; 0,6 kg $ZnSO_4$ monthly Aug., Sept., Oct., Nov., Dec., Jan., Feb., March.
(100,8 kg Urea; 40 kg potassium sulphate per application).

Treatment A represented the general field practice in use in the Eastern Cape at the time and consisted of basal leaf dressings of sulphate of ammonia, superphosphate and sulphate of potash.

Treatments B, C, F and G were based on standard field practices in use in Hawaii with N, K, Fe and Zn applied as foliar sprays of urea, sulphate of potash, ferrous sulphate and zinc sulphate. Phosphorus was applied in varying amounts as a preplanting application of superphosphate in order to determine phosphorus requirements.

Treatment F was given an additional preplanting application of sulphate of potash because of the low values of potassium in the soil (K = 66 p.p.m. see Table 8).

Treatments D and E were included as possible combinations of the above treatments (basal leaf and foliar sprays) in an effort to gain some knowledge regarding fertilizer placement. Nitrogen was applied both as a basal leaf dressings and foliar sprays; potassium as a preplanting and basal leaf dressing in treatment D and solely as a basal leaf dressing in treatment E; phosphorus as a preplanting application and iron and zinc as foliar sprays.

Fertilizer applied for the ratoon crop totalled 214 kg N/ha in three applications of sulphate of ammonia at 340 kg/ha/application to the basal leaves of the ratoon suckers in treatment A, applied in April, Sept. and Dec. following the harvesting of the plant crop. Ten foliar sprays of urea, ferrous sulphate and zinc sulphate totalling 214 kg N/ha; 78 kg $FeSO_4$/ha and 6 kg $ZnSO_4$/ha were applied to treatments B, C, D, E, F and G monthly from April to Jan. following the harvesting of the plant crop. Details of which are as follows:-

April - May : 58,1 kg urea in 1123,3 l water/ha + 7,8 kg ferrous sulphate + 0,6 kg zinc sulphate.

June - Sept. : 29,1 kg urea in 1123,3 l water/ha + 7,8 kg ferrous sulphate + 0,6 kg zinc sulphate.

Oct. - Jan. : 58,1 kg urea in 1123,3 l water/ha + 7,8 kg ferrous sulphate + 0,6 kg zinc sulphate.

Treatment X, the control, was not fertilized. The whole experimental area was fumigated three weeks before planting with 449 l D-D/ha applied by injector gun in the plant row at 30,5 cm. intervals and at a depth of 20 cm.

2. EXPERIMENTAL DESIGN.

Randomised blocks with treatments replicated five times.

3, PLOT SIZE.

1,60 x 9,14 m.
Plant spacing in double rows: 106,7 x 53,3 x 30,5 cm.
Sixty plants per plot (Fig. II).

4. RESULTS AND DISCUSSION.

i) Fruit yields.

Highly significant responses to all treatments were found in the plant crop when compared with the unfertilized control. Treated plots outyielded the control by 45 to 64%, indicating the necessity for fertilizer applications. Treatment D which had basal leaf and foliar spray applications of fertilizer, yielded 69,30 tonne/hectare (t/ha). Treatment F with foliar sprays and additional preplanting potassium had the next highest yield of 67,86 t/ha. Treatment D outyielded treatment A (61,27 t/ha) which had no foliar sprays, highly significantly, while treatments E and F outyielded it significantly. There were no other significant differences between treatments when comparing the plant crop yields (Table 9).

The yields for the ratoon crop showed similar trends with the responses to fertilizer being even more pronounced (Table 9).

Taking the two crops together the fertilizer applied to the weakest treatment almost doubled the yield of fruit when compared with the control. Treatment D (157,74 t/ha) gave the highest overall yield which was highly significantly better than that of treatments A, B and G and significantly better than treatment C. Treatment E (149,26 t/ha) which had basal leaf and foliar spray applications had the second highest yield and significantly outyielded treatments B and G. Treatments F and C also significantly outyielded treatment G (Table 9).

The treatments which had both foliar sprays and basal leaf applications (D and E) gave the highest yields. Treatment D which had more potassium (308 kg K/ha) than E (191 kg K/ha) had a higher yield but the difference was not significant. Treatment D which had the same total N, P and K applications as

treatment F which received only preplanting and foliar spray applications, outyielded it but again not significantly although the difference was more than ten t/ha. Of the comparable treatments receiving only preplanting applications and foliar sprays (B, C, F and G), treatment F with the highest potassium application gave the highest yield (147,29 t/ha) but this was not significantly better than treatment C (144,29 t/ha) which had identical fertilizer apart from a lower potassium application. Treatments B, C and G which had identical fertilizer applications apart from phosphorus showed some response to phosphorus in that treatment C (74 kg P/ha) had higher yields than both B (nil P) and G (37 kg P/ha). The fact that treatment G had the lowest yield is unaccountable, although it was not significantly lower than treatment B, it was significantly lower than treatment C. The response to phosphorus applications appears to be more marked in the ratoon crop where treatment C significantly outyielded treatments B and G. A positive response to phosphorus applications would have been expected as the soil level was low (4 p.p.m. P see Table 8).

A comparison of the yields (t/ha) from Table 9 of three treatments receiving different field practices and comparable amounts of fertilizer is as follows:-

Treatments		Plant crop	Ratoon crop	Total yields.
A	Basal leaf applications	61,27	76,47	137,74
C	Preplanting + foliar sprays	64,46	79,83	144,29
E	Preplanting + basal leaf + foliar sprays	67,55	81,71	149,26
	L.S.D. (05)	5,13	10,40	12,30
	(01)	6,92	14,03	16,58

Although treatment E outyielded treatment C in both crops, the differences were not significant. Treatment C outyielded treatment A in both crops but again the differences were not significant. Treatment E outyielded treatment A significantly in the plant crop and very nearly significantly when the two crops were taken together. The ratoon crop differences were not significant.

The differences in treatment were that treatment A with only basal leaf applications had no iron or zinc applications and treatment E which had basal leaf and foliar sprays only had 72 kg $FeSO_4$ and 8 kg $ZnSO_4$ in eight sprays while treatment C had a total of 124 kg $FeSO_4$ and 10 kg $ZnSO_4$ in 16 sprays to plant crop.

The increased yields were probably due to the inclusion of iron and zinc in the two treatments receiving foliar sprays, rather than due to the methods of applying fertilizer. The fact that treatment E which had both basal leaf and spray applications of fertilizer gave higher yields than treatment C does indicate that basal leaf applications could be advantageous even though the differences were not significant. The local fertilizer programme (treatment A) in which fertilizer was applied only as basal leaf applications was not outyielded significantly by the basic programme used in Hawaii (treatment C) while a combination of the two programmes (treatment E) gave the best results.

ii) Number of suckers and slips.

Fertilizer applications increased the number of suckers produced highly significantly, treatments D and E giving the best results (Table 10). Treatments D and E which had both basal leaf and foliar sprays, had significantly more suckers than those which only had foliar sprays, namely B, C, F and G; but not significantly more than treatment A which only had basal leaf applications. This would seem to indicate that the application of sulphate of ammonia to the basal leaves before plant crop resulted in the production of more suckers than did urea sprays.

The number of slips produced appears to be inversely proportional to the numbers of suckers produced in that the treatments having the largest numbers of suckers had the smallest number of slips, excluding the unfertilized control (Table 10). Here treatment A had highly significantly more slips than treatments D and E, and significantly more than B. Treatment G produced highly significantly more slips than treatment D and significantly more than treatments B and E. Treatment F produced significantly more slips than treatment D. When comparing treatments B, C, F and G, there are indications that

the application of phosphates increased the number of slips while the number of suckers was not affected. Treatment B (nil P) had significantly less slips than treatment G (37 kg P/ha) and also less than C (74 kg P/ha) and F (74 kg P/ha) although the latter differences were not significant.

5. CONCLUSIONS.

The application of fertilizers resulted in considerable increases in plant crop yields and even greater increases in ratoon crop yields when treated plots were compared with unfertilized control plots.

The local fertilizer programme in which nutrients were applied only as basal leaf applications was not significantly outyielded by the basic programme used in Hawaii where nutrients are applied as preplanting and foliar spray applications. A programme in which nutrients were applied as preplanting, basal leaf and foliar sprays gave the best results, being significantly better than the local programme but not significantly better than the Hawaiian programme.

Increases in potassium applications of 191 kg K/ha to 308 kg K/ha resulted in non-significant increases in yield.

Applied phosphorus in comparable treatments resulted in significant increases in ratoon crop yields, where an application of 74 kg P/ha outyielded treatments receiving nil and 37 kg P/ha.

Applied fertilizers resulted in highly significant increases in the numbers of suckers and slips produced. Treatments producing the highest numbers of suckers had the lowest numbers of slips.

TRIAL 2.

The results of Fertilizer Trial 1 indicated that basal leaf applications of nitrogen may give better results than foliar spray applications. More information regarding fertilizer

placement under local conditions was considered necessary. Nitrogen, phosphorus and potassium were applied as preplanting, basal leaf and foliar spray applications in order to determine whether there were any differences in response to these nutrients when applied in different ways. Nutrients are still applied by hand to the basal leaves in the dry form on many plantations in the Eastern Cape as labour is relatively plentiful. Mechanization has not advanced to the same extent as in Hawaii and any benefits which may be derived from basal leaf applications of nutrients could thus be exploited.

In this trial all the applied phosphorus was given either as a preplanting, basal leaf or foliar spray application. The total quantities of nitrogen and potassium were not applied as preplanting or basal leaf applications because of the relatively large requirements of these nutrients by the plant and also because of its relatively long growth cycle. Instead one tenth of the total nitrogen and one third of the total potassium applied to the plant crop was given as a preplanting application, the balance being applied as a foliar spray. While all the potassium was applied to the basal leaves in the 'basal leaf' treatment, only two fifths of the nitrogen applied to plant crop was applied to the basal leaves in the dry form, the balance being applied as a foliar spray. The main reason for applying a proportion of the nitrogen in the 'basal leaf' treatment as a foliar spray was that iron and zinc should be applied with nitrogen. In order to keep the application of iron and zinc comparable in all treatments it was necessary to apply nitrogen as foliar sprays to all treatments. Since it is generally accepted that sulphate of ammonia is the form in which nitrogen is applied as preplanting and basal leaf applications and as urea in foliar sprays, it was decided that these forms of nitrogen would be applied in the respective treatments.

This trial was planted on 5/11/1967.

1. TREATMENTS.

The differences in treatment applied only to the placement of nitrogen, phosphorus and potassium which was given to the plants

before harvesting the plant crop. During this period all the phosphorus and all the potassium was applied, none being given subsequently to the ratoon crop. Ferrous sulphate and zinc sulphate were applied as foliar sprays to all treatments. All treatments also received uniform applications of urea, ferrous sulphate and zinc sulphate as foliar sprays for the ratoon crop, there being no variations in methods of application or quantities applied.

The treatments applied up to plant crop were as follows:-

Preplanting nitrogen.

56 kg N/ha before planting.
504 kg N/ha as foliar sprays.

Basal leaf nitrogen.

224 kg N/ha to basal leaves.
336 kg N/ha as foliar sprays.

Foliar spray nitrogen.

560 kg N/ha as foliar sprays.

Preplanting phosphorus.

56 kg P/ha before planting.

Basal leaf phosphorus.

56 P/ha to basal leaves.

Foliar spray phosphorus.

56 kg P/ha as foliar sprays.

Preplanting potassium.

75 kg K/ha before planting.
149 kg K/ha as foliar sprays.

Basal leaf potassium.

224 kg K/ha to basal leaves.

Foliar spray potassium.

224 kg K/ha as foliar sprays.

Details regarding the application of the nutrients were as

follows:-

i) Preplanting applications.

Nitrogen	November 56,0 kg N (267,7 kg ammonium sulphate).
Phosphorus	November 56,0 kg P (627,0 kg superphosphate).
Potassium	November 75,0 kg K (187,0 kg potassium sulphate).

ii) Basal leaf applications.

Nitrogen	February 44,8 kg N (212,8 kg ammonium sulphate). Oct., Jan. 89,6 kg N (425,7 kg ammonium sulphate).
Phosphorus	February 11,2 kg P (134,4 kg superphosphate). Oct., Jan. 22,4 kg P (268,8 kg superphosphate).
Potassium	February 44,8 kg K (112,0 kg potassium sulphate). Oct., Jan. 89,6 kg K (224,0 kg potassium sulphate).

iii) Foliar spray applications (applied monthly).

Nitrogen	(a) preplant and foliar spray. 504,0 kg N/ha
Jan. - Aug.	28,0 kg urea in 1123,3 l water/ha + 5,6 kg ferrous sulphate + 1,1 kg zinc sulphate.
Sept. - Nov.	84,0 kg urea in 2246,6 l water/ha + 5,6 kg ferrous sulphate + 1,1 kg zinc sulphate.
Dec. - Feb.	112,0 kg urea in 2246,6 l water/ha + 8,4 kg ferrous sulphate + 1,1 kg zinc sulphate.
March - June	70,6 kg urea in 2246,6 l water/ha + 8,4 kg ferrous sulphate + 1,1 kg zinc sulphate.
	(b) basal leaf and foliar spray. 336,0 kg N/ha
Jan. - Aug.	22,4 kg urea in 1123,3 l water/ha + 5,6 kg ferrous sulphate + 1,1 kg zinc sulphate.
Sept. - Nov.	56,0 kg urea in 1123,3 l water/ha + 5,6 kg ferrous sulphate + 1,1 kg zinc sulphate.
Dec. - Feb.	84,0 kg urea in 2246,6 l water/ha + 8,4 kg ferrous sulphate + 1,1 kg zinc sulphate.

March - June	38,0 kg urea in 2246,6 l water/ha + 8,4 kg ferrous sulphate + 1,1 kg zinc sulphate.
	(c) Foliar spray.
	560,0 kg N/ha
Jan. - Aug.	28,0 kg urea in 1123,3 l water/ha + 5,6 kg ferrous sulphate + 1,1 kg zinc sulphate.
Sept. - Nov.	84,0 kg urea in 2246,6 l water/ha + 5,6 kg ferrous sulphate + 1,1 kg zinc sulphate.
Dec. - Feb.	112,0 kg urea in 2246,6 l water/ha + 8,4 kg ferrous sulphate + 1,1 kg zinc sulphate.
March - June	88,5 kg urea in 2246,6 l water/ha + 8,4 kg ferrous sulphate + 1,1 kg zinc sulphate.
Phosphorus	(a) Foliar spray.
	56,0 kg P/ha
Feb.	48,2 kg di-ammonium phosphate in 1123,3 l water/ha.
Oct. - Jan.	96,3 kg di-ammonium phosphate in 2246,6 l water/ha.
Potassium.	(a) preplant and foliar spray.
	149,0 kg K/ha
Jan. - Aug.	11,2 kg potassium sulphate in 1123,3 l water/ha.
Sept. - Feb.	33,6 kg potassium sulphate in 1123,3 l water/ha.
March - May	22,4 kg potassium sulphate in 1123,3 l water/ha.
June	14,1 kg potassium sulphate in 1123,3 l water/ha.
	(b) foliar spray.
	224 kg K/ha
Jan. - Aug.	16,8 kg potassium sulphate in 1123,3 l water/ha.
Sept. - Feb.	50,4 kg potassium sulphate in 1123,3 l water/ha.
March - May	33,6 kg potassium sulphate in 1123,3 l water/ha.
June	22,4 kg potassium sulphate in 1123,3 l water/ha.

Di-ammonium phosphate (4% N : 23,3% P) was used as the source of phosphorus for spray applications. The nitrogen content of the spray was neglected, thus in actual fact all treatments in which di-ammonium phosphate was applied received an additional 50,5 kg N/ha.

Total fertilizer applied for plant crop.

560,0 kg N/ha
56,0 kg P/ha
224,0 kg K/ha
100,8 kg $FeSO_4$/ha
19,8 kg $ZnSO_4$/ha

Fertilizer applied for the ratoon crop was applied to all treatments and consisted of foliar sprays of urea, ferrous sulphate and zinc sulphate applied monthly as follows:-

April - May	60,9 kg urea in 2246,6 l water/ha + 8,4 kg ferrous sulphate + 1,1 kg zinc sulphate.
June - Sept.	30,4 kg urea in 1123,3 l water/ha + 8,4 kg ferrous sulphate + 1,1 kg zinc sulphate.
Oct. - Jan.	60,9 kg urea in 2246,6 l water/ha + 8,4 kg ferrous sulphate + 1,1 kg zinc sulphate.

Total fertilizer applied for ratoon crop.

224,0 kg N/ha (487,0 kg urea)
84,0 kg $FeSO_4$/ha
11,0 kg $ZnSO_4$/ha

2. EXPERIMENTAL DESIGN.

3^3 factorial in two replications.

3. PLOT SIZE.

1,52 x 9,22 m

Plant spacing in double rows : 99,1 x 53,3 x 27,9 cm.

Sixty six plants per plot, see Fig. II.

4. RESULTS AND DISCUSSION.

i) Fruit yields.

Nitrogen applied as basal leaf + foliar sprays resulted in higher yields than nitrogen applied only as foliar sprays or as preplanting + spray applications in the plant crop. The yield of 88,1933 kg/plot which resulted from basal leaf + foliar spray applications was highly significantly better than the yield of 83,9567 kg/plot following preplanting + foliar sprays and 84,1444 kg/plot following foliar spray applications (Table 11). There was no

significant differences between the latter two treatments. This result confirms the non-significant indication in the Fertilizer Trial 1 where nitrogen applied as basal leaf + foliar sprays out-yielded treatments in which nitrogen was only applied as foliar sprays. It is conceivable that had more nitrogen been applied as basal leaf applications of sulphate of ammonia, greater increases in yield would have been obtained.

All the nitrogen applied to the ratoon crop was applied as foliar sprays of urea and the differences in placement of nitrogen applied to the plant crop had no effect on the ratoon crop yields (Table 12). There were also no significant differences in yield when the two crops were considered together indicating that the yield differences encountered in the plant crop were inadequate in maintaining an overall significant effect on yield (Table 13). The application of sulphate of ammonia to the ratoon suckers is a time and labour consuming operation. It can only be contemplated where labour is plentiful and on small plantations which have no mechanised equipment. For these reasons this method of application was not considered for the ratoon crops.

The three methods of phosphorus placement had no effect on either the plant or ratoon crops (Tables 11 and 12). The additional 50,5 kg N/ha applied in the foliar spray application of di-ammonium phosphate had no significant effect on yield. Had the trial shown an increase in yield due to the foliar spray application of phosphorus such an increase might have been due at least in part to this additional nitrogen.

Potassium applied in different ways did not affect plant crop yields while it did affect the ratoon crop yields. Potassium applied to the basal leaves yielded 59,1789 kg/plot which was highly significantly better than that in which potassium was applied as foliar sprays (51,6900 kg/plot) but not significantly better than that in which potassium was applied as a preplanting application + foliar sprays (55,2739 kg/plot) (Table 12). As all the potassium applied was given before the plant crop and none for the ratoon crop, differences in yield may have been anticipated in the plant crop rather than in the ratoon crop. It is, however, possible that the uptake of potassium applied to the basal leaves is slower than

that applied as foliar sprays, in which case there could be a delayed effect which may show up in the subsequent crop. Samuels et al (1955) recorded increases in leaf-K three to four months after basal leaf applications of potassium, a fact which would tend to support the above argument. When the two crops were taken together the different methods of applying potassium no longer had any significant effect (Table 13).

ii) Numbers of suckers and slips.

Different methods of fertilizer placement had no significant effect on the number of suckers produced (Table 14). These results do not support the findings in the earlier trial in which basal leaf applications of nitrogen produced more suckers than treatments in which nitrogen was applied as foliar sprays. Nitrogen, potassium and phosphorus applied in different ways had no effect on the number of slips produced. These findings were similar to those reported by Sanford (1959) on results of fertilizer placement experiments in Hawaii.

5. CONCLUSION.

The application of a proportion of the nitrogen to the basal leaves in the form of sulphate of ammonia resulted in an increase in the plant crop yields when compared with the application of nitrogen as a foliar spray of urea and when nitrogen was applied as a preplanting and foliar spray application. This effect was not carried over to the ratoon crop and the yield increases although highly significant in the plant crop were not sufficient to produce an overall significant effect.

Potassium applied to the basal leaves had a delayed effect which resulted in ratoon yield increases when compared with potassium applied as foliar sprays. Taken over both crops this finding was also non-significant.

The different methods of application of phosphorus had no effect on yields.

Fertilizer placement had no effeot on sucker or slip production.

In general the differences encountered between the different

methods of fertilizer placement on yield are such that they could be neglected, one method of application being as good as the next. These findings are similar to those reported by Sanford (1959). The methods of nutrient application used in the main Fertilizer/ Fumigation trial could thus not have affected the results in any way and can be considered as having been satisfactory.

B. SOIL FUMIGATION TRIALS

TRIAL 1.

Field trials with different fumigants were conducted in order to determine whether plant parasitic nematodes could be effectively controlled under local conditions.

In this initial trial, guidance as to the quantities of fumigants to be tested were given by Girton (1963), as there was very little local knowledge of nematode control in pineapples at that time. The trial was planted on 14/11/63.

1. TREATMENTS.

The soil fumigants listed below were applied by injector gun at 30,5 cm intervals in the plant row at a depth of 20 cm three weeks prior to planting. A post planting application of DBCP (5,2 ccs/injection) was given ten months after planting to half of each plot. In this case each injection was applied in the plant row between the plants at a depth of 20 cm.

Whole plot treatments.

A	D-D	449,3 l/ha 10,42 ccs/inj.
B	EDB	67,4 l in 269,6 l diesoline/ha 7,81 ccs/inj.
C	EDB	89,8 l in 359,5 l diesoline/ha 10,42 ccs/inj.
D	EDB	112,3 l in 449,3 l diesoline/ha 13,02 ccs/inj.
E	EDB	89,8 l in 359,5 l water/ha 10,42 ccs/inj.
F	DBCP	22,5 l in 202,2 l diesoline/ha 5,21 ccs/inj.

G	DBCP	33,7 l in 181,0 l diesoline/ha 5,21 ccs/inj.
H	DBCP	22,5 l in 337,0 l D-D/ha 8,34 ccs/inj.
X	CONTROL	No fumigation

Sub-Plot treatments.

(a) No post planting fumigation.

(b) DBCP 33,7 l in 202,2 l water/ha as a post planting application.

The fertilizer applied to the whole trial was the same as that applied to treatment E of Fertilizer Trial 1, namely:-

(a) For the plant crop.

	N	P	K	$FeSO_4$	$ZnSO_4$
Preplanting		74			
Basal leaf	331		191		
Foliar spray	225			72	8
	556	74	191	72	8

Details of application being :

(i) Preplanting application.

Phosphorus 37 kg P November
(445,8 kg superphosphate).

(ii) Basal leaf applications.

Nitrogen 66,2 kg N in five applications
Jan., March, Sept., Dec., Feb.
(313,2 kg ammonia sulphate per application).

Potassium 38,2 kg K in five applications
Jan., March, Sept., Dec., Feb.
(95,5 kg potassium sulphate per application).

(iii) Foliar spray applications.

Nitrogen, iron and zinc in 1123,3 l water/ha.

18,7 kg N; 8,8 kg $FeSO_4$; 1,0 kg $ZnSO_4$ every two months Jan., March, May, June (40,6 kg urea per application).

37,5 kg N; 8,8 kg $FeSO_4$; 1,0 kg $ZnSO_4$ every two months Aug., Oct., Dec., Feb. (81,2 kg urea per application).

(b) For the ratoon crop.

Ten foliar sprays of urea, ferrous sulphate and zinc sulphate totalling 214 kg N; 78 kg $FeSO_4$ and 6 kg $ZnSO_4$/ha were applied monthly from April to Jan. following the harvesting of the plant crop. For details see p. 28.

2. EXPERIMENTAL DESIGN.

Randomised blocks split plot in five replications.

3. PLOT SIZE.

Whole plots : 3,04 x 9,14 m.

Two double rows of plants spaced 99,1 x 53,3 x 30,5 cm apart containing 120 plants per plot.

Sub-Plots : 1,52 x 9,14 m.

One double row of plants spaced as above containing 60 plants per plot (Fig. III).

4, RESULTS AND DISCUSSION.

i) Fruit yields.

The differences in plant crop yields due to the preplanting application of fumigants were not very great. Treatment A (449, 3 l/ha D-D) outyielded all other treatments, being highly significantly better than treatments B, C and E which received varying amounts of EDB, significantly better than treatment F whioh had a low dosage of DBCP and significantly better than the control with no fumigation. The only other significant differences in yield were between treatment H which had a mixture of DBCP and D-D and B which had a low rate of EDB (Table 16).

The post planting application of 33,7 l DBCP/ha resulted in a highly significant increase in yields over all treatments, the mean yields being 66,41 t/ha for untreated and 72,82 t/ha for treated plots (Table 16). The analysis of variance showed no significant evidence of interaction between the post planting application and any of the preplanting treatments. The response to post planting fumigation was thus consistent over all the preplanting treatments.

In the ratoon crop, yield differences were much greater, with treatments A and H outyielding all others highly significantly, the differences between these two treatments not being significant. The only other treatment which had any significant effect on yield was D which received the highest application of EDB, namely 112 l/ha. This treatment outyielded treatment B which had the lowest rate of EDB significantly and outyielded the control highly significantly (Table 16).

When considering the total yields (Table 16) treatment A (449,3 l D-D/ha) with a cycle yield of 140,40 t/ha highly significantly outyielded all other treatments with the exception of treatment H (22,5 l DBCP + 337,0 l D-D/ha) which yielded 137,69 t/ha. The latter treatment outyielded all other treatments highly significantly except for treatment D (112,3 l EDB/ha) where the difference was significant, but not highly significant. Treatment D with a yield of 124,18 t/ha outyielded treatments B, C, F and the control significantly. The control gave the lowest cycle yield of 107,54 t/ha. The application of 33,7 l DBCP/ha as a post planting application resulted in highly significant increases in yield in the ratoon crop. Here treated plots gave 52,72 t/ha and untreated plots gave 43,84 t/ha (Table 16).

The poor results obtained following the application of EDB were most likely caused by the soil condition. The soil was very dry at the time of application, a condition which has been found to render the application of EDB relatively ineffective in the control of nematodes (Carter, 1953).

(ii) Numbers of suckers and slips.

Treatment H (D-D/DBCP Mixture) produced the largest number of suckers per plot (123,4) which was highly significantly more

than all other treatments apart from A (110,9) which was given 449,3 l D-D/ha. Treatment A produced highly significantly more suckers than the control and significantly more than treatments B (67,4 l EDB/ha) and F (22,5 l DBCP/ha). Treatments D (112,3 l EDB/ha) and E (89,8 l EDB/ha) also produced significantly more suckers than the control which had only 83,6 suckers per plot (Table 17). Owing to the great variation in the number of slips per plot (C.V. = 50,7%) no significant differences between treatments were established.

The post planting application of DBCP had no significant effect on the numbers of suckers or slips produced.

(iii) Nematode counts.

Nematode counts were determined in soil samples taken from the two best treatments (A and H) and the control two years after the initial application of soil fumigants (Table 18). In the absence of a post planting application, the number of Meloidogyne per 100 ml of soil was 288 after the application of D-D and 689 after the application of D-D/DBCP mixture. The number of Helicotylenchus on the other hand was 1276 after the application of D-D and 192 after the application of the mixture. The populations of both genera were considerably reduced by the post planting application of DBCP. This is clearly indicated in the control plots where the population of Meloidogyne sp. was reduced from 348 to 160 and that of Helicotylenchus sp. reduced from 552 to 48 by the post planting application of DBCP.

5. CONCLUSIONS.

The application of soil fumigants increased the ratoon crop yields far more than they increased the plant crop yields. D-D applied at 449,3 l/ha gave the best results while a mixture of 337,0 l D-D + 22,5 l DBCP/ha also gave good results. EDB at rates of up to 112,3 l/ha did not result in satisfactory yield increases probably the result of application under adverse conditions. The results with DBCP applied at 33,7 l/ha were also unsatisfactory.

The application of 33,7 l DBCP/ha as a post planting appli-

cation resulted in highly significant increases in yield in both the plant and ratoon crops.

Nematode counts in soil samples taken two years from planting indicated that D-D had a greater effect on Meloidogyne sp. while a mixture of D-D and DBCP was more effective against Helicotylenchus sp. The post planting application of DBCP reduced the populations of both genera very considerably.

While the number of suckers produced was greatly increased by the application of D-D and the D-D/DBCP mixture, the number of slips produced was apparently not affected by treatment.

TRIAL 2.

Indications from the earlier trial, Fumigation Trial 1 planted in 1963, which at that stage had not run to completion were that DBCP, D-D and mixtures of these two fumigants would give the best results under local conditions. In order to save time, the second trial was initiated in an attempt to obtain more effective control of nematodes before completion of the first trial. The planting date of this trial was 28/10/1965.

1. TREATMENTS.

Three dosage rates of treatments as listed below were applied by injector gun at 30,5 cm intervals in the plant row at a depth of 20 cm and three weeks prior to planting. A post planting application of DBCP (5,47 ccs/injection) was given 12 months after planting to half of each plot, each injection being applied in the plant row between the plants and at a depth of 20 cm.

Whole plot treatments.

A DBCP 44,9 l in 179,7 l water/ha : 5,47 ccs/injection.
B DBCP 56,2 l in 168,5 l water/ha : 5,47 ccs/injection.
C DBCP 67,4 l in 157,3 l water/ha : 5,47 ccs/injection.
D D-D 359,4 l/ha : 8,75 ccs/injection.
E D-D 449,3 l/ha : 10,95 ccs/injection.

F D-D 539,2 l/ha : 13,12 ccs/injection.
G DBCP 22,5 l in 179,7 l D-D/ha : 4,92 ccs/injection.
H DBCP 22,5 l in 269,6 l D-D/ha : 7,11 ccs/injection.
I DBCP 33,7 l in 269,6 l D-D/ha : 7,38 ccs/injection.
X CONTROL

Sub-plot treatments.

(a) No post planting fumigation.
(b) DBCP 44,9 l in 179,7 l water/ha as a post planting application.

The fertilizer applied as a blanket treatment was the same as that for Fumigation Trial 1, namely a total of 556 kg N; 74 kg P; 191 kg K; 72 kg $FeSO_4$ and 8 kg $ZnSO_4$ for the plant crop and 214 kg N; 78 kg $FeSO_4$ and 6 kg $ZnSO_4$ for the ratoon crop. The details of application were also the same as for Fumigation Trial 1 (see p. 41).

2. EXPERIMENTAL DESIGN.

Randomised blocks split plot in five replications.

3. PLOT SIZE.

Whole plots : 3,20 x 9,14 m.

Two double rows of plants spaced 106,7 x 53,3 x 30,5 cm apart giving 120 plants per plot.

Sub-plots : 1,60 x 9,14 m.

One double row of plants spaced as above and resulting in 60 plants per plot (Fig. III).

4. RESULTS AND DISCUSSION.

i) Fruit yields.

Once again the differences in plant crop yields between treatments were not great. In fact, few treatments significantly outyielded the control. The treatments in which mixtures of D-D and DBCP were applied, gave the best results. Treatment H (22,5 l DBCP + 269,9 l D-D/ha) which yielded 83,42 t/ha gave the best plant crop yields and significantly outyielded treatments A, B,

C, D and the control. Treatment I (33,7 l DBCP + 269,6 l D-D/ha) with a yield of 82,95 t/ha significantly outyielded treatments A, B and C which had varying amounts of DBCP, and also the control. The only other differences were treatment E (449,3 l D-D/ha) which significantly outyielded treatments B and C; and treatment G (22,5 l DBCP + 179,7 l D-D/ha) which significantly outyielded treatment B (Table 19). In the ratoon crop the yield differences were more marked with treatment I giving highly significantly better yields than treatments A, C and control; treatment F (539,2 l D-D/ha) being highly significantly better than control and significantly better than treatments A and C and treatment H significantly outyielding the control (Table 19). When the cycle yields were considered treatments B, D, E, F, G, H and I were all highly significantly better than the control and treatments A and C significantly better than control. Treatments receiving DBCP/D-D mixtures (treatments G, H and I) gave the best results with pure D-D (treatments D, E and F) also giving very good results at the higher dosage rates. The only significant difference between these sets of treatments was that treatment D which had the lowest level of D-D (359,4 l/ha) was outyielded significantly by treatments H and I. Treatments in which DBCP was applied did not come up to expectation, having no difference in plant crop yield when compared to the control and having relatively small although significant increases in ratoon crop yields. The post planting application of DBCP had no significant effect on the plant or ratoon crop.

ii) Number of suckers and slips.

Treatments C and H produced highly significantly more suckers than the control while treatments G and I produced significantly more suckers than the control (Table 20). There were no significant differences between any of the treated plots and it is obvious once more than the DBCP/D-D mixtures gave the best result, an exception being the highest dosage of DBCP (treatment C) which produced the highest numbers of suckers recorded. Post planting fumigation had no effect on sucker production. The DBCP treatments gave the highest numbers of slips with treatment C having highly significantly more than treatments D, H and the control and

treatment A having significantly more than treatments D, H and the control. There were no other significant differences between treatments. Post planting applications had no significant effect on slip production.

iii) Nematode counts.

Soil samples drawn six months after planting revealed no plant parasitic nematodes in any of the treated plots while 124 nematodes per 100 ml soil were found in the untreated control plots (Table 21). Nematode counts in samples taken 18 months after planting are presented in Table 22. When considering the effect of preplanting treatments alone, D-D was highly effective in the control of Meloidogyne sp. with the higher dosage of DBCP and the mixtures also being very effective. Only the lowest level of the mixtures (22,5 DBCP + 179,7 l D-D/ha) and the lowest level of DBCP (44,9 l/ha) could be considered as ineffective in the control of this genus. Helicotylenchus sp. was effectively controlled by all treatments but particularly by the higher rates of D-D (Table 22).

Trichodorus sp. appeared in relatively low numbers and was absent in the control (Table 22). From its sporadic occurrence it is difficult to assume any specific control by fumigation. In fact the counts indicate that none of the treatments applied were effective in controlling this species.

The post planting application of DBCP which was applied six months prior to sampling resulted in excellent control of both Meloidogyne and Helicotylenchus sp. as indicated by the counts in the control where Meloidogyne counts were 260 and 5 and Helicotylenchus 980 and 35 in untreated and treated plots respectively (Table 22).

iv) General discussion.

In both fumigation trials the effects of fumigants on yields were more marked in the ratoon crops than in the plant crops, greater increases in yield being encountered in the ratoon crops.

In both trials DBCP as a preplanting application did not result in substantially increased yields. In the first trial

the higher application of 33,7 l/ha in diesoline did not result in significant increases in yield while in the second trial applications of 67,4 l/ha in water resulted in significant increases in yield. Other treatments which included D-D and mixtures of DBCP and D-D gave far higher yields than relatively high levels of DBCP.

The application of 33,7 l DBCP/ha as a post planting application applied one year after planting resulted in significantly increased yields in the first trial while there was no significant effect on yield in the second trial when DBCP was applied at a rate of 44,9 l/ha. There is no obvious reason for this negative result for the control of plant parasitic nematodes by the latter post planting treatment was excellent, as indicated by the nematode counts in soil samples taken 18 months from planting, i.e. six months after treatment. The fact that the yields in the second trial were generally much higher than in the first could possibly account for there being a less obvious effect from the post planting application of DBCP. The total yields in the control plots were 107,54 t/ha in the first trial and 153,52 t/ha in the second trial. The fumigants applied in the second trial were generally less effective in increasing the yields particularly in the plant crop, not withstanding the fact that the rates of application were much higher.

From the nematode counts in soil samples taken from the two trials, D-D appeared to be more effective in the control of Meloidogyne sp. than was the D-D/DBCP mixture. In the first trial D-D at 449,3 l/ha was more effective in the control of Meloidogyne sp. than a mixture of 22,5 l DBCP + 337,0 l D-D/ha while in the second trial D-D at a rate as low as 359,4 l/ha was more effective than a mixture of 33,7 l DBCP + 269,6 l D-D/ha. In the first trial the mixture (22,5 l DBCP + 337,0 l D-D/ha) was more effective than D-D at 449,3 l/ha in controlling Helicotylenchus sp. In the second trial the applications of D-D at 449,3 and 539,2 l/ha were more effective in controlling this genus than a mixture of 33,7 l DBCP + 269,6 l D-D/ha. The control of both genera was excellent in both trials following the post planting applications of DBCP at 33,7 l/ha and 44,9 l/ha

respectively.

5. CONCLUSIONS.

The preplanting application of soil fumigants had little significant effect on the plant crop yields while they increased the ratoon crop yields considerably. The highest yields were obtained where mixtures of D-D and DBCP were applied. Good results were also obtained with D-D at rates of 449,3 and 539,2 l/ha. DBCP applied as a preplanting fumigant at rates of up to 67,4 l/ha did not result in marked increases in yield although the increases were significant. The application of 33,7 l DBCP/ha as a post planting treatment resulted in increased yields in the one trial while it had no significant effect on yields when applied at 44,9 l/ha in the other trial.

Soil fumigation applied as a preplanting application resulted in an increase in the numbers of suckers and slips produced. The post planting application of DBCP had no effect on the numbers of slips or suckers produced.

All preplanting treatments effectively controlled plant parasitic nematodes as indicated by nematode counts in soil samples taken six months after planting. In samples taken 18 months from planting, D-D appeared highly effective in the control of Meloidogyne sp. This genus was not very effectively controlled by the lowest level of mixture applied (22,5 l DBCP + 179,7 l D-D/ha) or the lowest level of preplanting DBCP (44,9 l/ha). Helicotylenchus sp. was effectively controlled by all treatments but particularly by D-D at 449,3 and 539,2 l/ha. Trichodorus sp. which was found in relatively low numbers was apparently not controlled by applied fumigants. The post planting application of DBCP resulted in excellent control of both Meloidogyne and Helicotylenchus genera as indicated by counts in samples taken six months after the post planting application. Both D-D and DBCP were effective in controlling these two plant parasitic nematode genera which were encountered in the greatest numbers.

C. FERTILIZER/FUMIGATION TRIAL.

TRIAL 1.

This trial was conducted to determine the effects of nematodes on pineapple plant growth and utilization of applied nutrients under field conditions.

The area chosen for the trial was first planted to pineapples in 1952 and replanted in 1958. By the time the trial was planted on 26/10/1965, the land had grown pineapples in monoculture for 14 years. The soil had been fallow for one year prior to the trial being planted.

1. EXPERIMENTAL DESIGN.

A 2^6 factorial in three replications was used. Two replications were for yield, leaf analysis and other data taken throughout the normal growing cycle for pineapples. The third replication was included for such data as plant and root weights taken after 12 and 24 months.

2. PLOT SIZE.

1,60 x 9,14 m.

One double row of plants spaced 106,7 x 53,3 x 30,5 cm was planted, resulting in 60 plants per plot. Guard plants and border rows were included (Fig. II).

3. TREATMENTS.

The six factors included in the trial were fumigation, phosphorus, nitrogen, potassium, iron and zinc. They were all applied at two levels, none and some, with the exception of nitrogen. This element was applied at a low and high rate so as to ensure that all the plots received some nitrogen. The reason for this was that the pineapple plant is a gross feeder of nitrogen and without it, the plants in half the experiment would probably have failed to grow.

Where nutrients were applied as foliar sprays each nutrient was applied separately at a rate equivalent of 1123,3 l/ha and at

a concentration giving the correct equivalent amount of nutrient per hectare.

A. Fumigation.

In order to ensure a good control of nematodes, high rates of fumigants were applied, together with a post planting application 12 months after planting.

A preplanting application of a mixture of 449,3 l D-D and 33,7 l DBCP/ha was applied by injector gun three weeks prior to planting. This mixture was applied as a row treatment at 30,5 cm intervals and a depth of 20 cm.

The post planting application was applied at a rate of 33,7 l DBCP in 191,0 l water/ha by injector gun between the plants in the row and at a depth of 20 cm.

B. Phosphorus.

Phosphorus was applied as granular superphosphate at a rate of 674,7 kg/ha (56,0 kg P/ha) broadcast over the whole area and worked into the top 15 cm of soil. No further applications of phosphorus were made.

C. Nitrogen.

Initial applications of nitrogen were given as basal leaf dressings of sulphate of ammonia. Subsequent applications were applied as foliar sprays of urea. Nitrogen was applied throughout the growth cycle of the plants with a break in application from flower differentiation to harvesting of the plant crop.

i) High nitrogen : plant crop. (672,0 kg N/ha).

Basal leaf applications : 44,8 kg N/ha Nov., 1965.
44,8 kg N/ha Jan., 1966.

Foliar sprays : 22,4 kg N/ha monthly Jan.-June, 1966.
44,8 kg N/ha monthly Sept.-Dec., 1966.
56,0 kg N/ha monthly Jan.-April, 1967.
22,4 kg N/ha monthly May-June, 1967.

Ratoon crop (448,0 kg N/ha).

Foliar sprays : 56,0 kg N/ha monthly April-May, 1968.
28,0 kg N/ha monthly June-Sept., 1968.

56,0 kg N/ha monthly Oct.,1968-Jan., 1969.

Total N applied : 1120,0 kg/ha.

ii) Low Nitrogen : Plant crop. (336,0 kg N/ha).

Basal leaf applications : 22,4 kg N/ha Nov., 1965.
22,4 kg N/ha Jan., 1966.

Foliar sprays : 11,2 kg N/ha monthly Jan.-June, 1966.
22,4 kg N/ha monthly Sept.-Dec., 1966.
28,0 kg N/ha monthly Jan.-April, 1967.
11,2 kg N/ha monthly May-June, 1967.

Ratoon crop (224,0 kg N/ha).

Foliar sprays : 28,0 kg N/ha monthly April-May, 1968.
14,0 kg N/ha monthly June-Sept., 1968.
28,0 kg N/ha monthly Oct.-Jan., 1969.

Total N applied : 560 kg/ha.

D. Potassium.

Potassium was applied both as a preplanting application and as foliar sprays in the form of potassium sulphate. The preplanting application was applied in a band 15 cm wide in the plant row and worked in to a depth of 15 cm, the rate of application being 112,0 kg K/ha. In accordance with general findings regarding pineapple nutritional requirements, potassium was not applied after flower differentiation for the plant crop.

Details of the foliar sprays were as follows:-

6,7 kg K/ha monthly Jan.-June, 1966.
20,2 kg K/ha monthly Sept., 1966 - April, 1967.
11,1 kg K/ha monthly May - June, 1967.
Total K applied as foliar sprays was 224,0 kg/ha.
Total K applied : 336 kg/ha.

E. Iron.

Iron was applied throughout the growth cycle as foliar applications of ferrous sulphate at the following times and rates:-

$FeSO_4$ plant crop. (112 kg/ha).

5,6 kg $FeSO_4$/ha monthly Jan. - June, 1966.
5,6 kg $FeSO_4$/ha monthly Sept. - Oct., 1966.
8,4 kg $FeSO_4$/ha monthly Nov., 1966 - June, 1967.

$FeSO_4$ ratoon crop. (84 kg/ha).

8,4 kg $FeSO_4$/ha monthly April, 1968 - Jan., 1969.

Total Fe applied : 39,2 kg/ha.

F. Zinc.

Zinc was applied throughout the growth cycle as zinc sulphate in foliar sprays at the following times and rates:-

$ZnSO_4$ plant crop. (17,6 kg/ha).

1,1 kg $ZnSO_4$/ha monthly Jan. - June, 1966.
1,1 kg $ZnSO_4$/ha monthly Sept., 1966 - June, 1967.

$ZnSO_4$ ratoon crop. (11,0 kg/ha).

1,1 kg $ZnSO_4$/ha monthly April, 1968 - Jan., 1969.

Total Zn applied : 6,3 kg/ha.

6. RESULTS AND DISCUSSION.

Significant treatment effects and significant interactions as indicated by analysis of variance and concerning all relevant data collected are presented in Tables 23 to 63. A complete example of the analysis of variance is presented as Table 69.

Reference to the level of significance between treatment differences recurs so frequently in the discussion of results in this trial that the following abbreviations were used: significant* referring to significance at the 5% level and significant** referring to significance at the 1% level.

i) Root weights.

Soil fumigation resulted in significant** increases in root growth as indicated by the weights determined one and two years from planting. The mean increases in weight per plant were 13,17 g after one year and 23,1 g after two years (Tables 23 (a) and 24 (a)). It is a well known fact that nematodes inhibit

root growth and fumigation which controls them, would be expected to lead to an increase in growth. The effects of nematodes on root growth can be seen in Plates I and II.

Apart from a significant* increase in root weight (5,3 g) after two years as a result of the application of iron, there were no other significant main effects on root growth by applied treatments (Table 24 (b)).

High nitrogen, in the absence of phosphorus increased the root weight significantly** and in the presence of phosphorus had a nearly significant depressing effect. Phosphorus on the other hand, had no effect on root weight in the absence of high nitrogen while there was a significant** reduction when high nitrogen was applied (Table 24 (c)). The actions of high nitrogen and phosphorus are thus antagonistic with regard to root development as indicated by the root weights taken two years from planting.

According to Teiwes et al (1963) investigations in Taiwan revealed that phosphorus stimulated the formation of secondary roots, while the main roots were restricted. They state that Pan in 1956/57 found that phosphorus stimulated root development. The results of this trial do not indicate a stimulation of root growth by phosphorus, but a rather pronounced detrimental effect, particularly when phosphorus is applied together with a high level of nitrogen.

ii) D-leaf weights.

Soil fumigation had no significant effect on D-leaf weight at one year while its effect was significant**, increasing leaf weight by 5,8 g at two years (Table 26 (a)).

The application of potassium resulted in a significant* increase in D-leaf weight (3,23 g) at one year and a significant** increase (6,20 g) at two years (Tables 25 (a) and 26 (b)). This result confirms the findings of Py et al (1957) who reported increases in weight and surface area of D-leaves following the application of potassium.

Iron applications had no effect at one year and a significant** effect at two years, increasing the D-leaf weight by

2,7 g (Table 26 (c)).

Although the effect of fumigation on D-leaf weight at one year was significant**, its effect was greater (19,76 g) in the absence of iron than when iron was applied (12,88 g) (Table 25 (b)). This interaction was not significant after two years, however.

The D-leaf weight at two years was increased significantly** (9,4 g) by fumigation in the presence of high nitrogen while there was no effect when low nitrogen was applied. High nitrogen applied in the absence of fumigation had no effect while in the presence of fumigation resulted in a significant** 4,6 g increase in mean D-leaf weight (Table 26 (d)). Better root growth resulting from soil fumigation thus leads to a better usage of high nitrogen applications.

Van Lelyveld (1964) found that increasing levels of nitrogen increased the D-leaf weight while Py, Haendler, Huet and Silvy (1956) report that nitrogen applications led to a general development of the leaves. By increasing the level of nitrogen applied to the plant crop from 336 kg/ha to 672 kg/ha, there was no significant increase in D-leaf weight in this experiment.

iii) Number of suckers.

Two factors, namely high nitrogen and phosphorus did not have any significant effect on the number of suckers. All other factors produced significant** changes (Tables 27 (a); (b); (c) and (d)).

Fumigation	59,8907** more suckers per plot.
Potassium	-8,8907** less suckers per plot.
Iron	5,5469** more suckers per plot.
Zinc	6,8281** more suckers per plot.

The above effects were not consistent over all levels of the other factors. High nitrogen which had no significant role as a main effect did alter the role of fumigation with regard to sucker production. The high level of nitrogen significantly** depressed sucker production in the absence of fumigation by 7,9062 suckers/plot, while in the presence of fumigation, the number of suckers was increased by a non-significant amount of 2,6875 suckers/plot. Fumigation in the absence of high nitrogen

increased sucker production by 54,5938 suckers/plot, whilst in the presence of high nitrogen, the number of suckers was increased by 65,1875 per plot (Table 27 (e)).

Iron and zinc affected each other negatively in that each factor in the absence of the other increased the number of suckers per plot at the higher level of significance whilst in combination they had a non-significant effect (Table 27 (f)). This effect on sucker production could account for the fact that applied iron and zinc showed no significant interaction on the final plant weight (Table 31) while significance was obtained in the earlier stages of growth (Tables 29 (c) and 30 (d)).

While increased nitrogen did not result in an increase in the number of suckers in this trial, van Lelyveld (1964) found that increasing levels of nitrogen led to increasing numbers of suckers. The lower level of 336 kg N/ha applied to plant crop was probably adequate for optimum sucker production. Py et al (1956) found that nitrogen had no effect on the number of suckers while he reports that G. Samuels found increases in the number of suckers with nitrogen. Py et al (1957) recorded increases in the number of 'shoots' following the application of potassium. It is not known whether 'shoots' are slips or suckers or both. In the event of them being slips, then the results are similar to the findings in this trial (See (iv) below).

Phosphorus deficiency decreases plant vigour and planting material which includes slips according to Collins (1960). K. Pan (quoted in Teiwes et al, 1963) found that phosphorus stimulated ratoon growth while applied phosphorus was found to have no effect on the number of suckers under local conditions, possibly because there was sufficient available in the soil at the time of planting.

iv) Number of slips.

Fumigation, potassium and zinc had significant** effects on the number of slips produced. The number of slips was increased by 33,0313 per plot following the application of potassium, while it was decreased by both fumigation (-10,5000 slips/plot) and zinc (-9,6563 slips/plot) (Tables 28 (a);

(b) and (c)).

There was an interaction between fumigation and applied iron where in the presence of iron, fumigation decreased the number of slips per plot significantly** by 18,0625 per plot while there was no significant difference in the absence of iron. Iron on the other hand, had no significant effect in the presence or absence of fumigation (Table 28 (d)).

Potassium in the absence of phosphorus increased the number of slips significantly** by 25,0625 per plot, while in the presence of phosphorus it increased the number even further i.e. by 40,9999 slips per plot. Phosphorus showed no further effects on the number of slips produced (Table 28 (e)).

The number of slips is known to be affected by the availability of nitrogen and phosphorus, deficiences in these nutrients leading to loss of plant vigour and reduction in the number of slips (Collins, 1960). Increases in the number of slips with increasing levels of nitrogen were recorded by van Lelyveld (1964) and Samuels et al (1955). The lack of response to nitrogen and phosphorus in this trial are probably due to the fact that the lower level of nitrogen applied was adequate for slip production and the available phosphorus in the soil before planting also being adequate.

v) Plant weights.

Soil fumigation was found to have a marked effect on plant growth throughout the growth cycle, this cycle being the period from planting until after harvesting of the ratoon crop. The improvement in growth due to soil fumigation can be clearly seen in Plates III, IV, V and VI.

The effects of the different treatments on plant growth can be seen in Plate VII while a summary of their effects on plant growth as indicated by plant weight is as follows:-

Mean increase in plant weights (kg).

Treatment.	at one year.	at two years.	at end of cycle.
Fumigation	0,455**	0,863**	1,6776**
Nitrogen	N.S.	N.S.	0,4095**
Phosphorus	N.S.	0,150*	N.S.

Treatment.	at one year.	at two years.	at end of cycle.
Potassium	N.S.	0,191*	0,2158*
Iron	N.S.	N.S.	0,2264*
Zinc	N.S.	N.S.	0,2286*

From the above, it can be seen that plant growth was increased significantly** by soil fumigation throughout the growth cycle (Tables 29 (a); 30 (a) and 31 (a)). This is a general finding following the application of soil fumigants which led to better root growth and subsequently a better uptake of nutrients (Sanford, 1964).

While high nitrogen did not increase plant growth during the first two years, it did eventually lead to a significant** increase in growth (Table 31 (b)). The effects of nitrogen on plant growth are generally found to be very marked (Sideris et al 1946 (b); Py et al 1956; van Lelyveld 1964; Sanford 1964). It would appear from these results as if the low nitrogen applications were sufficient for maximum growth during the first two years from planting, but that the higher rate was necessary for increased growth for the remainder of the cycle.

Applied phosphorus gave a slight increase in plant weight at two years, but this increase was only just significant* (Table 30 (b)), and was not encountered again.

The initial effects of potassium were not significant, but in the later stages of growth it did show significance* (Tables 30 (c) and 31 (c)). The application of potassium has also been found by others to increase plant weight and growth (Sideris et al, 1945; Py et al, 1957).

Both iron and zinc showed no significant effect on growth during the first two years, but resulted in significant* increases in plant weight by the end of the cycle (Tables 31 (d) and (e)).

Iron in the absence of fumigation resulted in a significant* increase in plant weight after one year, while it was found to significantly* decrease plant weight when fumigation also was applied. Soil fumigation resulted in a greater increase in growth in the absence of iron than when applied in

the presence of iron (Table 29 (b)). This effect was not significant in the later stages of growth. There appears to be no explanation for these results as an increase in growth would normally have been anticipated where fumigation and iron were applied together. Further investigations are necessary before definite conclusions can be drawn. It may be assumed from these results that iron is important when fumigation is not applied, while its application may not be necessary when fumigation is applied.

After one year of growth iron in the absence of zinc resulted in a decrease in plant weight. The same was found when zinc was applied in the absence of iron but although the decrease in this case was not significant, the increase when iron was also applied was significant* (Table 29 (c)). The interactions of iron and zinc at this stage of growth were complementary. After two years of growth this interaction showed a similar pattern with zinc in the absence of iron resulting in a significant** decrease in plant growth. Iron in the presence of zinc significantly* increased plant growth, and although not significant iron had a depressing effect when zinc was not applied (Table 30 (d)). The need for simultaneous application of iron and zinc is thus emphasized by these results.

Fumigation with high nitrogen increased the plant weight at the end of the cycle considerably when compared with the weights following fumigation and low nitrogen. The effect of high nitrogen was emphasized when fumigation was also applied (Table 31 (f)). The higher level of nitrogen was thus required to utilize the increased growth potential following soil fumigation.

Iron applied with low nitrogen increased the plant weight by the end of the cycle significantly** while the increase when high nitrogen was applied was not significant. The same effect was encountered when high nitrogen was applied with and without iron, plant weight increases being negligible when both high nitrogen and iron were applied (Table 31 (g)). The application of high nitrogen and iron are thus independent, either increasing the plant weight in the absence of each other, or having no

significant effect when applied together.

There were again strong indications of the number of slips produced affecting the number of suckers on the plant or vice versa. Fumigation, which resulted in the highest number of suckers gave the lowest number of slips. Applied zinc also increased the number of suckers, but decreased the number of slips while applied potassium resulted in a decrease in the number of suckers and an increase in the number of slips. With the same indications being observed in Fertilizer Trial I, it was decided that the data be subjected to further statistical treatment. In order to find out whether this phenomenon was due to treatment, time of harvesting or the number of slips or suckers actually produced, an analysis of co-variance involving the number of slips to number of suckers, the number of suckers to number of slips and the number of slips to time of harvesting was done. The results of these tests were not significant, indicating that the production of slips and suckers was essentially a factor involving treatment.

vi) Fruit yields.

Applied phosphorus and potassium had little or no effect on fruit yields, while all other treatments had significant and highly significant effects as indicated below.

Mean differences in fruit (kg) per plot.

Treatment	Plant crop	Ratoon crop	cycle total
Fumigation	21,2213**	38,3820**	58,3760**
Nitrogen	N.S.	5,6118*	9,4164**
Phosphorus	-2,3243*	N.S.	N.S.
Potassium	N.S.	N.S.	N.S.
Iron	2,6197*	N.S.	8,9460**
Zinc	2,7135*	5,4414*	9,2290**

Soil fumigation had a very marked effect on yield and increased it significantly** in both the plant and ratoon crops. Its effect on the ratoon crop (38,38$\frac{20}{1}$ kg/plot) was even more marked than on the plant crop, where there was a mean increase in yield of 21,2213 kg/plot (Tables 32 (a) and 33 (a)).

The application of a high level of nitrogen did not affect the plant crop while it significantly* increased the ratoon crop

yield and also had a significant** effect on yield when the two crops were taken together (Tables 33 (b) and 34 (b)).

Iron significantly* increased plant crop yields while its effect on the ratoon crop was not significant and its effect on the total yield being a significant** increase (Tables 32 (c) and 34 (c)).

Zinc significantly* increased the yields of both the plant and ratoon crops and its effect was more significant** when the two crops were taken together (Tables 32 (d); 33 (c) and 34 (d)).

Of the other factors, potassium had no significant effect at all on yield, while phosphorus decreased the plant crop yield significantly* by 2,3243 kg/plot but had no further effect on fruit production (Table 32 (b)).

There was no significant evidence that the main effects encountered were not consistent over all levels of all the other factors, the only exception being zinc which produced significantly* better yields in the plant crop when applied with phosphorus than without it (Table 32 (e)).

The marked increases in yield resulting from the application of soil fumigation are in agreement with the findings of others (Carter, 1953; Sanford, 1964 and Ayala et al, 1969).

Although the higher rate of nitrogen applied (672 kg/ha) did not significantly affect the plant crop, it did increase the yield in the ratoon crop. Its effect on yield was thus similar to that encountered on plant growth i.e. that the lower level was apparently sufficient for the first two years while the higher rate was necessary for later growth.

The depressing effect of phosphorus on the plant crop could have been caused by its application under conditions where the soil reserves were adequate. Samuels et al (1956) suggest that phosphorus depresses yields when too much is applied, but that small increases in yield may be obtained when low levels are applied. While yield increases have been recorded following the application of substantial amounts of phosphorus (Nyenhuis, 1967), the responses to applied phosphorus have generally been poor (Py et al, 1957; Teiwes et al, 1963). The interaction between

zinc and phosphorus may be of significance in that when the two were applied together, better yields were recorded in the plant crop. The fact that phosphorus was usually applied in the absence of zinc could be the reason for poor results from phosphorus applications in the past.

The fact that no yield response was recorded following the application of potassium can only be ascribed to the possibility of there having been adequate available potassium in the soil before planting.

The responses to the application of iron and zinc indicate the need for these trace elements. It is as well to note that these elements were necessary for improved growth as well as crop yields.

vii) Number of months to harvesting.

Two factors, namely phosphorus and iron had no significant effect on the time of harvesting of either the plant or ratoon crop. A summary of the results of the other factors from Tables 35 (a), (b), (c) and 36 (a), (b), (c), (d)) are as follows:-

	Months to plant crop.	Months to ratoon crop.
Fumigation	-2,0391**	-1,6484**
Nitrogen	1,2578**	0,7956**
Potassium	N.S.	0,5266**
Zinc	-0,7922**	-0,7078**

Fumigation, which had a significant** effect, brought the plant crop forward by 2,0391 months and the ratoon crop forward by 1,6484 months. The high nitrogen applications delayed the plant crop by 1,2578 months and the ratoon crop by 0,7956 months, the effects on both crops being significant**. Potassium delayed the ratoon crop by a significant** period of 0,5266 months while it did not affect the plant crop. Zinc had a similar effect to fumigation and brought the plant crop forward by 0,7922 months and the ratoon crop forward by 0,7078 months, both effects being significant**.

High nitrogen in the presence of fumigation delayed the plant crop by 0,8687 months, while without fumigation it delayed the crop by 1,6468 months. Fumigation on the other hand,

brought the crop forward by 1,6500 months when low nitrogen was applied and by 2,4281 months when high nitrogen was applied (Table 35 (d)). The increased nitrogen application thus apparently afforded quicker development in the fumigated plots which resulted in an earlier crop, the usual effect of high nitrogen applications being to delay the crop (Table 35 (d)). This interaction was, however, not significant for the ratoon crop.

Iron in the presence of phosphorus brought the ratoon crop forward by 0,4094 months while it delayed this crop by a non-significant 0,1125 months when phosphorus was not applied. Phosphorus in the presence of iron also brought the crop forward while in the absence of iron, this effect was non-significant (Table 36 (e)).

The earlier fruiting following soil fumigation is a direct result of the increased growth rate and consequent earlier maturing of the plant. It is a well known fact that plants which grow and develop quicker, fruit sooner.

The crop delays caused by increasing levels of nitrogen are also well known, and these results confirm the findings of others (Nightingale, 1942 (a); van Lelyveld, 1964). An effect which was not encountered is that phosphorus tends to hasten fruiting (Samuels et al, 1956).

viii) Fruit total soluble solids (T.S.S.).

Fumigation and high nitrogen decreased the total soluble solids of the fruit by 0,7564% and 0,2375% respectively while they were increased significantly** by phosphorus and iron by 0,2688% and 0,2594% respectively (Tables 37 (a), (b), (c) and (d)).

The only other significant effect was that fumigation in the presence of zinc decreased the total soluble solids more than when zinc was not applied. Zinc in the absence of fumigation significantly* increased the T.S.S. while this effect was not significant when fumigation was applied.

Martin-Prevel (quoted in Teiwes et al, 1963) found that potassium increased the 'dry extract' of the juice while it was

decreased by calcium and magnesium applications. These findings were not supported by the results of this trial.

The juice content of the fruit was increased with increasing applications of potassium and magnesium according to Martin-Prevel, but these findings are contradicted by Py et al according to Teiwes et al, (1963). Van Lelyveld, (1964) found that increasing levels of nitrogen increased the degree of translucency of the fruit which is in effect an increase in the juice content of the fruit. Fumigation and high nitrogen which increase the juice content of the fruit, would in fact, decrease the T.S.S. of the juice by dilution. The effect of fumigation which leads to a better uptake of nutrients could thus be interpreted as confirming the findings of Martin-Prevel.

ix) Fruit density.

Only fumigation, which significantly** increased fruit density by 0,0214 had any measurable effect at all (Table 38 (a)). The method used for the determination of fruit density was not particularly accurate but did serve as a guide to the effects of treatment on density. The increased density of the fruit following soil fumigation was the result of this fruit having a higher juice content, this condition being brought about by better root growth.

x) Fruit sugar (brix).

Fumigation lowered the sugar content of the fruit significantly** by 0,8203° (Table 39 (a)), while the application of iron increased it significantly** by 0,3515° (Table 39 (b)).

Fumigation applied in the presence of applied phosphorus decreased the sugar content even further than when applied in the absence of the phosphorus. Phosphorus in the presence of fumigation led to a significant* decrease in the sugar content while it had a non-significant effect when applied in the absence of fumigation (Table 39 (c)). Fumigation in the presence of iron on the other hand, did not decrease the sugar content as much as in the absence of iron. Thus the effect of iron which has the opposite effect to fumigation on the sugar content, neutralised the effect of fumigation to some extent. Iron in the presence

of fumigation increased the sugar content of the fruit significantly** (Table 39 (d)).

Potassium increased the sugar content in the absence of zinc while it decreased it in the presence of zinc. Similarly, zinc increased the sugar content in the absence of potassium and decreased it in the presence of potassium, all these effects being non-significant. The interaction between zinc and potassium was, however, significant* (Table 39 (e)).

Apart from slight increases in the sugar content being recorded by Martin-Prevel, (quoted in Teiwes et al, 1963), the effects of nitrogen, phosphorus and potassium have been negative (Py et al, 1956; 1957).

xi) Fruit acidity.

Of the treatments applied only potassium had any effect on acidity, and increased it significantly** by 0,0494% (Table 40 (a)).

Both fumigation and iron non-significantly reduced fruit acidity when applied in the absence of each other. Their effect on each other was significant* although they increased acidity also non-significantly in the presence of each other (Table 40 (b)).

Zinc in the absence of potassium decreased the acidity of the fruit significantly*. Potassium, on the other hand, in the presence of zinc increased acidity significantly** while in the absence of zinc, its effect was not significant (Table 40 (c)).

The increase in acidity resulting from the application of potassium has also been recorded by Py et al, (1956; 1957); Martin-Prevel and Su (quoted in Teiwes et al, 1963). A result not encountered in this trial was a reduction in acidity following the application of high nitrogen as found by Py et al (1956).

Although fruit quality for canning in the Eastern Cape is generally good, fruit produced in summer is porous and has large cavities which are undesirable. By increasing the juice content these cavities can be reduced in size, thus fruit with high density is more desirable. Generally speaking the need is for higher levels of T.S.S. and sugar while the acidity is more than

adequate under local conditions. In more tropical climates the fruit produced has more juice and smaller cavities but in some cases the acidity is too low. When the fruit is canned in natural juice the acidity is found to be too high locally in certain seasons and fruit with a lower acidity would be more desirable. From the results it is obvious that fruit quality can be altered significantly by treatment.

xiii) Soil analysis after ratoon crop.

(a) Available phosphorus.

Soil phosphorus was depleted very significantly** by soil fumigation by 3,8907 p.p.m. and significantly* by applied iron by 2,0157 p.p.m. (Tables 41 (a) and (b)). Applied phosphorus resulted in a significant** increase of 5,7969 p.p.m. in the amount of available phosphorus in the soil (Table 41 (c)).

Fumigation in the presence of potassium resulted in a greater uptake of phosphorus than in the absence of potassium while potassium in the absence of fumigation led to a lesser uptake of phosphorus (Table 41 (d)). Applied phosphorus resulted in a greater increase in available soil phosphorus when iron was not applied than when iron was applied. When phosphorus was applied in the presence of iron it resulted in a significant** decrease in available phosphorus (Table 41 (e)).

(b) Available potassium.

Fumigation resulted in a marked reduction of available soil potassium of 16,7188 p.p.m., while applied potassium resulted in a significant** increase in available soil potassium of 11,8438 p.p.m. (Tables 42 (a) and (b)).

When potassium was applied in the absence of fumigation it gave a very significant** increase in available potassium and a significant* increase when fumigation was also applied. Fumigation resulted in a significant** reduction in available potassium whether potassium was applied or not, but this decrease was greater when potassium was also applied (Table 42 (c)).

(c) Calcium content.

There was no significant effect by any treatment on

the concentration of calcium in the soil.

(d) Magnesium content.

Soil fumigation decreased the magnesium content of the soil by 4,5312 p.p.m. (Table 43 (a)).

(e) Soil acidity.

The pH of the soil by the end of the cycle was not altered significantly by any of the applied treatments.

(f) General discussion.

The apparent increases in available nutrients in the soil are not necessarily actual increases in the amounts of these substances in the soil. Some will, of course, be the result of application of nutrients such as potassium and phosphorus to the soil, while others will be apparent increases because of relatively less of a particular element being absorbed because of suppressed uptake due to antagonism or less plant growth having taken place because of treatment.

Soil analysis at the end of the cycle showed a significant** increase in available phosphorus as a result of applied phosphorus, indicating that sufficient phosphorus had been applied. Both soil fumigation and applied iron resulted in highly significant and significant decreases in available phosphorus respectively by the end of the cycle. This is most likely the direct result of a greater uptake of phosphorus as a result of increased plant growth, particularly after soil fumigation.

The fumigation X potassium interaction indicates that when potassium is applied together with fumigation, there is a greater uptake of phosphorus. While the effect of fumigation in the presence of applied potassium is not significant, the effect of potassium without fumigation results in an apparent increase in available phosphorus. This is probably due to there being less plant growth when the soil is not fumigated.

The application of potassium gave a significant** increase in available potassium, a condition which persisted for the duration of the growth cycle. Soil fumigation on the other hand with its resultant marked increase in growth depleted the

available potassium by a significant** amount. Better root development and a subsequent increase in plant growth, obviously led to a greater uptake of potassium. When potassium was applied in the absence of fumigation, the increase in available potassium was greater than when fumigation was also applied. This again indicates the increased uptake of potassium as a result of soil fumigation. Available potassium was decreased when fumigation was applied in the presence or the absence of potassium. The fact that this decrease was greater when potassium was applied is the opposite of what may have been expected. The decrease in soil-K may, however, be due to the higher concentration of leaf-K found when these two treatments were applied together. From Table 47 (b) it can be seen that when the soil was fumigated the leaf-K concentration was decreased by the non-significant amount of 0,0625% in the absence of applied potassium and increased by the significant* amount of 0,0946% when potassium is applied. Therefore more potassium was taken up by the plant when more was applied.

The significant reduction of available magnesium by the end of the cycle after soil fumigation is most likely the result of better uptake due to a better root system and greater plant growth.

The pH of the soil was not altered significantly by any of the applied treatments.

When the soil analysis of samples taken prior to the planting of the trial was compared with that of samples taken from the root zone of the plants immediately after the completion of the cycle, considerable differences in the amounts of available nutrients were observed (Table 44). This was particularly the case with potassium, calcium and magnesium, while the soil reaction and availability of phosphorus were not effected to the same extent. The available phosphorus was reduced from 10 p.p.m. to 8,8969 p.p.m. in plots where phosphorus had not been applied and increased to 14,6875 p.p.m. where phosphorus had been applied at a rate of 56,0 kg P/ha (Tables 41 (c) and 44). The available potassium was reduced from a mean of 210 p.p.m. to 43,0781 p.p.m. where potassium was not applied and to 54,9219 p.p.m. where

336,0 kg K/ha had been applied during the trial (Tables 42 (b) and 44). Responses to applied potassium were limited when plant weights were considered and not significant when fruit yields were considered. While calcium and magnesium were not applied, their availability in the soil dropped from adequate (mean value 228 p.p.m.) in the case of calcium to 55,0781 p.p.m. (Table 44) which is very near the critical response level of 50 p.p.m. (Table 2); and from adequate (mean value 154 p.p.m.) in the case of magnesium to 30,3906 p.p.m. (Table 44) which is below the critical response level of 65 p.p.m. (Table 2). There were no indications that either of these nutrients were not available in sufficient quantities. The pH (N-KCl) of the soil decreased from 4,1 to 3,5 over the cycle, this drop being most likely due to the reduction in the available cations.

xiv) Leaf analysis after flower differentiation for plant crop.

(a) Leaf nitrogen concentration (%).

Both fumigation and high nitrogen applications led to significant** increases in leaf-N concentration from 1,2306% to 1,3250% and 1,2083% to 1,3473% respectively (Tables 45 (a) and (b)). There were no other significant treatment effects.

(b) Leaf phosphorus concentration (%).

Both soil fumigation and applied phosphorus resulted in significant** increases in the concentration of leaf-P from 0,1380% to 0,1572% and 0,1416% to 0,1536% respectively while high nitrogen resulted in a significant* decrease in concentration from 0,1519% to 0,1433% (Tables 46 (a), (b) and (c)). These effects were consistent over all treatments.

(c) Leaf potassium concentration (%).

Of the six treatments, only applied potassium which significantly** increased leaf-K from 1,5319% to 1,7664% had any significant effect on the leaf-K concentration (Table 47 (a)).

Leaf-K concentration was increased significantly** by the application of potassium (0,1560%), particularly in the presence of soil fumigation where this increase (0,3131%) was

even more marked. Fumigation in the absence of applied potassium resulted in a non-significant decrease in leaf-K (-0,0625%) and a significant* increase (0,0946%) when potassium was applied (Table 47 (b)).

(d) Leaf calcium concentration (%).

The concentration of leaf-Ca was increased significantly** by soil fumigation from 0,0414% to 0,0767% and significantly* by both the application of phosphorus and iron from 0,0559% to 0,0622% and 0,0566% to 0,0616% respectively (Tables 48 (a), (b) and (c)). The application of potassium reduced leaf-Ca significantly** from 0,0700% to 0,0481% (Table 48 (d)).

The depressing effect of applied potassium on leaf-Ca was significant** in the absence of fumigation (-0,0160%), while it was even more marked in the presence of fumigation (-0,0278%). Soil fumigation on the other hand, increased leaf-Ca significantly** both in the absence (0,0412%) and presence (0,0294%) of potassium (Table 48 (e)).

(e) Leaf magnesium concentration (%).

Soil fumigation increased the leaf-Mg significantly* from 0,1272% to 0,1370% while it was significantly* reduced by the application of potassium from 0,1359% to 0,1283% (Tables 49 (a) and (b)). There were no other effects of applied treatments on leaf-Mg.

(f) Leaf manganese concentration (p.p.m.).

None of the treatments individually had a significant effect on the leaf-Mn concentration.

The manganese concentration was increased significantly** by 52 p.p.m. when potassium was applied in the presence of fumigation, while it was significantly** reduced when fumigation was applied in the absence of potassium by 36 p.p.m. (Table 50 (a)).

(g) Leaf iron concentration (p.p.m.).

Individually, the applied treatments had no significant effect on the leaf-Fe concentration.

Applied phosphorus in the presence of high nitrogen increased the iron content of the leaves significantly** by 14,6875 p.p.m. while in the absence of high nitrogen, there was no significant effect on concentration (Table 51 (a)).

The same effect was encountered by the application

of phosphorus in the presence of zinc where the iron concentration was increased from 27,8125 p.p.m. to 43,7500 p.p.m. In this instance, the application of zinc in the presence of phosphorus also increased the iron concentration by a significant* amount from 32,5000 p.p.m. to 43,7500 p.p.m., while a non-significant depressing effect of zinc was encountered in the absence of phosphorus (Table 51 (b)).

(h) Leaf zinc concentration (p.p.m.).

Only applied zinc significantly affected the zinc concentration in the leaf by increasing it significantly** from 17,8594 p.p.m. to 21,1719 p.p.m. (Table 52 (a)).

xv) Leaf analysis after flower differentiation for ratoon crop.

(a) Leaf nitrogen concentration (%).

Leaf-N concentration was significantly** decreased by soil fumigation from 1,1683% to 1,1142% while it was increased significantly** by the application of a high level of nitrogen from 1,0697% to 1,2128% (Tables 53 (a) and (b)).

(b) Leaf phosphorus concentration (%).

Two factors, namely fumigation and potassium, had no significant effect on leaf-P, while all other factors had significant** effects (Tables 54 (a), (b), (c) and (d), namely:-

Nitrogen	-0,0216**%
Phosphorus	0,0144**%
Iron	-0,0096**%
Zinc	-0,0162**%

Only applied phosphorus increased leaf-P, while, nitrogen, iron and zinc decreased the level of leaf-P significantly**.

(c) Leaf potassium concentration (%).

Fumigation reduced the concentration of leaf-K significantly** from 2,1272% to 1,9923%, while zinc reduced it significantly* from 2,1228% to 1,9967% and applied potassium resulted in a significantly** increased concentration from 1,8692% to 2,2503% (Tables 55 (a), (b) and (c)).

These factors were not consistent over all levels of other factors and fumigation in the presence of high nitrogen decreased leaf-K significantly** by 0,2890% while the effect in the absence of high nitrogen was not significant. Nitrogen in

the presence of fumigation also resulted in a significant** decrease in leaf-K of 0,2009% while without fumigation, the effect of high nitrogen was not significant (Table 55 (d)).

The increase in leaf-K was greater when zinc was applied with potassium (0,4866%) than when potassium was not applied alone (0,2756%). Zinc applied in the absence of potassium resulted in a significant** decrease in leaf-K from 1,9850% to 1,7534% while this decrease was not significant when potassium was applied (Table 55 (e)).

(d) Leaf calcium concentration (%).

Leaf-Ca was increased by a significant** amount following the application of soil fumigants from 0,2291% to 0,3108% while it was decreased significantly** by the application of potassium from 0,2875% to 0,2523% and significantly* by the application of zinc from 0,2783% to 0,2616% (Tables 56 (a), (b) and (c)).

Potassium in the absence of zinc, significantly** decreased leaf-Ca by 0,0534% while the effect was not significant in the presence of zinc. Similarly, zinc in the absence of potassium significantly** decreased leaf-Ca by 0,0350% while the effect was not significant in the presence of potassium (Table 56 (d)).

(e) Leaf magnesium concentration (%).

The concentration of leaf-Mg was increased significantly** by soil fumigation from 0,1783% to 0,2272% while it was reduced significantly** by the application of potassium from 0,2128% to 0,1927% and significantly* by the application of high nitrogen from 0,2095% to 0,1959% (Tables 57 (a), (b) and (c)).

Potassium in the absence of zinc led to a significant** decrease in leaf-Mg from 0,2228% to 0,1912% while this effect was not significant when zinc was applied. Zinc in the absence of potassium also decreased leaf-Mg significantly* from 0,2228% to 0,2028% while in the presence of potassium it resulted in a non-significant increase in leaf-Mg (Table 57 (d)).

(f) Leaf manganese concentration (p.p.m.).

Leaf-Mn was increased significantly** by both soil

fumigation from 397 p.p.m. to 531 p.p.m. and high nitrogen from 420 p.p.m. to 508 p.p.m. while it was decreased significantly* by the application of phosphorus from 481 p.p.m. to 447 p.p.m. (Tables 58 (a), (b) and (c)).

Fumigation in the absence of iron led to a greater increase in leaf-Mn (175 p.p.m.) than in the presence of iron (95 p.p.m.). The effect of iron both in the presence or absence of fumigation on leaf-Mn was not significant (Table 58 (d)).

(g) Leaf iron concentration (p.p.m.).

The concentration of leaf-Fe was decreased significantly* by the application of high nitrogen from 18,6563 p.p.m. to 17,8125 p.p.m. while it was increased significantly** by applied iron from 17,4062 p.p.m. to 19,0625 p.p.m. and less significantly* by applied potassium from 17,8125 p.p.m. to 18,6563 p.p.m. (Tables 59 (a), (b) and (c)).

High nitrogen in the absence of potassium resulted in a significant** decrease in leaf-Fe of 1,7500 p.p.m. and a non-significant increase when potassium was applied. Potassium in the presence of high nitrogen resulted in a significant** increase in leaf-Fe of 1,7500 p.p.m. while it resulted in a non-significant decrease when nitrogen was not applied (Table 59 (d)).

(h) Leaf zinc concentration (p.p.m.).

Applied zinc is the only factor which individually affected the zinc concentration of the leaves. It resulted in a significant** increase in the concentration of leaf-Zn from 22,1875 p.p.m. to 26,3281 p.p.m. (Table 60 (a)).

Phosphorus in the absence of zinc resulted in a non-significant decrease in leaf-Zn while it resulted in a significant** increase in leaf-Zn of 3,5938 p.p.m. when zinc was applied. The application of zinc in the absence of phosphorus gave a non-significant increase in the level of leaf-Zn while this increase was significant** (6,3750 p.p.m.) when phosphorus was applied (Table 60 (b)).

(i) General discussion.

The higher level of applied nitrogen (1120 kg/ha)

resulted in significant** increases in leaf-N concentration after differentiation of both the plant and ratoon crops. Van Lelyveld (1964) recorded increases in leaf nitrogen concentrations with increasing levels of applied nitrogen under local conditions at ten and 15 months after planting. This has been the general finding of others following the application of nitrogen (Sanford, 1964). Soil fumigation which resulted in a significant** increase in leaf-N after plant crop differentiation, led to a significant** decrease in concentration after ratoon crop differentiation. This decrease could be due to there not being sufficient nitrogen available to maintain the leaf-N level because of the very marked increases in plant growth resulting from fumigation. Increases in leaf-N similar to those recorded by Sideris et al, 1946 (a) following the application of iron were not encountered in this trial.

The concentration of leaf-P was increased significantly** after differentiation of both crops following the application of phosphorus. Soil fumigation which was found to increase the leaf-P level after the plant crop significantly**, had no significant effect after ratoon crop differentiation. This result is not substantiated by the findings of others for Smith (1963) found that while fumigation increased the availability of phosphorus, it did not lead to an increase in its uptake. Sanford (1961) mentions that the application of D-D depresses the leaf-P concentration while in a later publication (Sanford, 1964), he states that fumigation reduces leaf-P in the early stages of growth, but that this effect need not necessarily continue. The fact that the initial leaf sampling for analysis in this experiment was done just after plant crop differentiation i.e. approximately 20 months after planting, could be the reason for finding an increase in leaf-P because of a better uptake following increased root development. That this effect was not found in the analysis after ratoon crop differentiation could be because of insufficient uptake of phosphorus to result in an increase the leaf level. The application of a high level of nitrogen which resulted in a decrease in leaf-P is in agreement with the findings of Nightingale (1942 (b)) who found that high

nitrogen suppressed the uptake of phosphorus. Sideris et al (1946 (b)) recorded increases in the phosphorus concentration of the plant as a whole following the application of higher nitrogen but the concentration in the D-leaves was not specifically mentioned. The applications of both iron and zinc led to a significant** decrease in the level of leaf-P. According to Sideris et al (1943) leaf-P was not altered to any great extent by the presence of iron, but from these results it is apparent that both iron and zinc have some effect on the uptake of phosphorus.

Leaf-K was increased significantly** by the application of potassium indicating the necessity for its application. In the analysis after plant crop differentiation the application of potassium together with fumigation led to an increase in leaf-K, while without it, fumigation had a non-significant effect. Fumigation resulted in a significant** decrease in leaf-K by the time of flower differentiation for the ratoon crop. These findings are not what would be expected as the better root development should lead to a better uptake of potassium which was apparently available in sufficient quantities (Sanford, 1964). It could be that the very marked increase in growth following fumigation led to an apparent 'dilution' in the concentration of nutrients in the leaf even though the uptake was far greater as indicated by the soil analysis. The slight decrease in leaf-K following the application of zinc could be due to some antagonism between the two elements. The antagonistic effect of NH_4-N on the uptake of potassium was not encountered. This effect has been referred to by Sideris et al (1946 (b)); van Lelyveld (1964) and others. In experiments under local conditions, van Lelyveld (1964) found that increasing levels of ammonium sulphate decreased the concentration of leaf-K. When high nitrogen and fumigation were applied together, they resulted in significant** decreases in leaf-K while when applied in the absence of each other, their effects were non-significant. When zinc was applied without additional potassium, it had a significant** depressing effect on leaf-K while this effect was neutralised by the application of potassium.

Soil fumigation increased leaf-Ca concentration on both occasions of leaf sampling which is in accordance with the general findings of others (Sanford, 1964). The application of phosphorus in the form of superphosphate which contains calcium, increased the concentration of leaf-Ca in the analysis after plant crop differentiation, but not in the analysis after differentiation for the ratoon crop. Applied iron also increased its concentration in the analysis after plant crop differentiation, but not in the analysis after ratoon crop differentiation. Applied potassium had a marked depressing effect on leaf-Ca concentration in samples taken after differentiation of both the plant and ratoon crops. This is caused by the strong antagonistic effect of potassium on the uptake of calcium which has been encountered by others (Sanford, 1964). Zinc depressed leaf-Ca concentration to a limited extent in samples taken after differentiation for the ratoon crop. Applied potassium decreased leaf-Ca in this analysis irrespective of whether the soil was fumigated or not. Fumigation, on the other hand, increased the leaf-Ca independantly of whether potassium was applied or not. This indicates the independant strength of the effects of these two treatments on the uptake of calcium. This interaction was, however, not encountered in the analysis after ratoon crop differentiation. Potassium applied in the absence of zinc decreased leaf-Ca highly significantly while zinc applied in the absence of potassium had the same effect in the analysis after differentiation for the ratoon crop. When these two elements were applied together their effect was not significant.

As with calcium, fumigation resulted in significant** increases in leaf-Mg in samples taken after differentiation of both the plant and ratoon crops. Applied potassium had the same effect as on the calcium content i.e. of reducing the leaf-Mg concentration because of its antagonistic effect on the uptake of magnesium (Sanford, 1964). High nitrogen applications resulted in a significant* decrease in leaf-Mg in samples taken after differentiation for the ratoon crop. This depressing effect is due to the antagonistic effect of the NH_4 ions on magnesium absorption as described by Sideris (1946 (b)) and Sanford (1964). This effect was not significant when the

leaf-Ca concentration was considered. Sanford (1964) maintains that the magnesium and calcium requirements of the plant are difficult to evaluate because of the antagonistic effect of NH_4-N and potassium. A potassium X zinc interaction identical to the one encountered for calcium was found in the analysis of samples after differentiation for the ratoon crop. When these two elements were applied in the absence of each other, they resulted in significant** decreases in leaf-Mg while their effect was non- significant when they were applied together.

The increase in leaf-Mn after soil fumigation is in accordance with the findings of Smith (1963) who reports that fumigation increases the availability of manganese and also the uptake of this element. High nitrogen was also found to increase the level of manganese in the leaf in samples taken after ratoon crop differentiation. Fumigation applied in the presence or absence of iron resulted in significant** increases in leaf-Mn, while iron applied in the presence or absence of fumigation had no significant effect. Potassium applied in the presence of fumigation increased leaf-Mg while it was decreased when fumigation was applied in the presence of potassium.

Applied iron did not increase the leaf-Fe in the analysis after plant crop differentiation but a significant** increase was encountered in the analysis after ratoon crop differentiation. This may indicate that insufficient iron was applied during the early stages of growth, an indication which also became apparent when the results on plant growth were considered. Increases in leaf-Fe following the application of iron have also been recorded by Sideris et al (1943); Sanford (1964) and others. Applied potassium resulted in significant** increases in leaf-Fe while high nitrogen reduced it significantly* in samples taken after differentiation of the ratoon crop. The opposite effects of these elements are again shown in the nitrogen X potassium interaction, where nitrogen in the absence of potassium led to a significant** decrease in leaf-Fe, while potassium applied in the absence of high nitrogen resulted in a significant** increase in leaf-Fe. Soil fumigation did not increase the level of iron in the D-leaves. Smith (1963) found that fumigation sometimes increased and sometimes decreased

the availability of iron in the soil and although it improved the utilisation within the plant, it did not affect the uptake of iron by the plant.

The zinc concentration of the D-leaves was increased significantly** by the application of zinc in samples taken after differentiation of both the plant and ratoon crops. Zinc applied in the absence of phosphorus did not have a significant effect on the leaf-Zn while the effect was significant** when the two elements were applied together. This result could help to explain the positive response to phosphorus which gave increases in plant crop yield in the presence of zinc.

The overall effect of phosphorus applied at a rate of 56 kg P/ha was a depressing effect on the plant crop yield similar to that recorded by others (Py et al, 1957; Samuels et al, 1957; Montenegro et al, 1967). Increasing levels of applied phosphorus have been found to induce zinc deficiency in plants where available zinc is marginal or low in the soil (Marais; Diest; Heyns and Haasbroek, 1968). At one time it was thought by some that these induced deficiency symptoms were due to the immobilization of zinc in the roots by phosphorus, while others found no significant interactions between phosphorus applications and zinc absorption, concluding that zinc deficiency was not due to excess phosphorus (Halim, Wassom and Ellis, 1968). It has been shown by Marais et al (1968) that the concentration of phosphorus in the soil does not affect the availability of zinc in the soil nor its absorption from the soil. They concluded that plants which are given more phosphorus probably require more zinc as well. Studies by Halim et al (1968) also found nothing to indicate that high applications of phosphorus limit the uptake of zinc from the soil.

It is highly likely that where depressing effects of applied phosphates have been encountered, fertilizers were applied in the dry form to the basal leaves and in the absence of zinc applications. In the early trials with phosphorus at the local Government Research Stations its application resulted in decreased yields, nutrients being applied to the basal leaves in the dry form and zinc not being applied (von Blommestein, 1972). Subsequent trials in which zinc was also applied have resulted

in positive responses to applied phosphorus particularly where the available phosphorus in the soil was below 5 p.p.m. (von Blommestein, 1972). In places such as Hawaii where zinc is regularly applied as a standard practice, phosphorus applications to pineapples are recommended (Collins 1960). Of significance is the fact that when phosphorus and zinc were applied in the absence of each other, they did not affect the plant crop yield while then applied together they resulted in a highly significant increase in yield (Table 32 (e)). The same interaction indicated an increase in leaf-Fe in the analysis after plant crop differentiation when both phosphorus and zinc were applied togehter and a similar effect on the leaf-Zn concentration in samples taken at flower differentiation for the ratoon crop (Tables 51 (b) and 60 (b)). While these results do not contradict the findings of Marais et al (1968) or Halim et al (1968) they also do not suggest that phosphorus and zinc assist in iron utilization or that phosphorus facilitates the utilization of applied zinc as applied phosphorus did not decrease the concentration of leaf-Zn in the absence of applied zinc. The depressing effect of phosphorus was not observed in the ratoon crop possibly because phosphorus was applied once only as a soil dressing before planting and zinc was applied as monthly foliar sprays after the plants had begun growing. There was thus a continual accumulation of zinc in the plant which could have offset any detrimental effects of applied phosphorus by the time of harvesting of the ratoon crop.

xv) Nematode counts.

The mean nematode count in soil samples from the area to be planted to the trial was 376 plant parasitic nematodes per 100 ml of soil. These parasites consisted mainly of Helicotylenchus sp. (312) with Meloidogyne sp. (48) and Trichodorus sp. (16) also being present (Table 61). The relatively high counts in soil which had lain fallow for a year since the previous crop of pineapples, could be accounted for by the presence of volunteer plants which had resulted from the regrowth of stumps not destroyed by cultivation practices after completion of the previous cycle. In order to determine how effective soil fumigation had been in controlling nematodes, soil samples were

taken on four occasions during the course of the experiment and counts made of the plant parasitic nematodes occuring in them. On two occasions, the 19/3/66 and 18/2/70, the samples from four fumigated and four unfumigated plots from each block of eight treatments of the 2^6 factorial experiment were mixed at the time of sampling in order to cut down on the number of samples. On the two other occasions, the 30/3/67 and 3/2/69, each plot was sampled separately and the nematode counts determined separately. A summary of the nematode counts in samples taken on the above dates are presented in Table 61. The effects of fumigation applied as a preplanting treatment of 449,3 l D-D + 33,7 l DBCP/ha followed by a post planting application of 33,7 l DBCP/ha twelve months later on the total numbers of plant parasitic nematodes were as follows:-

Sampling date.	Fumigated plots.	Unfumigated plots.
20/8/65	Initial count.	376
19/3/66	4 ± 3	266 ± 85
30/3/67	10 ± 4	793 ± 98
3/2/69	77 ± 8	498 ± 104
18/2/70	503 ± 119	512 ± 115

From the above it can be clearly seen that plant parasitic nematodes were effectively controlled up to 3/2/69 or for 39 months from planting. A year later, however, there were as many nematodes in the treated as untreated plots. The populations of Helicotylenchus sp. were very effectively controlled up to the second sampling on 30/3/67 or 16 months from planting, after which there was a slight increase in numbers over the next two years to 26 ± 13 per 100 ml soil and as many as in the untreated samples were found a year later (Table 61). Meloidogyne sp. was even more effectively controlled during the first 16 months from planting with none being recorded in the first two batches of samples. The population was about the same as that of the initial sampling by the third time of sampling on 3/2/69 or 39 months from planting. During the following year the population increased to 207 ± 71 which was similar to the count in the untreated plots, namely 247 ± 66 per 100 ml soil (Table 61). Trichodorus sp. which occurred sporadically in low numbers did

not appear to be affected by the fumigation applied. The counts of this species of nematode remained very low in both treated and untreated plots in each of the four batches of samples and showed no signs of substantial population increases (Table 61). Other genera encountered sporadically in very low number included Pratylenchus, Paratylenchus, Aphelenchoides, Rotylenchus and Xiphinema.

The counts recorded in samples taken on 3/2/69 were subjected to further statistical treatment. The results show that of all treatments applied only fumigation had any significant effect on the nematode populations which were reduced from 504,6875 to 77,5000 plant parasitic nematodes per 100 ml soil (Table 62). This result was of course expected but some fertilizer treatments which affected plant growth may have had some significant indirect effect on the nematode population. This was of course not found to be the case.

7. CONCLUSIONS.

A preplanting application of 449,3 l D-D + 33,7 l DBCP/ha followed by a post planting application of 33,7 l DBCP/ha twelve months later effectively controlled the major species of plant parasitic nematodes for the greater part of the growth cycle of the pineapple plant. Nematode populations were reduced to the extent that their effect on growth was negligible for the first three years and probably for the entire growth cycle. Genera of plant parasitic nematodes causing the most damage to pineapple plants in the Eastern Cape were Helicotylenchus and Meloidogyne, while Meloidogyne and Rotylenchulus probably cause the greatest damage in Hawaii and Rotylenchulus and Helicotylenchus the greatest damage in Puerto Rico.

The improved root growth encountered as a result of effective nematode control led to better uptake and utalization of nutrients, increased plant growth and increased yields. Plant growth and yield increases were particularly marked.

The lower level of nitrogen applied, 336,0 kg N/ha to plant crop and 560,0 kg N/ha for the cycle, appeared to be adequate for plant growth up to plant crop and for plant crop yields. The higher level, 672,0 kg N/ha to plant crop and

1120,0 kg N/ha for the cycle, gave better results over the whole cycle. Indications are that the higher level which is the recommended level of application could be reduced during the early stages of growth without detrimental results.

The limited responses to phosphorus applied at a rate of 56,0 kg P/ha are most likely due to there being adequate reserves of available phosphorus in the soil prior to the planting of the trial. The initial level of available phosphorus was 10 p.p.m. above which researchers in Hawaii have seldom obtained responses to applied phosphorus. Applied phosphorus led to an increase in available phosphorus in the soil as determined four and a half years after application, indicating that it was not all used by the plant or fixed in the particular soil concerned. The decrease in plant crop yields experienced could be due to the application of phosphorus under conditions where adequate phosphorus was already available or where the zinc availability was inadequate. The results tend to indicate that zinc application given with phosphorus application could lead to positive yield responses to applied phosphorus.

Limited responses to applied potassium encountered are thought to be due to adequate supplies of this nutrient in the soil prior to the planting of the trial. The initial soil level was 210 p.p.m. which is above the critical response level of 200 p.p.m. as determined by researchers in Hawaii. Decreased leaf-K levels in samples taken after flower differentiation for the ratoon crop, particularly where fumigation was applied, was probably caused by the fact that all potassium was applied prior to differentiation for the plant crop. Soil analysis of samples taken after the end of the cycle indicated depleted soil reserves of potassium even after application of 336 kg K/ha. Soil reserves of 200 p.p.m. may be adequate for yields but are not necessarily optimim for plant growth.

Indications were that iron applied monthly to give a total of 112 kg $FeSO_4$/ha by flower differentiation for the plant crop was inadequate and that had more iron been applied greater increases may have resulted. Application totalling 84 kg $FeSO_4$/ha for the ratoon crop on the other hand appeared to be adequate, indicating the need for more iron during the

early stages of growth only. There were also indications that soil fumigation decreased the need for applied iron presumably because of better uptake and utalization of iron within the plant.

The positive responses to applied zinc suggest this element to be essential under local conditions. There are indications that more zinc should be applied earlier, possibly as a pre-planting application with phosphorus for best results.

The soil reaction which became more acid during the cultivation of one cycle of pineapples would have to be corrected before continued cultivation of subsequent crops, particularly those requiring more alkaline soil reactions.

In general the results of fumigation and applied nutrients on pineapple plant were similar to the findings of others in other pineapple producing countries.

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CHAPTER IV.

PLANT GROWTH AND NUTRIENT LEVELS.

In order to determine the growth pattern, samples of plants were taken from plantations at monthly intervals and weighed. The weights of the D-leaves were recorded and the nutrient status of the plants established. Areas for sampling were selected within plantations planted during the 1968 and 1969 seasons. To avoid variations due to aspect and soil heterogeneity, sampling was confined to selected areas which were almost level and of approximately one hectare in extent in each of the plantations from which samples were drawn. Sampling commenced once the plants were well established and continued until flower differentiation for the plant crop.

1. SAMPLING TECHNIQUE.

Sampling consisted of carefully uprooting five adjacent plants, two from one side of the double row and three from the other at four different points at random within the sampling area each month. Samples were taken at least two weeks after the last fertilizer applications.

After the soil had been shaken from the roots, the plants were weighed, the four samples containing five plants each being kept separately. Four D-leaves were then pulled from each plant, these being weighed before being prepared for analysis as described in Chapter II. Each sample for analysis thus consisted of 20 leaves from five plants. The four samples taken each month from each area were analysed separately and in duplicate as described in Annexure C.

2. DETAILS CONCERNING PLANTATIONS.

Where soil fumigants were applied, a mixture of 303 l D-D/ha and 22 l DBCP/ha was given in a row treatment at a depth of 20 cm three weeks prior to planting. Fumigation was done mechanically and applied as a continuous flow in the plant row to give the correct quantity. The fumigant was pumped at low pressure into the soil through nozzles placed behind tines at the required depth.

Fertilizer applications were made either as basal leaf dressings or foliar spray applications of commercially available fertilizers. Basal leaf dressings of sulphate of ammonia, sulphate of potash and superphosphate were applied by hand to give approximately 11,5g per plant per application.

The foliar sprays included urea, ferrous sulphate, zinc sulphate and sulphate of potash and were applied by boom with nozzles directed over the rows. In these high volume sprays either 1123 l/ha or 2246 l/ha of water was used depending on the amount of fertilizer applied at the time, the total nutrient concentration not exceeding 5% by weight.

Details concerning individual plantations are as follows:

Plantation C11: Virgin land planted to tops November, 1968.

Soil analysis (p.p.m.) : P = 15
K = 120
Ca = 400
Mg = 160

Soil reaction (K Cl) : pH = 5,0

Soil fumigation : Nil

Fertilizer applied (kg/ha).

Month	Method	N	P	K	$FeSO_4$	$ZnSO_4$
Jan. 1969	basal leaf	63	15	40		
Feb.	foliar spray	21			12	2
March	" "	13			7	2
April	" "	18			10	2
May	" "	19			10	2
June	" "	21			11	2
July						
Aug.						
Sept.						
Oct.	foliar spray	21			9	2
Nov.	basal leaf	74	10	52		
Dec.	foliar spray	45			9	1
Jan. 1970	" "	45			9	2
Feb.	basal leaf	74	10	52		
March	foliar spray	22			8	1
April	" "	25			8	1
Total		461	35	144	93	17

Plantation W1: Third cycle pineapples, replanted to slips December, 1968.

Soil analysis (p.p.m.) : P = 30
K = 190
Ca = 320
Mg = 120

Soil reaction (K Cl) : pH = 4,7

Soil fumigation : Mixture of D-D and DBCP.

Fertilizer applied (kg/ha).

Month	Method	N	P	K	$FeSO_4$	$ZnSO_4$
Feb. 1969	basal leaf	57	15	36		
March	foliar spray	21			12	2
April	" "	13			8	2
May						
June						
July	foliar spray	14			8	2
Aug.						
Sept.	foliar spray	28			11	2
Oct.	" "	28			11	2
Nov.	basal leaf	66	9	47		
Dec.						
Jan. 1970	foliar spray	28			11	2
Feb.	basal leaf	66	9	47		
March	foliar spray	28			11	2
April	basal leaf	66				
May	foliar spray	35			9	1
Total		450	33	136	81	15

Plantation W6: Third cycle pineapples, replanted to slips November, 1969.

Soil analysis (p.p.m.) : P = 12
K = 150
Ca = 380
Mg = 160

Soil reaction (K Cl) : pH = 4,6

Soil fumigation : Mixture of D-D and DBCP.

Fertilizer applied (kg/ha).

Month	Method	N	P	K	$FeSO_4$	$ZnSO_4$
Dec. 1969	basal leaf	28	8	18		
Jan. 1970	foliar spray	10			5	1,0
Feb.	basal leaf	92				
March	foliar spray	10		9	8	1,5
April	" "	10		9	8	1,5
May						
June	foliar spray	10		9	8	1,5
July	" "	7		7	5	1,0
Aug.	" "	16		7	7	1,0
Sept.	" "	20		9	8	1,5
Oct.	basal leaf	28	8	18		
Nov.	foliar spray	20		9	8	1,5
Dec.	" "	41		9	8	1,5
Jan. 1971	" "	41		9	8	1,5
Feb.	" "	41		9	8	1,5
March	" "	41		9	8	1,5
April	" "	41		9	8	1,5
Total		456	16	140	97	18,0

3. RESULTS AND DISCUSSION.

i) Plant growth.

The mean weights of the plants samples each month are given in Table 63. The general pattern of growth in the three plantations was very similar (Fig. IV). Steady growth took place up to May, after which little growth was recorded before November, the mean plant weights for the three plantations C11, W1 and W6 being 0,92; 0,78 and 1,09 kg during May and 1,21; 1,06 and 1,22 kg during October. In fact losses in average weight were found during the winter months in the tops from plantation C11, where the weights were 1,10 kg in June and 1,02 kg in August. This loss of weight was most likely due to considerable leaf dieback of the older leaves which was generally evident during the winter months (Plate VIII). From November, however, the plants increased in weight until flower differentiation during the following May, after which

no further increases were recorded. The respective weights were 1,50; 1,18 and 1,49 kg during November and 3,32; 3,40 and 3,10 kg during May for plantations C11, W1 and W6 (Table 63, Fig. IV).

The relative growth rates (RGR), determined by the formula

$$\frac{\log_e W_2 - \log_e W_1}{t_2 - t_1}$$

being applied to the increases in total plant weight for the three plantations are presented in Fig. V. The mean RGR for the three plantations indicates a steep decline between February and June and an increase between August and February of the following summer, the June, July, August period showing little or no growth. From February to flower differentiation in May the growth rate again slows down.

The RGR of pineapple calculated from total leaf weight increases was found to rise steeply from the fourth month from planting to a peak between the sixth and seventh month and drop gradually to the tenth month by Tay et al (1971) in studies in Malaya. Malaya which is situated about 5°N has very small variations in temperature when compared with the local pineapple growing areas which are situated as far South as 33° 30'S. The mean temperatures for Malaya and Bathurst are $25,6^{\circ}$C and $16,2^{\circ}$C respectively (Table 1), which result in comparatively slower growth under local conditions and a longer period to maturity. While the nett assimilation rate (NAR) was not determined, it was found to follow the RGR very closely in Malaya (Tay et al, 1971). The NAR was found to increase rapidly to the fourth month from planting because light was not a limiting factor due to lack of shading of the lower leaves by new leaves. The NAR was found to be maintained for ten months under Malayan conditions. Since the NAR and RGR are inter related it is possible that not only falling temperatures but also the shortening of daylight hours during winter affect the RGR of pineapples grown under local conditions.

When the mean RGR for the three plantations is graphed against the mean monthly temperatures for Bathurst, the

effect of temperature on the RGR can be clearly seen (Fig. VI). The rate of growth falls with temperature to the lowest point in about July but the increase in RGR appears to lag behind the increase in mean monthly temperature as the season progresses. This lag in the growth rate could be caused by the lack of uptake of nutrients during the period of low temperatures. The increase in RGR continues to February after which it drops again with temperature.

From graphs of the results of other as presented by Sanford (1961), it would appear that the threshold temperature for pineapple plant growth was 8,1°C as no leaf or root elongation was measured below this temperature. Sanford (1964) however, suggests that no significant growth takes place below 20°C. Since temperatures below 8,1°C are recorded locally between June and October (Table 5), there are possibly times when growth ceases altogether. The mean monthly temperatures for Bathurst are below 20°C from April to November and the mean monthly maximum temperature is below 20°C during July (Table 5), suggesting that only limited growth would take place during this period and that virtually no growth would take place during July. Of course, one would expect times when considerable growth could take place during this period as the temperature fluctuates considerably and warm spells are experienced periodically throughout the winter. From the plant weights (Table 63), very little increase in weight was recorded between June and August indicating that the plant growth was negligible. In fact the plant weight records show relatively little increase between June and October during which period the mean monthly temperatures were below 17°C (Table 6). From these observations, it would appear that a mean monthly temperature of 17°C is critical for the growth of the pineapple plant and that temperatures below this are inadequate for "significant" growth.

The tops planted in virgin soil (C11) grew faster initially than slips on old soil (W1), but the eventual weight of the slips was slightly higher (3,40 kg) than that of the tops (3,32 kg). The plant growth, as indicated by the final plant weight, thus showed that plants can be grown as well on

old soil as on virgin soil. The slower initial growth of the slips (W1) can be accounted for by the fact that they were planted a month later than the tops (C11). Another factor which must be considered is that because of the late planting, the slips received less nitrogen (91 kg N) up to June than the tops (155 kg N). The nitrogen applications are considered because of the known effect of nitrogen on vegetative growth (Py et al, 1956). Being planted a month earlier the following season and also having had more nitrogen (160 kg N) during the early stages, the slips in W6 also grew faster initially than the slips planted in W1. The growth in W1 was, however, better during the second summer and the final mean plant weight (3,40 kg) was considerably higher than that in W6 (3,10 kg). The earlier planting (W6) would normally have been expected to result in larger plants as experiments in Hawaii have shown this to be the case (Sanford, 1961).

This difference in growth during the second period could be attributed to differences in temperature between the two seasons affecting these stages of growth. The average of the monthly mean temperatures for the latter 12 months of growth for W1 was 19,0°C, while it was 17,8°C for W6 (Table 64). The increased growth of the plants in W1 could be due to the higher levels of nitrogen (359 kg N) applied during this latter period when compared with C11 (306 kg N) and W6 (296 kg N). This, however, does not explain why C11 should attain a higher mean plant weight (3,32 g) than W6 (3,10 g), particularly as slips generally produce larger plants than tops as they are larger at the time of planting (Sanford, 1961; Mitchell, 1962). The growth pattern of the tops planted in 1968 (C11) and the slips planted in 1969 (W6) was more similar than that of the tops in C11 and the slips of W1, which were planted during the same year (Fig. IV). The fertilizer applications and planting time were the same for C11 and W6 which would account for this similarity. The main difference is that less growth took place in W6 than in C11 during the latter 12 month period, indicating that seasonal differences were responsible for the growth differences. This once more indicates that the lower temperatures experienced during the

second summers' growth of W6 was responsible for the slower growth and final low plant weight at differentiation when compared with the growth of tops in C11 and slips in W1.

(ii) D-leaf weights.

The mean weights of 80 D-leaves from the three sampling areas are presented in Table 65.

The D-leaf weights were not as regular as the plant weights and their increase in weight in different plantations showed different trends (Fig. VII). The general trend was an increase in leaf weight to about June (54 and 42 g) in plants from C11 and W6, after which the weights varied from month to month, showing a loss of weight between November (58 and 59 g) and February (57 and 54 g), followed by an increase to differentiation in May (71 and 72 g). The D-leaves from W1 on the other hand, increased in weight up to September (50 g) before levelling off in growth to December (48 g) and then increasing again to May (74 g). The growth of D-leaves followed a closer pattern in plantations C11 and W6 which were planted in different years (Fig. VII) than in plantations C11 and W1 which were planted in the same year. A possible explanation for these differences is that C11 and W6 had similar nitrogen applications and were both planted during November while W1 was planted during December. As will be seen, there is a correlation between D-leaf weight and plant weight thus the same arguments used for plant weight differences hold good for D-leaf weight differences.

A close correlation between D-leaf weight and plant weight was found during the period February to November, after which the correlation became more indefinite (Fig. VIII, IX, X). Positive correlations of 0,8036; 0,8908 and 0,8403 were found for plantations C11, W1 and W6 respectively. Between December and June, the correlations were 0,6483; 0,6038 and 0,5546 respectively. From these results it would appear that the increase in D-leaf weight was not in the same proportion as the increase in plant weight after November. The larger plants did not have proportionately heavier leaves and there was also much more variation between plant weight and

corresponding D-leaf weight after November when the mean D-leaf weight had reached 60 g.

When the relative growth rates calculated from total plant weights and total D-leaf weights are presented graphically this assumption is more obvious (Fig. XI). The mean RGR based on plant weight and that based on D-leaf weight is very similar to June and comparable to November after which they become more divergent. Whereas the RGR of the plants based on total plant weight increased between August and February of the second summer, that based on D-leaf weight continues to decline indicating that plants above a certain weight do not have leaves increasing proportionately in weight. Similar findings are reported by Sanford, (1961) on D-leaf weight/plant weight correlations in Hawaii where there is a good correlation until the D-leaves weigh between 60 and 70 g, after which the plant weight tends to increase without a corresponding D-leaf weight increase.

iii) Leaf nutrients.

The results of leaf analysis of samples taken monthly in plantations G11, W1 and W6 are presented in Tables 66, 67 and 68 respectively. The seasonal trends in concentration of the ten elements analysed for are illustrated in Figures XII-XXI. With few exceptions the concentration of elements reach a peak in about March of the first summer then fall rapidly to September after which there is an increase to the following February/March and a further sharp decline after differentiation in about May.

The fall in the concentration of nutrients after March would in part be due to the ageing of the plant as reported by Sanford (1961), but in the main due to low temperatures which affect the uptake of nutrients. With the translocation of nutrients to other parts of the plant without replenishment because of lack of uptake due to low temperatures, the concentration in the leaves would be expected to drop sharply. Sanford (1961) maintains that nutrients applied at temperatures below 23,7°C would be of little value to the plant. This would mean that there would be

no beneficial effect from the application of nutrients after April and before December if one considers the mean monthly maximum temperatures for Bathurst (Table 5). If the mean monthly temperatures are considered, then applied nutrients would be of little value at any time as the highest means are below 23,7°C (Table 5). On the other hand, according to Sanford (1964), Noffisinger in 1961 found that leaf temperatures in sunlight under Hawaiian conditions were 5°C above the air temperatures. As the local pineapple growing areas experience considerable sunshine, one would often expect leaf temperatures to be above 23,7°C, particularly during the period from November to April, which in fact coincides with the period during which the leaf concentrations of nutrient are found to be at relatively high levels (Tables 66, 67, 68). From these observations and those on plant growth, the applications of nutrients could well be restricted to this period.

The nitrogen concentration from samples drawn from the three plantations C11, W1 and W6 reached the highest level in the March (2,39; 2,28 and 2,65%) of the first summer. Thereafter there was a steady drop until about September when some of the lowest concentrations were recorded (1,12; 1,46 and 1,20%), after which a slight rise was recorded during the following summer. The rise was most marked in C11 where concentrations of nitrogen were much higher than those for W1 and W6 during the period January to May. The highest readings during the second period for the three plantations were 2,13% (C11) during February; 1,67% (W1) during January and 1,41% (W6) during January (Fig. XII). The local seasonal variations in the concentration of leaf-N differ from those found in Hawaii. Nightingale (1942 (a)), found that the leaf nitrate content increased initially and could be maintained at a high level until near flower differentiation. The relatively large amounts of nitrogen applied as basal leaf applications during January/February of the first summer and in November and February of the second summer did not result in an expected marked increase in leaf-N as reported by Sameuls et al (1955), who found that basal leaf applications of nitrogen greatly increased leaf-N

three to four months after application. The difference in findings could be due to the supplimentary applications of nitrogen applied as foliar sprays, which may have masked the effects of basal leaf applications to some extent.

The potassium concentration for plantations C11, W1 and W6, reached some of the highest levels in March of the first summer (5,53; 6,32 and 6,16%) and the lowest levels in September, (1,84; 2,56 and 1,47%). There was an increase to the following March (3,48; 2,58 and 2,33%) after which there was a sharp rise in concentration to May in plantations C11 and W1 (5,14 and 4,75%). This may have been due to a 52 and 47 kg/ha basal leaf application of sulphate of potash applied to plantations C11 and W1 at the end of February, assuming that it would take three to four months before the leaf-K concentration was affected by basal leaf applications (Sameuls et al, 1955). This effect was not found with the basal leaf applications of potassium applied during November or the previous January which makes it difficult to explain the high concentrations found in May.

The effect of temperature on leaf concentration of nutrients is again evident as the levels of leaf-K during the second summer were lower in W6 than in C11 and W1, the temperatures being lower during the 1970-71 summer than the previous year (Fig. XIII; Tables 66, 67, 68). In contrast to local findings, the potassium concentration of the leaves in Hawaii remains about the same for the first nine months of growth, after which there is a fairly steep drop to differentiation at 13 to 15 months (Sanford, 1961).

The trends in concentration of phosphorus are similar for plantations C11 and W6 with high concentrations in March (0,245 and 0,307%) falling to lowest in August - October period (0,115 and 0,142%) and rising to reasonably high levels in the January - May period (0,257 and 0,254%) of the second summer before falling off again. In the case of C11, the concentration during the second summer (0,257%) was higher than that recorded during the first summer (0,245%). The concentration of phosphorus reached an initial high point in June (0,226%) and the lowest point in September (0,144%) in

samples from W1. The phosphorus level then rose to the highest levels during December and January (0,275%) of the second summer, after which the concentration again fell. In all plantations the concentration of phosphorus dropped after May of the second summer, i.e. at flower differentiation (Fig. XIV). It is doubtful whether there were any responses to applied phosphorus as W6 which had the lowest soil level (12 p.p.m. P) and the lowest total application (16 kg P), had higher leaf-P levels initially and subsequently very comparable concentrations to those of the other two plantations. This result may have been anticipated as the Hawaiian response levels (Table 2) indicate no response to applied phosphorus at levels above 12 p.p.m. in the soil. Sanford (1961) reports that the phosphorus level tends to increase with the ageing of the plant in contrast to the decreasing concentration of other elements. In Hawaii the leaf-P concentration increases rapidly during the first nine months of growth after which there may be a gradual decline to flower differentiation at the age of 13 to 15 months (Sanford, 1961). This seems to be supported to some extent by local findings as there are no great differences in concentrations between the first and second summers. It would appear from the results that the phosphorus level in the leaf might be maintained if it was not for the low temperatures during winter. The marked fall off in concentration of leaf-P during the winter months is thus once more most likely due to the low winter temperatures experienced under local conditions.

The calcium concentration was highest in February (1,080 and 0,970%) of the first summer and lowest in August and September (0,188 and 0,272%) for C11 and W1, rising again during the second summer (0,700 and 0,673%) and falling after April. The lowest concentrations were recorded in December (0,068%) in samples from W6, otherwise the same general pattern of an initial dropping off during the winter then rising again late in the second summer was found (Fig. XV). These variations in leaf-Ca concentrations differ from those in Hawaii in that leaf-Ca levels remain high during the first four months of growth after which there is a steady drop to differentiation (Sanford, 1961).

The magnesium concentrations dropped from February (C11 0,374%; W1 0,434% and W6 0,728%) to low levels during spring (C11 0,137%; W1 0,158% and W6 0,156%), after which they rose steeply particularly in plantations C11 and W1 to the highest levels recorded in the following May (0,640% and 0,695% respectively), after which they dropped very sharply (Fig. XVI). Magnesium concentrations in Hawaii have been found to drop from the initial analysis, whether magnesium was applied or not (Sanford, 1961). The marked rise in concentration during the second summer to levels above those of the first summer under local conditions without application of the element was thus not anticipated.

Manganese concentrations in C11 were very low (below 117 p.p.m.) and showed little seasonal variation. In W1, the level dropped from March (461 p.p.m.) to June (118 p.p.m.) and continued at a low level. In W6 on the other hand, where far higher concentrations were found, high readings were recorded up to April (955 p.p.m.) of the first summer after which there was a drop during the winter months to 166 p.p.m. followed by a steep rise the following summer to a peak in February (805 p.p.m.) and thereafter a second decline in concentration (Fig. XVII). It would appear from these results that when an element is in short supply and this condition is not corrected, the normal seasonal trends of increased concentrations during the second summer are not experienced.

The concentration of iron fluctuated from month to month but the general trend was a high level to April (C11 31,3 p.p.m.; W1 26,8 p.p.m. W6 37,5 p.p.m.) of the first summer followed by a gradual drop to the August - November period (C11 13,2 p.p.m.; W1 14,2 p.p.m.; W6 13,5 p.p.m.) and a slight rise the following summer with a final fall off in concentration after April (Fig. XVIII). The more regular applications of iron to W6 (12 sprays) compared with C11 (10 sprays) and W1 (8 sprays) did not appear to alter the monthly variations in leaf-Fe concentration (Tables 66, 67,68). These fluctuations in concentration could be due to the fact that iron was applied irregularly at monthly intervals and should have been applied at shorter intervals and more regularly to

achieve more uniform leaf-Fe concentration trends. Sanford (1961) found that even fortnightly sprays of ferrous sulphate did not eliminate iron deficiency symptoms entirely, indicating that monthly applications could not be expected to result in uniform leaf-Fe concentration.

The zinc concentration in W6 was highest in February (72,7 p.p.m.) and lowest in September (12,3 p.p.m.) with a slight rise the following summer. In plantations C11 and W1, the zinc levels were initially low (<22 p.p.m.) and remained low until the second summer where they rose above those of W6 (C11 31,4 p.p.m.; W1 33,5 p.p.m.; W6 25,1 p.p.m.) before dropping again (Fig. XIX). Although no visual symptoms of zinc deficiency were noticed, it is possible that plantations C11 and W1 were initially deficient in zinc and that the application of zinc satisfactorily improved the leaf-Zn concentration by the second summer.

The concentration of copper did not show marked seasonal variations, but there was a general trend following the pattern of the other elements, i.e. a drop during the winter months and a rise during the second summer followed by a second decline (Fig. XX).

The amount of sodium in the D-leaves was relatively high during the first summer, but dropped to a low value during the winter. Unlike the other elements the sodium concentration did not increase during the second summer (Fig. XXI).

4. CONCLUSIONS.

Temperature has a profound effect on the growth of pineapples under local conditions. Unlike the continuous growth experienced in Hawaii for example, the plants grow rapidly during the summer months and almost stop growing during the winter months. From the results it would appear that a mean monthly temperature of 17°C is critical for the growth of the plant and that growth is very slow during the May - October period when mean monthly temperatures are below 17°C. The greatest increase in plant growth takes place during the second summer and growth ceases at flower differentiation for the plant crop. The RGR of the plant, which shows

a steady decline with falling temperatures after the first summer to the lowest point in mid winter and a subsequent rise during the second summer, differs from that described by Tay et al (1971) for pineapple plants grown in Malaya.

The increase in the weights of D-leaves is found to vary with temperature, slowing down during winter and almost ceasing by early spring. Losses in D-leaf weight can be recorded during the winter because of the adverse weather conditions which are experienced. D-leaf weights which are considered as giving a good indication of plant weights can only be recommended for plant weight estimation during the first twelve months after planting because the correlation between D-leaf weight and plant weight is not good after this period.

Leaf nutrient concentrations show very marked seasonal trends. In general the nutrient levels are highest towards the end of the first summer, lowest at the end of the first winter, high again during the second summer and drop off after flower differentiation in May. The nutrient concentrations decline as the temperature drops, irrespective of whether nutrients are applied or not. These findings differ from these of workers in Hawaii where nutrient concentrations, with the exception of phosphorus, tend to drop as the plant ages and do not show marked seasonal fluctuations (Sanford, 1961). The fluctuations in iron concentration in the leaves indicate that iron should be applied more frequently than at monthly intervals in order to overcome deficiencies and so produce more uniform levels in the leaf. There are also indications that where the zinc level is low it should be corrected by applying more zinc in the early stages of growth.

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CHAPTER V.

SUMMARY OF RESULTS AND CONCLUDING REMARKS.

1. SOIL FUMIGATION.

The application of soil fumigants for the control of plant parasitic nematodes resulted in marked increases in plant growth and yield, affecting the uptake of nutrients and their concentration in the plant as well. Genera of plant parasitic nematodes identified in soil samples taken from time to time were: Helicotylenchus, Meloidogyne, Trichodorus, Pratylenchus, Paratylenchus, Aphelenchoides, Rotylenchus and Xiphinema. Of these, Helicotylenchus sp. occurred in all samples from unfumigated plots in very high numbers, often in excess of one thousand per 100 ml soil. Meloidogyne sp. was also found in all untreated samples while Trichodorus sp. occurred sporadically but more frequently than the other genera.

Mixtures of D-D and DBCP effectively reduced populations of Helicotylenchus and Meloidogyne when applied at rates of 22,5 l DBCP + 269,6 l D-D/ha, while rates of 22,5 l DBCP + 179,7 l D-D/ha were not particularly effective in controlling Helicotylenchus sp. D-D applied at 449,3 l/ha was found to control both genera effectively. The application of 44,9 l/ha DBCP applied before planting was not effective in the control of Helicotylenchus while rates of 56,2 l/ha and higher were effective. A mixture of 33,7 l DBCP + 449,3 l D-D/ha applied before planting followed by a post planting application of 33,7 l DBCP/ha one year later effectively reduced plant parasitic nematode populations for more than three years.

Although the application of soil fumigants resulted in increases in plant crop yields, far greater increases in ratoon crop yields were obtained. Of the fumigants applied, D-D and mixtures of D-D and DBCP applied as preplanting applications resulted in the largest increases in yield. DBCP applied before planting at rates below 44,9 l/ha had no significant effect on yield. The application of DBCP as a post planting treatment led to significant increases in yield

in one trial but was found to be ineffective in another. A preplanting application of EDB at rates of up to 112,3 l/ha did not result in increased yield. Subsequent research has, however, shown EDB to be effective in the control of nematodes and yield increases similar to those obtained with D-D have been found.

Soil fumigation resulted in an improved root growth and a marked increase in plant growth and development. The effects of soil fumigation alone on plant growth were far more marked than the effects of applied nutrients or nutrient combinations applied in the absence of fumigation. The increased plant growth experienced as a result of fumigation led to earlier fruiting in both the plant and ratoon crops. While the number of slips produced was sometimes increased and sometimes decreased, the number of suckers was significantly increased, a factor which subsequently resulted in increased ratoon crop yields.

Soil fumigation was found to decrease the total soluble solids of the fruit, increase its density, lower the sugar content and have no effect on acidity. It decreased the soil reserves of phosphorus, potassium and magnesium, indicating a better uptake of these nutrients by the plant. The concentrations of phosphorus, calcium, magnesium and manganese in the basal white portion of the D-leaves were increased, again indicating a better uptake of these nutrients, probably the direct result of better root development following the application of soil fumigation. The leaf-K concentration as indicated by leaf analysis at the time of flower differentiation for the plant crop was not affected, while it was reduced in the analysis at the time of flower differentiation for the ratoon crop. The leaf-N concentrations were found to be affected in the same way as the leaf-K concentrations. It is thought that the application of nitrogen and potassium had been inadequate for they failed to maintain their leaf levels following soil fumigation.

The necessity for the application of soil fumigants to ensure successful cultivation of pineapples cannot be over emphasized. The need for adequate application under suitable

conditions is very important for if insufficient fumigant is applied no benefits will be obtained and if adverse soil conditions prevail at the time of application negative results can be expected.

2. APPLIED NUTRIENTS.

Applied fertilizers resulted in increased plant growth and yields, the increases in the ratoon crop being substantially greater than the increases in the plant crop. The numbers of suckers and slips produced were also affected by the nutrients applied. Nutrients such as nitrogen, phosphorus and potassium which can be applied either to the soil as a preplanting application; to the basal leaves in the dry form or as foliar sprays were found to have little or no effect on yield when applied in the different ways. Nitrogen applied to the basal leaves in the form of sulphate of ammonia resulted in increased plant crop yields but this effect was not significant when the total yields were considered. There were indications of improved yields in other trials as well, when nitrogen was applied in the dry form as sulphate of ammonia as opposed to foliar sprays of urea. Practical reasons such as the inability to apply fertilizers to the basal leaves in the dry form mechanically and increasing labour costs for applying by hand, would tend to offset any advantages of this method of application. The basal leaf application of sulphate of potash had a delayed effect and was found to increase the ratoon crop even though all the potassium was applied prior to flower differentiation for the plant crop. The overall effect of this method of application of sulphate of potash did not result in significant yield increases. The different methods of applying fertilizer was found to have no effect on the number of suckers or slips produced.

i) Nitrogen.

Nitrogen, which is generally recognised as being required in large amounts by the pineapple plant was applied at two levels, a higher level (1120 kg N/ha) which was similar to that generally recommended for commercial production, and a lower level (560 kg N/ha). Results indicated that the lower

level was adequate during the early stages of plant growth and the higher level, which resulted in increases in ratoon crop yields but not in plant crop yields, sufficient for the later stages of growth. The higher rate of application delayed both the plant and ratoon crops and decreased the total soluble solids of the fruit. No other effects on fruit quality were detected. The higher rate also increased the leaf-N concentration in samples taken after flower differentiation for both the plant and ratoon crops. Increased nitrogen application decreased the leaf-Fe concentration in samples taken after flower differentiation for the ratoon crop.

ii) Phosphorus.

The application of phosphorus in the form of superphosphate resulted in increased ratoon crop yields when applied at a rate of 74 kg P/ha where the available soil-P was 4 p.p.m. A depressing effect on plant crop yields was encountered when 56,0 kg P/ha was applied where available soil-P was 10 p.p.m. The only other effect of applied phosphorus was a slight increase in plant growth after two years from planting and an increase in the total soluble solids of the fruit. The concentration of leaf-P was increased in samples taken after differentiation for both the plant and ratoon crops indicating uptake of the additional phosphorus. The application of phosphorus also increased the concentration of leaf-Ca in samples taken after differentiation of the plant crop and decreased leaf-Mn concentration in samples taken after differentiation of the ratoon crop.

The application of 56,0 P/ha resulted in an increase in available phosphorus in the soil as indicated by soil analysis after the pineapple cycle i.e. four and a half years after application. Applied phosphorus was thus found to remain available for long periods in the particular soils on which the experiments were conducted. Indications are also that the plant requirements for phosphorus are relatively low.

iii) Potassium.

Increased potassium applications of 191 to 308 kg

K/ha did not lead to increased yields under conditions of relatively low available soil-K (66 p.p.m.) Potassium applied at a rate of 336 kg K/ha did not result in yield increases when the initial soil-K level was 210 p.p.m. This application increased the D-leaf weight and resulted in a slight increase in overall plant weight by the end of the growth cycle. It resulted in a decrease in the number of suckers and an increase in the number of slips. It had no effect on the plant crop but delayed the harvesting of the ratoon crop. The only observed effect on fruit quality was an increase in acidity.

Applied potassium resulted in increases in leaf-K concentration in samples taken after differentiation for both the plant and the ratoon crops. It resulted in significant decreases in the concentrations of calcium and magnesium in the leaves because of the antagonistic effect it has on the uptake of these nutrients. Applied potassium was found to increase the leaf-Fe concentration in samples taken after differentiation for the ratoon crop. The available potassium in soil was reduced from 210 p.p.m. to 57 p.p.m. in samples taken from the root zone by the end of the cycle, even after the application of 336 kg K/ha.

iv) Iron.

Iron applied as foliar sprays of ferrous sulphate at monthly intervals to give a total application of 39,2 kg Fe/ha increased root weight slightly and D-leaf weight considerably. It also resulted in an increase in plant weight by the end of the cycle, increased the number of suckers produced but had no effect on the number of slips. Applied iron also increased fruit yields but did not affect the time of harvesting. It resulted in an increase in the total soluble solids and the sugar content of the fruit.

Applied iron was found to increase the leaf-Ca concentration in samples taken after flower differentiation for the plant crop and to decrease the leaf-P in samples taken at flower differentiation for the ratoon crop. It was found to increase the level of leaf-Fe concentration in samples taken after differentiation for the ratoon crop. There were indications that the application of iron at

monthly intervals was not sufficiently frequent to overcome deficiencies in this nutrient, particularly in the early stages of growth.

v) Zinc.

Zinc applied monthly in foliar sprays as zinc sulphate to give a total application of 6,3 kg Zn/ha resulted in small increased in plant weight and significant increases in fruit yields. Applied zinc increased the number of suckers and decreased the number of slips produced. It resulted in earlier fruiting of both the plant and ratoon crops while it had no effect on fruit quality. Applied zinc also resulted in an increase in the leaf-Zn concentrations in samples taken after flower differentiation of both the plant and ratoon crops. There were no other effects except for a slight decrease in the leaf-K concentration in samples taken after flower differentiation for the ratoon crop. There were indications that zinc should be applied in larger quantities during the early stages of growth, particularly where leaf analysis showed the concentrations of zinc to be low.

3. INTERACTIONS.

Some of the more important interactions which were found to affect a number of factors are presented below.

i) Fumigation X Nitrogen.

When fumigation and high nitrogen (1120 kg N/ha) were applied together they resulted in increased in D-leaf weight, plant weight and the number of suckers produced. The crops were advanced more when fumigation was applied in the presence of high nitrogen (1120 kg/ha) . than when applied in the presence of low nitrogen (560 kg/ha). When fumigation was applied with high nitrogen the leaf-K concentration was decreased, probably because of the increase in growth experienced when these two factors were applied together.

ii) Fumigation X Potassium.

Potassium applied at a rate of 336 kg K/ha in the absence of fumigation resulted in an apparent increase in

available soil-P. When fumigation and potassium were applied together there was a decrease in available soil-P, probably due to a greater uptake of phosphorus. The soil-K level was decreased by a greater amount when potassium was applied without potassium. There was thus a greater uptake of potassium from the soil when potassium was applied in the presence of fumigation. In samples taken after differentiation for the plant crop, leaf-K was increased more when fumigation was applied together with potassium than when potassium was applied in the absence of fumigation. Fumigation in the absence of applied potassium decreased leaf-Mn in samples taken after flower differentiation for the plant crop while it increased leaf-Mn when potassium was also applied. The latter effects were not significant in samples taken after flower differentiation for the ratoon crop.

iii) Fumigation X Iron.

The increase in D-leaf weight at one year was greater when fumigation was applied in the absence of applied iron than in the presence of applied iron. Similarly the plant weights at one year were found to be increased more by fumigation in the absence of applied iron than when iron was also applied. The number of slips produced was decreased when fumigation and iron were applied together.

From observations made in the field, iron deficiency symptoms tend to disappear when soil fumigation is applied. As already intimated the applications of iron in the early stages of growth were probably inadequate as shown by the lack of response in the early stages. The fact that the applied iron tends to reduce plant growth when the soil is fumigated does not, however, indicate a deficiency of this nutrient, but perhaps the opposite. Smith (1963) found that soil fumigation did not result in a greater uptake of iron from the soil but that it appeared to improve the utilization of iron within the plant. Further studies are thus required to determine the effects of soil fumigation on the iron requirements of the plant, particularly in the early stages of plant growth.

iv) Potassium X Zinc.

The sugar content of the fruit was increased slightly when both potassium and zinc were applied. The fruit acidity was not affected by potassium in the absence of zinc while it was increased when zinc was applied with potassium. Zinc applied in the absence of potassium also increased fruit acidity.

Potassium applied in the presence of zinc increased the leaf-K level more than when potassium was applied in the absence of zinc. Both leaf-Ca and leaf-Mg concentrations were decreased when potassium and zinc were applied in the absence of each other. When applied together they did not affect the levels of either element in the leaf in samples taken at flower differentiation for the ratoon crop.

v) Phosphorus X Zinc.

Both phosphorus and zinc applied in the absence of each other had no effect on plant crop yields, while in the presence of each other they resulted in highly significant increases in yield. In the leaf analysis of samples taken after flower differentiation for the plant crop both phosphorus and zinc applied in the absence of each other had no effect on the leaf-Fe concentration while when applied together they increased it highly significantly. The same interaction was found in samples taken after flower differentiation for the ratoon crop when considering leaf-Zn concentration. Applied zinc thus only increased the leaf-Zn concentration when phosphorus also was applied. The overall effect of applied zinc on the leaf-Zn concentrations was thus due to increases obtained in treatments where phosphorus was also applied. In the absence of phosphorus, zinc did not increase the concentration of leaf-Zn.

The depressing effect of applied phosphorus on yields could possibly be overcome by the application of sufficient zinc applied either together with the phosphorus in the early stages of plant growth. This field requires further study as it is felt that beneficial responses to applied phosphorus may be obtained provided adequate zinc is

also applied as has been shown to be the case with other plants.

4. NUTRIENT CONCENTRATIONS IN D-LEAVES.

Nutrient concentrations determined monthly in the middle third of the basal white portion of D-leaves from plants growing under field conditions showed considerable seasonal variations. The concentrations of ten elements, namely N, P, K, Ca, Mg, Mn, Fe, Zn, Cu and Na were found to more or less follow the same pattern of seasonal variation. The concentrations of nutrients reached a peak in March at the end of the first summer, after which they declined during the winter to reach their lowest levels during September. The concentrations were then found to increase with the warmer weather to a lower peak in February/March of the second summer, then to decline to May when flower differentiation took place, after which they dropped sharply. Indications were that nutrients applied between March and September failed to halt the downward trend in concentrations. It can only be surmised at this stage that nutrients are not taken up by the plant in sufficient quantities below certain temperatures, and that with translocation of nutrients from the D-leaves to other plant parts without replenishment the concentration in the D-leaves falls. The need for considerable research in this field still exists. Apart from the need for determining at what temperature the uptake of nutrients slows down or ceases, it is necessary to determine what happens to nutrients which are translocated from the D-leaves. An analysis of the total plant and plant parts sampled periodically between planting and flower differentiation would be required to determine the movement of nutrients. The quantity of nutrients required by a plant increases as the plant increases in size and applied nutrients are usually given in increaseing quantities. With lower temperatures and consequently slower growth during the winter it is likely that only small amounts of nutrients can be absorbed by the plant. The effects of climatic conditions on the absorption and utilization of nutrients by the plant still have to be determined. By determining the concentration of elements in the plant as a whole and the increase in plant weight with time, the mean

relative uptake of nutrients could be determined under varying climatic condition. Such knowledge would be of considerable practical value in the cultivation of pineapples as it is not known whether nutrients applied under certain conditions are of any benefit at all. The relative quantities of nutrients which can be taken up by the plant are also expected to vary with climatic conditions. In agriculture, the concentrations of nutrients in the leaves of plants are being relied upon to an even increasing extent as indicators of nutrient requirements. The seasonal variations in nutrient concentrations encountered emphasize the need for the establishment of norms at specific periods rather than at certain stages of plant growth. The conditions under which nutrients could effectively be applied to correct deficiencies also have to be determined.

5. PLANT GROWTH TO FLOWER DIFFERENTIATION.

The pattern of plant growth was determined by weighing samples of plants taken at monthly intervals from commercial plantations. Plants planted during November grew at a more or less constant rate until March after which the rate of growth dropped and only small gains in weight were recorded during the next eight months. From November there was a sharp increase in the rate of growth which persisted until flower differentiation in May. Losses in plant weight were sometimes recorded during winter between June and August.

The relative growth rate determined from monthly plant weights was found to decline with temperature after the first summer to its lowest point in mid winter. Thereafter it increased until the middle of the second summer after which it again decreased.

The increase in the weight of D-leaves followed a similar pattern to that of the plant growth with losses in weight being recorded during the winter and increases in weight during the summer months. The increases in plant and D-leaf weights were closely correlated during the first twelve months from planting, after which the correlation became more indefinite.

It would appear from the results that the seasonal variations in plant growth as determined by plant weights and

the seasonal variations in nutrient concentrations as determined by analysis of D-leaves are the direct result of variations in temperature. While temperature is probably one of the most important environmental factors affecting plant growth and nutrient uptake, other factors may also be involved. The RGR and NAR can be considered as being inter-dependent because the RGR of a plant depends mainly upon the NAR which is the rate of increase of dry matter per unit area of leaf. When light is not a limiting factor then there is a steep rise in the NAR which also results in a steep rise in the RGR. Apart from the effect of partial shading of the older leaves by new leaves as the plant grows, the NAR is also affected by the number of hours of daylight. Variations in day length within the tropics are not nearly as great as those experienced under local conditions i.e. at a latitude of $33^{\circ}30'$S. Under these conditions the NAR could be affected considerably and in turn the RGR would be affected. From this one can only conclude that apart from temperature, day length may also affect the growth of pineapples under local conditions. By keeping the temperature constant and varying the lighting under controlled conditions, the effect of day length on the NAR and RGR of pineapples could be determined. The results would indicate whether day length was involved with temperature in determing the rate of growth of the plants under local conditions.

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ANNEXURE A.

PROCEDURE FOR DETERMINATION OF AVAILABLE NUTRIENTS IN SOIL SAMPLES.

The determinations of available nutrients in soil samples were done by courtesy of Messrs. African Explosives and Chemical Industries Ltd. The methods used were based on the recommendations of the Analytical Sub-committee of the Fertilizer Society of South Africa Agronomic Committee and are briefly as follows:

"Soil sample preparation.

The sample is air dried if damp, then crushed to pass a 2 mm sieve and mixed thoroughly. Care must be taken to break up only the soil aggregates and not any stones which may be present.

PREPARATION OF SOIL EXTRACTS.

Preparation of Bray extract.

A weighed amount of soil is extracted by shaking it for 40 seconds with the Bray No. 2 extracting solution consisting of a 0,03 N solution of ammonium fluoride in 0,1 N hydrochloric acid, at a soil/extractant ratio of 1:7,5. Charcoal is added to the suspension to remove the interfering organic acids and to decolourise the extract. This Bray procedure extracts acid soluble and adsorbed phosphates, the extract being used for the determination of phosphorus.

Preparation of neutral ammonium acetate extract.

A weighed amount of soil is extracted by shaking it for 2 hours with a N ammonium-acetate solution of pH 7,0 at a soil/extractant ratio of 1:10.

By this procedure the adsorbed and ammonium acetate soluble cations Na, K, Ca, Mg, etc. are extracted from the soil.

Determination of Phosphorus (Vanado-Molybdate procedure).

The phosphate content of the Bray extract is determined by measuring the optical densities of the yellow vanado molybdate phosphate complex in comparison with the optical densities of

standard phosphate solutions at a wavelength of 360 - 380 mu. Iron does not interfere at this wavelength as it is complexed by the fluorine present in the Bray solution. Excess fluorine interferes with the formation of the vanado molybdate complex and is complexed by thorium. In order to increase the precision of the optical density reading an additional, fixed amount of phosphate is added to all samples, standard and blank solutions.

Determination of Potassium (By flame photometer).

The available potassium is determined flame photometrically on the ammonium acetate soil extract.

Determination of Calcium (EDTA titration).

The ammonium acetate extractable calcium is determined on a portion of the extract after volatilising ammonium salts, by EDTA titration at pH12 using Calred as indicator.

Determination of Magnesium (Colorimetric titan yellow procedure).

The magnesium content of the ammonium acetate soil extract is determined colorimetrically by measuring the optical density of the red lake formed by magnesium hydroxide in the presence of the organic dye Titan yellow. The optical density of the lake in the soil is compared with that of standard magnesium solutions.

Determination of soil pH.

The reaction of the soil is determined by measuring the pH of a 1:2,5 soil /N-KCl suspension using a pH meter fitted with a glass electrode. Equilibrium between the electrodes and the soil suspension is not attained very rapidly and sufficient time must be allowed for the attainment of equilibrium before taking the pH reading. Equilibrium is attained more rapidly if a ground glass sleeve-type calomel electrode is used."

ANNEXURE B.

PROCEDURE FOR EXTRACTION, IDENTIFICATION AND COUNTING OF NEMATODES.

The extraction, identification and counting of nematodes in soil samples taken from the various trials was done by the courtesy of Messrs. Shell Chemical South Africa (Pty.) Ltd. The method of extraction used was as described by Brown (undated) which is as follows:

"Method

The following actions should be carried out in sequence (1-11):-

Operation 1. (Time 5 minutes)

To remove sand and large soil debris from the sample

1. First mix the soil sample thoroughly, and place 100 cc of the sample into a pan or dish (Pan A).
2. Approximately 400 cc of water is added to the soil in the pan and mixed thoroughly (samples from clay based soils should be well broken up).
3. Hold the pan steady for 3 seconds immediately after mixing, to permit the sand particles to precipitate.
4. The nematodes and silt particles in suspension are then immediately decanted through a coarse sieve (20 mesh to the inch) into another pan (Pan B). Retain the sandy particles remaining in Pan A, but the roots and humus debris caught in the coarse sieve may be discarded.

Operation 1 should be repeated three times. This entails adding a further 400 cc of water to the sandy precipitate in Pan A at the start of each repetition.

The water in the second pan will now contain all the nematodes obtained by four successive decantations from the sample.

Operation 2. (Time 5 minutes)

To remove heavy silt and colloidal particles from the sample

5. The contents of Pan B are mixed carefully by hand to ensure that all nematodes and silt particles on the base of the pan are in suspension.

6. Hold the pan steady for 10 - 12 seconds after mixing to permit the heavy silt to precipitate.

7. Immediately decant the suspension of nematodes and fine silt particles from Pan B onto a fine sieve of 325 mesh per inch where they will be retained. The water passing through the sieve can then be discarded as this contains mainly colloidal particles and no nematodes.

Operation 2. should be repeated twice. Each repetition is initiated by completely filling Pan B with water.

The water passing through the fine sieve after the repetitions must be clear. If it is not then a further repetition should be made.

Operation 3. (Time required 48 hours minimum)

To remove the nematodes from the fine silt

8. The nematodes and fine silt are washed off the fine sieve into a beaker. They are then poured onto a layer of paper tissues* or waxed paper cup+ modified as shown in Diagram 2.

9. Fill the funnel or cup with water until the nematodes and fine silt on the paper are just covered with water.

10. Leave the funnel or cup for at least 48 hours (the level of water should be topped up if necessary after 24 hours). During this period the nematodes are able by their motility and random movements to find the minute gaps in the paper tissue and then pass through them. They then fall to the base of the cup and remain there, leaving the majority of fine silt particles retained on the paper.

11. To remove the nematodes from the paper cup most of supernatant water in the cup be removed. This may be done by pipette or by punching successive small holes of approximately 1/8 inch diameter and 1 inch apart down the surface and end 1 inch above the cup base.

* The quality of paper used is important - paper handkerchief brands "Kleenex" and "Scottie" are amongst those that will be found to be satisfactory. Laboratory filter papers are not as a rule satisfactory for the purpose.

+ Paper cups should be pretested to ensure that they hold water for 48 hours.

Identification of nematodes.

Nematodes that have been extracted from the sample should first be examined under a microscope to establish the presence or absence of a mouth spear or stylet. This spear is used by the nematode to pierce and feed on cell tissues.

All nematodes observed with a spear however are not necessarily parasites of higher plants - some may be parasites of fungi, insects or predatory on other nematodes. Nevertheless, a considerable proportion of spear-bearing nematodes obtained from soil samples will be found to belong to genera known to be parasitic on higher plants.

Counting nematodes.

An estimate of the number of nematodes of each plant parasitic genera present should now be made, using the following technique:-

1. Allow the suspension of nematodes (alive or dead or preserved) to stand for a 2 hour period, so that they settle out of suspension.

2. Remove the supernatant water by pipette, reducing the bulk of the solution to 10 cc.

3. Shake up the suspension of nematodes and pipette an aliquot of 1 cc into the chamber of a nematode counting slide.

4. Count the number of parasitic nematodes of the various genera present in each of three 1 cc aliquots in the counting slide, using a microscope magnification of between 40 and 100. When nematode populations are high, tedious counting can be reduced if the counting of any 1 cc aliquot is terminated when the number of plant parasitic nematodes exceeds 100 - a proportion calculation based on the number of squares on the slide already counted should then be made."

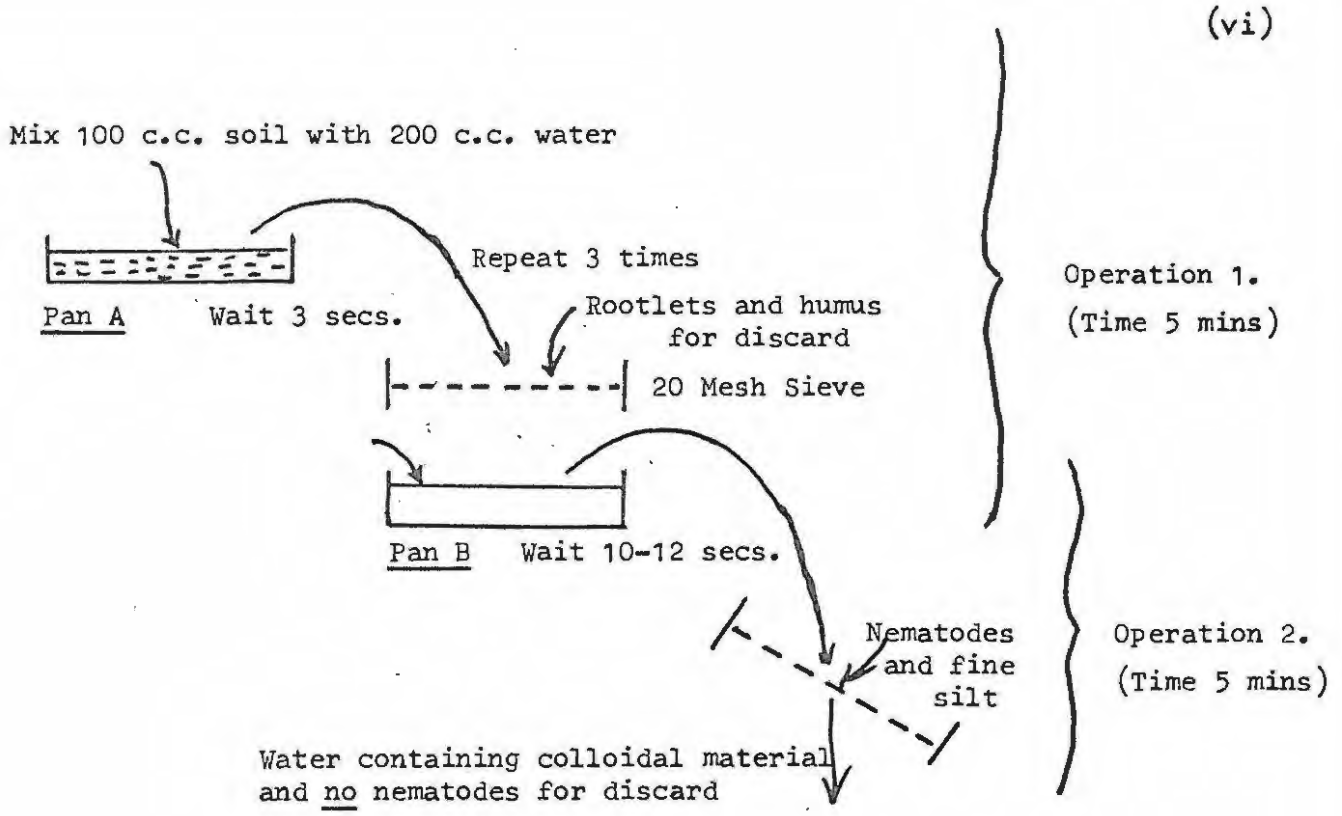
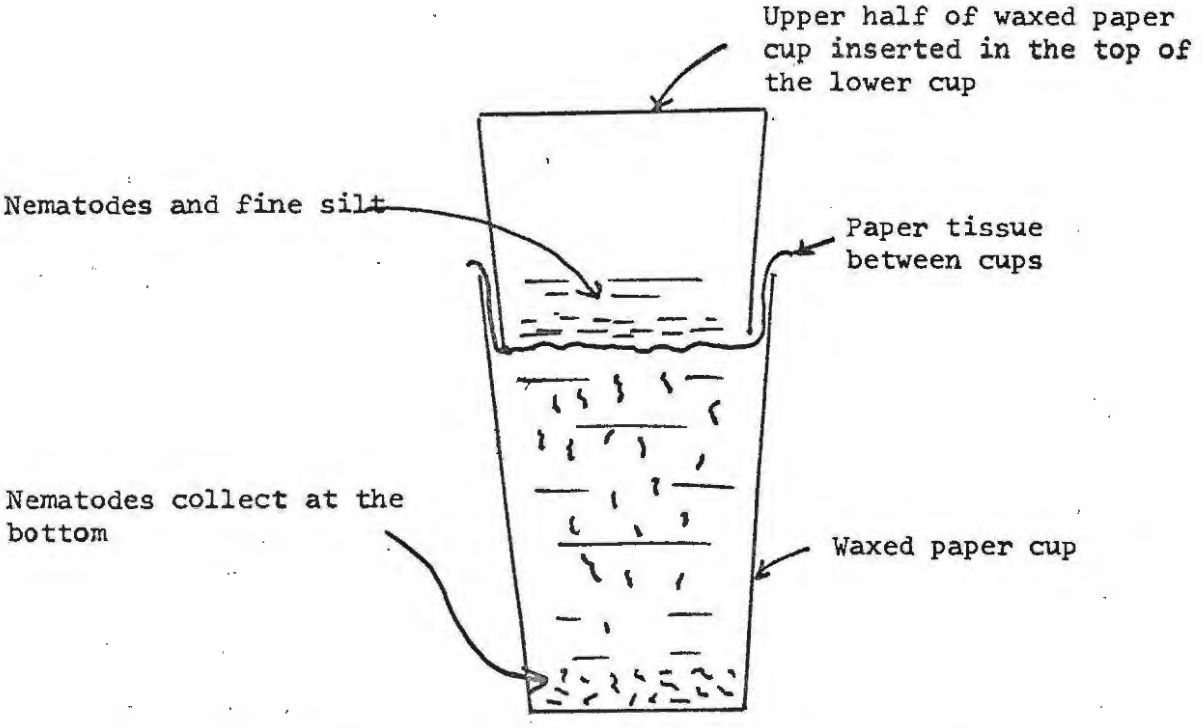


Diagram 1. SEPARATION OF NEMATODES AND FINE SILT FROM A SOIL SAMPLE



Waxed paper cup as an alternative for the Baermann funnel

Diagram 2. SEPARATION OF NEMATODES FROM FINE SILT IN A SOIL SAMPLE

ANNEXURE C.

PROCEDURE USED FOR THE CHEMICAL ANALYSIS OF D-LEAVES OF PINEAPPLE PLANTS.

1. Grinding of leaf material.

A Casella grain mill of internal stainless steel construction fitted with an 0,53 mm sieve was used to grind the samples. The dried leaves were first crushed into pieces in the linen bags and then added slowly to the mill. Each sample was passed through the mill twice and the mill cleaned between samples. The sample was then collected in a glass bottle and oven dried at 65°C for at least five hours i.e. to constant weight. Preliminary trials comparing a mechanical agate mortar and pestle with the casella mill indicated no detectable contamination of minor elements by using the latter. Only a few minutes were required by the Casella mill while one sample took up four hours to grind in the pestle and mortor.

2. Preparation for chemical analysis.

i) Weighing.

A 2,5 gm sample of leaf material was weighed into a tared fused silica dish for ashing. A further 0,1 gm sample was weighed into a 30 ml Borosilicate glass microkjeldahl flask for N determination. Duplicates of each sample were weighed.

ii) Ashing and diluting.

The 2,5 gm samples were then placed in a furnace at 490°C $\pm$ 5°C and ashed for at least five hours, usually overnight. After removing from the furnace the samples were cooled to room temperature, 5 ml conc. H Cl was added, then evaporated to dryness on a water bath at about 90°C for two hours. Five ml of conc. HNO_3 was then added and the sample then stirred with a teflon rod to loosen any materials which may have stuck to the dish. Five to ten ml deionised water was then added before filtering through No 541 Whatman paper into a 50 ml volumetric flask and making up to volume with deionised water. This gave

a 1/20 dilution of the dry leaf material (solution A).

An aliquot taken from solution A was used without further dilution for the determination of Cu, Fe, Zn, Mn and low concentrations of Na.

Five ml of 5% lanthanum solution was added to 5 ml of solution A in a 100 ml flask which was then made up to volume with deionised water. Thus 1/400 dilution of the leaf sample was used for the determination of Ca, Mn and high concentrations of Na.

One ml of solution A was made up to volume in a 50 ml flask with deionised water to give a 1/20000 dilution for the determination of K and Mg.

Five ml of solution A was added to a 50 ml flask together with sufficient HNO_3 to adjust to a $\pm$ 1,0 N acid. After adding 10 ml vanado-molybdo-nitric acid (VMN) reagent the solution was made up to volume, resulting in a 1/200 dilution to be used for the determination of P.

3. Analytical procedure.

Determination of Ca, Cu, Fe, Mg, Na, Mn and Zn by atomic absorbtion spectrophotometer.

Using the required operating parameters for a Techtron AA 4 instrument, calibration curves of absorbance versus concentration were drawn up for each of the elements using a series of standards containing proportional amounts of the chemicals used in the preparation of leaf samples. The standards were flamed and the resultant absorbance values used to draw up calibration curves for each element. The absorbance values of the samples were then determined after which the concentrations of the analytes in the leaf were determined by comparisons with the standard calibration curves. The K concentration was determined by using the Techtron AA 4 after re-setting to zero with a fresh blank. After setting to the required parameters K was determined by flame emission.

Determination of P by D.B. spectrophometer.

i) Preparation of standards.

A 50 p.p.m. stock solution of P was made up by dis-

solving 0,2195 gm of K H_2PO_4 (dried at 40°C) in deionised distilled water to which 4,86 ml conc. H_2SO_4 was added before making up to one litre. Using this stock solution four standards were made up in the range 5-20 p.p.m. by adding the required amounts to 50 ml flasks and making up to volume. In order to adjust the acidity of the standards to $\pm$ 1 M, 1,5 ml conc. HNO_3 was added to each flask before making up to volume.

ii) Determination of concentration.

Firstly a calibration curve was drawn up after noting the absorbance values of standards and a blank containing reagents used. The absorbance values of the 1/200 dilution samples were then determined and the concentration of P in the leaf determined by reading the values off the calibration curve.

Note Although the acidity of the solution is not critical, it should be above 0,2 N so as to eliminate the yellow colour of nitric acid, but it should not be over 1,6 N because colour development is slowed up by high acidity.

Determination of N using a microkjeldahl.

To the 30 ml Borositicate microkjeldahl flasks containing the sample 2,0 gm K_2SO_4; 2,5 ml conc H_2SO_4 and 0,5 ml $HgSO_4$ (10 gm red HgO dissolved in 100 ml distilled water containing 11 ml conc. Hg SO_4) were added. Digestion was completed within 25 minutes but allowed to continue for a further 20 minutes after the solution had cleared. After allowing to cool, 5-10 ml water was added and the digest transferred to the Buchi reaction chamber, the flask being rinsed 5-6 times with 2 ml volumes of water.

Ten ml 1% H_2BO_3 solution, 2 drops of screened indicator and 20 ml distilled water were then added to a 250 ml Erlenmeyer flask and positioned under the delivery tube of the Buchi steam distilation apparatus so that the end of the tube was under the surface of the liquid. Ten ml of 40% Na OH : 2,5% $Na_2S_2O_3$ was then added to the digest in the reaction chamber. After rinsing the funnel of the reaction chamber with distilled water the tap was closed and steam passed through the reaction vessel.

The absorbtion flask was then lowered and distillation continued for about two minutes to rinse out the condenser tube. Four drops of screened indicator were then added to the absorbtion flask and titrated against 0,01 M HCl to grey (lilac) end point. Blank determinations using above procedure and chemicals without material were also made. The concentration of N in the sample was calculated as follows:-

$$\% \text{ N} = \frac{(\text{ml HCl} - \text{ml blank}) \times \text{M HCl} \times 14{,}007 \times 100}{\text{wt. of sample in milli-grams}}$$

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THE EFFECTS OF SOIL FUMIGATION, APPLIED FERTILIZERS AND CLIMATE ON THE GROWTH AND NUTRIENT LEVELS OF CAYENNE PINEAPPLES UNDER FIELD CONDITIONS.

VOLUME II

Tables, plates and figures.

A dissertation submitted to Rhodes University in fulfilment of the requirements for the degree of Doctor of Philosophy.

G. S. Marr.

December, 1972.

TABLE 1.

MEAN TEMPERATURES OF SOME PINEAPPLE GROWING AREAS - AFTER MALAN (1954).

		Mean Temperatures		
	Latitude	Minimum	Maximum	Average
Honolulu (Hawaii)	20° 18'N	20,9°C	25,3°C	23,3°C
Malaya	5° 04'N	25,2°C	26,4°C	25,6°C
Bathurst	33° 30'S	13,1°C	23,8°C	16,2°C
East London	33° 01'S	14,7°C	22,8°C	18,8°C
Nelspruit	25° 28'S	13,9°C	26,9°C	20,4°C
Port Shepstone	30° 44'S	16,6°C	23,7°C	20,2°C

TABLE 2.

SOIL NUTRIENT LEVELS (P.P.M.) AND RESPONSES TO APPLIED FERTILIZER - AFTER GIRTON (1966).

	No response	Some response	Definite response	Critical level
P	13+	9-12	8	10
K	200+	130-200	130	200
Ca	100+	200 (with high rainfall)		50
Mg	75+	25-75	25	65

TABLE 3.

NUTRIENT LEVELS IN PINEAPPLE LEAVES* AS A PERCENTAGE OF DRY WEIGHT - AFTER GIRTON (1966).

	High	Critical	Low
P	0,36	0,24	0,06
K	7,2	3,6	1,2
Ca	1,2	0,12	0,024
Mg	0,72	0,168	0,096
N	3,6	—	1,2
Chlorophyll	0,546	0,384	0,240
Fe	0,17	0,12	0,036
Mn	2,4	—	0,06
B	0,072	—	0,018
Mo	0,012	—	0,0012
Zn	0,036	—	0,002
Cu	0,036	—	0,0036

*Basal section sampled for P K Ca Mg Zn.

Mid third of green tissue sampled for chlorophyll N Fe Mn B Mo Cu.

TABLE 4.

MEAN MONTHLY RAINFALL RECORDS FOR BATHURST.

	28 year period		experimentation period 1963 - 1970	
	mm.	Days	mm.	Days
Jan.	44,2	7	39,3	10
Feb.	63,8	7	44,3	8
March	70,8	9	66,0	9
April	61,4	7	46,8	8
May	63,4	6	40,9	5
June	29,4	4	58,6	7
July	34,9	5	32,2	5
Aug.	39,6	5	69,7	7
Sept.	72,7	7	58,8	8
Oct.	84,9	9	65,8	9
Nov.	70,0	9	53,4	10
Dec.	56,0	8	59,0	7
Total	691,1	83	634,8	93

TABLE 5.

MEAN MONTHLY TEMPERATURE °C FOR BATHURST (22 YEAR PERIOD).

	Max.	Min.	Mean	Abs.Max.	Abs.Min.
Jan.	26,1	16,9	21,5	34,7	10,7
Feb.	26,4	16,9	21,7	34,7	12,3
March	25,2	15,9	20,6	35,0	11,0
April	24,0	14,1	19,1	33,1	9,3
May	22,0	11,9	16,9	31,6	7,6
June	20,4	10,3	15,4	27,7	6,4
July	20,0	10,1	15,1	28,2	5,8
Aug.	21,3	10,3	15,8	30,6	5,9
Sept.	21,2	10,8	16,1	33,1	6,3
Oct.	21,8	11,8	16,8	33,2	7,5
Nov.	23,3	13,7	18,5	33,0	9,5
Dec.	24,8	15,3	20,1	34,4	10,7

TABLE 6.

MEAN MONTHLY TEMPERATURE ^{o}C FOR BATHURST DURING THE EXPERIMENTATION PERIOD 1963 - 1970.

	Max.	Min.	Mean	Abs.Max.	Abs.Min.
Jan.	26,7	17,2	21,9	35,4	13,0
Feb.	26,6	16,8	21,7	35,5	12,5
March	26,4	16,4	21,5	36,7	11,5
April	23,1	13,9	18,5	33,9	9,0
May	22,4	12,5	16,9	31,3	8,4
June	19,8	10,3	15,0	27,1	6,1
July	20,2	10,0	15,1	29,1	5,5
Aug.	21,0	10,5	15,7	30,9	5,9
Sept.	21,2	11,7	16,5	35,3	6,7
Oct.	22,0	12,6	17,3	32,6	7,7
Nov.	22,9	13,8	18,4	33,2	10,1
Dec.	25,6	15,5	20,5	36,0	11,0

TABLE 7.

MEAN MONTHLY TEMPERATURES (^{o}C) FOR BATHURST AND MOLOKAI* HAWAII.

	Bathurst			Molokai		
	Max.	Mean	Min.	Max.	Mean	Min.
Jan.	26,1	21,5	16,9	28,7	23,1	17,5
Feb.	26,4	21,7	16,9	27,5	22,5	17,5
March	25,2	20,6	15,9	28,1	22,8	17,5
April	24,0	19,1	14,1	29,4	24,1	18,8
May	22,0	16,9	11,9	30,0	25,0	20,0
June	20,4	15,4	10,3	31,2	25,9	20,6
July	20,0	15,1	10,1	31,9	26,5	21,2
Aug.	21,3	15,8	10,3	32,5	27,2	21,9
Sept.	21,2	16,1	10,8	32,5	26,9	21,2
Oct.	21,8	16,8	11,8	31,2	25,9	20,6
Nov.	23,3	18,5	13,7	29,4	24,7	20,0
Dec.	24,8	20,1	15,3	30,0	23,7	18,7

* After Girton (1962).

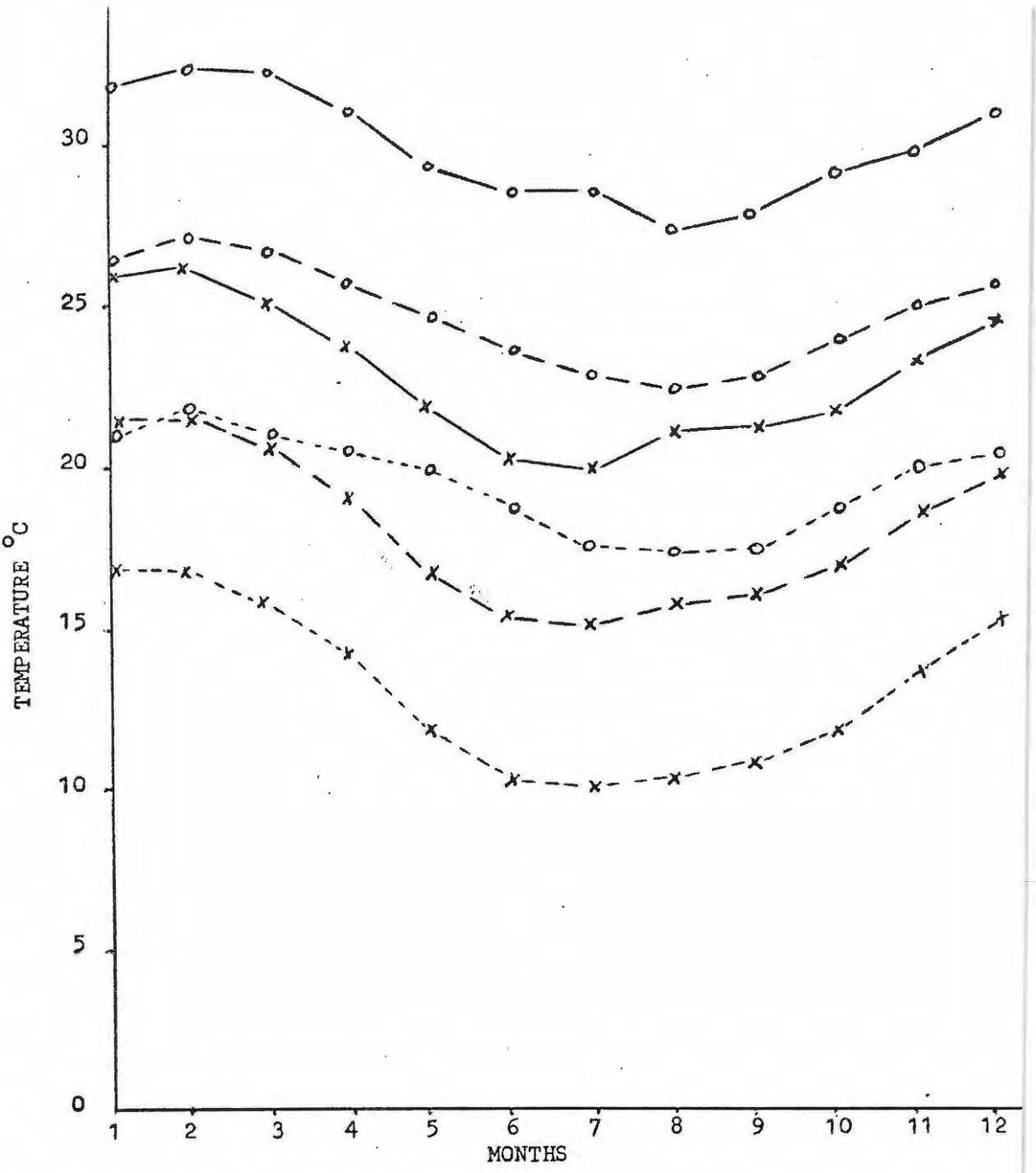

Fig. I. Mean monthly temperatures for Molokai Hawaii and Bathurst East Cape.

o———o mean max. Molokai (July - June)

o— —o mean temp. "

o- - - - -o mean min. "

x ——— x mean max. Bathurst (Jan. - Dec.)

x — — x mean temp. "

x- - - - -x mean min. "

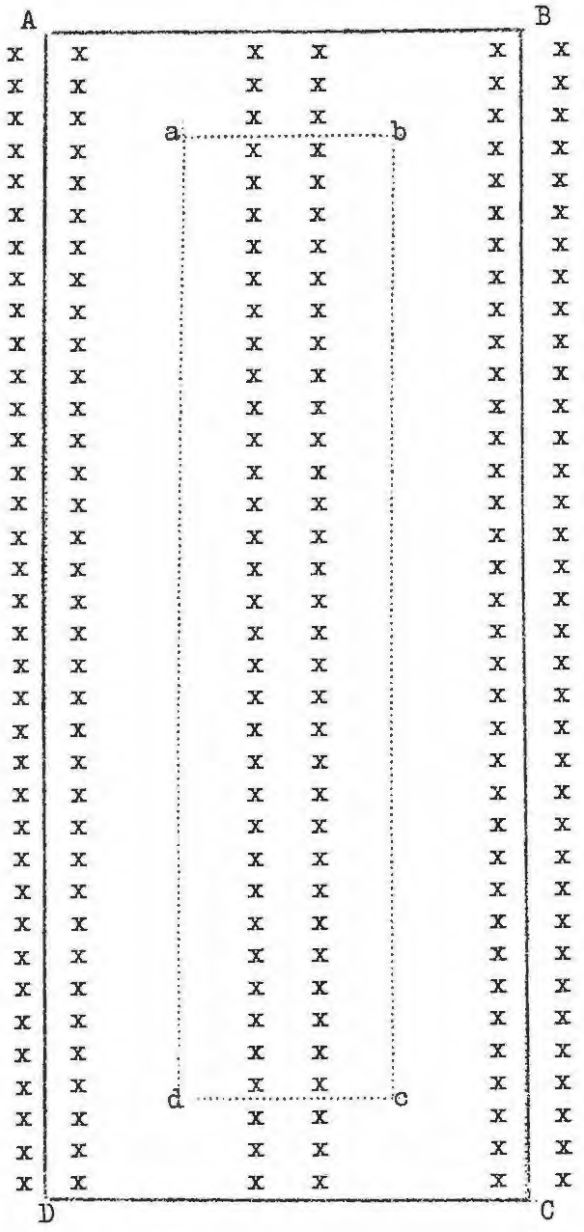

Fig. II. Diagramatic field plot layout for experiments.

Treated area : A B C D containing 144 plants.

Data area : a b c d containing 60 plants.

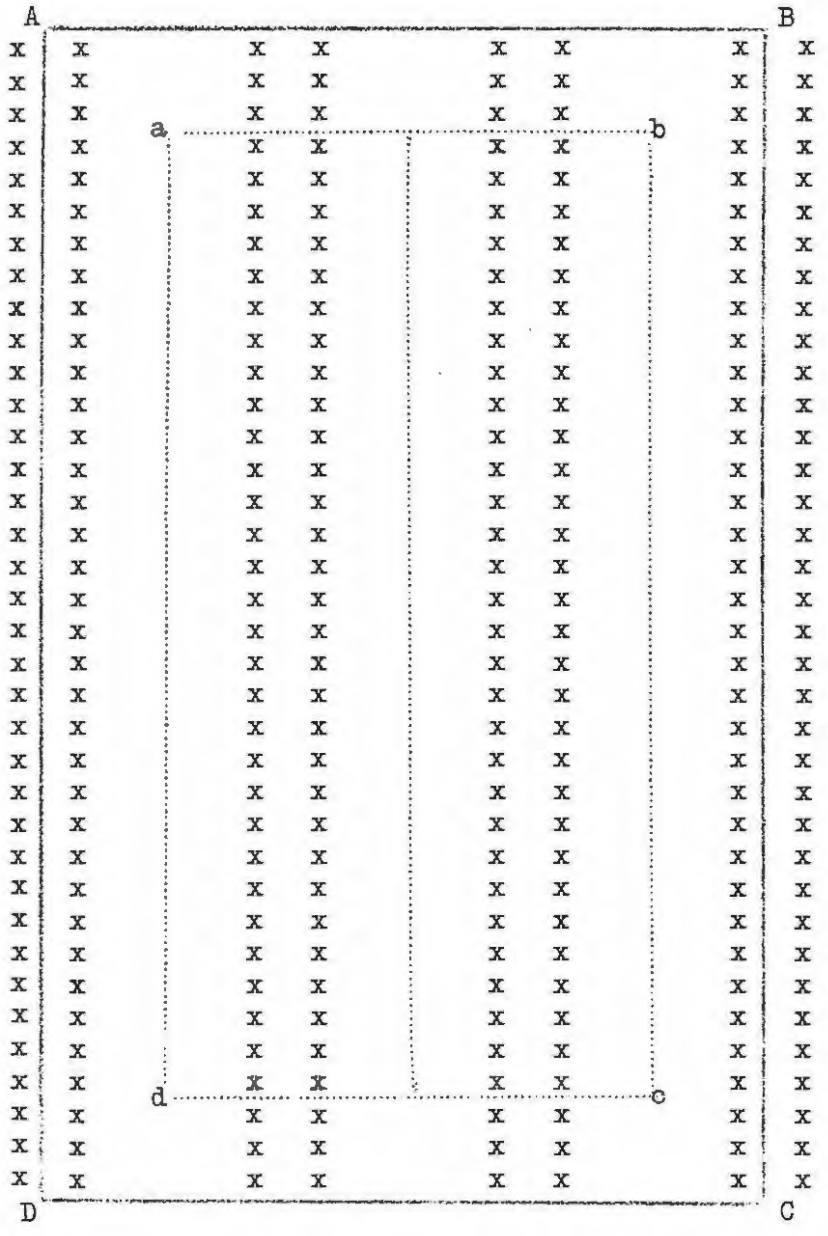

Fig. III. Diagramatic field plot layout for split plot experiments.

Treated area : A B C D containing 216 plants.

Data area : a b c d containing 120 plants whole plots.

½ a b c d containing 60 plants sub-plots.

TABLE 8.

SOIL ANALYSIS OF AVAILABLE NUTRIENTS (P.P.M.) TAKEN BEFORE PLANTING OF EXPERIMENTS.

	P	K	Ca	Mg	pH(N-KCl)
Fertilizer trial 1.	4	66	200	50	3,8
Fertilizer trial 2.	6	150	250	120	3,7
Fertilizer/Fumigation trial rep. 1.	10	200	216	169	4,1
Fertilizer/Fumigation trial rep. 2.	10	220	240	139	4,0
Fertilizer/Fumigation trial rep. 3.	10	180	240	200	4,1
Soil Fumigation trial 1.	4	52	180	40	3,7
Soil Fumigation trial 2.	10	220	240	139	4,0

TABLE 9.

MEAN YIELDS OF FRUIT (t/ha) AFTER DIFFERENT FERTILIZER PROGRAMMES HAD BEEN APPLIED.

	Treatments	Plant Crop	Ratoon Crop	Total Yields
A	Basal leaf applications.	61,27±1,77	76,47±3,58	137,74±4,23
B	Foliar sprays.	66,11	68,94	135,05
C	Foliar sprays + high preplanting phosphorus.	64,46	79,83	144,29
D	Basal leaf + foliar sprays + preplanting phosphorus and potassium.	69,30	88,44	157,74
E	Basal leaf + foliar sprays + preplanting phosphorus.	67,55	81,71	149,26
F	Foliar sprays + pre-planting phosphorus and potassium.	67,86	79,43	147,29
G	Foliar sprays + low preplanting phosphorus.	65,44	66,25	131,69
X	No applied fertilizer.	42,13	25,28	67,41
L.S.D.	(05)	5,13	10,40	12,30
	(01)	6,92	14,03	16,58
C.V.		6,3%	11,3%	7,1%

TABLE 10.

MEAN NUMBER OF SUCKERS AND SLIPS PER PLOT PRODUCED WITH DIFFERENT FERTILIZER PROGRAMMES.

	Treatments	Numbers of Suckers	Number of Slips
A	Basal leaf applications.	117,0 ± 7,1	32,4 ± 4,7
B	Foliar sprays.	106,0	14,0
C	Foliar sprays + high pre-planting phosphorus.	103,4	23,0
D	Basal leaf + foliar sprays + preplanting phosphorus and potassium.	125,2	8,8
E	Basal leaf + foliar sprays + preplanting phosphorus.	134,2	13,0
F	Foliar sprays + pre-planting phosphorus and potassium.	101,6	26,4
G	Foliar sprays + low preplanting phosphorus.	93,6	29,6
X	No applied fertilizer.	54,8	1,2
L.S.D.	(05)	20,7	13,8
	(01)	27,9	18,5
C.V.		15,3%	57,8%

TABLE 11.

MEAN YIELDS OF FRUIT (kg/PLOT) FOR THE PLANT CROP FOLLOWING DIFFERENT PLACEMENTS OF N, P AND K. (INTERACTION TABLE).

Phosphorus.

	Preplanting	Basal leaf	Foliar spray	Means
Nitrogen pre-planting.	84,2967	82,4067	85,1667	83,9567
Nitrogen basal leaf.	87,1400	87,3783	90,0617	88,1933
Nitrogen foliar spray.	84,2200	84,5367	83,6767	84,1444
Means	85,2189	84,7739	86,3017	85,4315

Potassium.

	Preplanting	Basal leaf	Foliar spray	Means
Nitrogen pre-planting.	84,2183	83,3517	84,3000	83,9567
Nitrogen basal leaf.	88,0867	86,9833	89,5100	88,1933
Nitrogen foliar spray.	85,2533	82,2467	84,9333	84,1444
Phosphorus pre-planting.	84,7700	85,4817	85,4050	85,2189
Phophorus basal leaf.	85,7200	82,1683	86,4333	84,7739
Phophorus foliar spray.	87,0683	84,9317	86,9050	86,3017
Means	85,8528	84,1939	86,2478	85,4315

	Marginal means.	Body of Table.
L.S.D. (05)	2,2617	3,9173
(01)	3,0741	5,3244

C.V. = 3,83%

TABLE 12.

MEAN YIELDS OF FRUIT (kg/PLOT) FOR THE RATOON CROP FOLLOWING DIFFERENT PLACEMENTS OF N, P AND K. (INTERACTION TABLE).

Phosphorus.

	Preplanting	Basal leaf	Foliar spray	Means
Nitrogen pre-planting.	57,7467	55,4117	57,7150	56,9578
Nitrogen basal leaf.	56,6650	52,5050	55,0667	54,7456
Nitrogen foliar spray.	53,4750	54,9100	54,9333	54,4394
Means	55,9622	54,2756	55,9050	55,3809

Potassium.

	Preplanting	Basal leaf	Foliar spray	Means
Nitrogen pre-planting.	60,1067	56,2433	54,5233	56,9578
Nitrogen basal leaf.	51,8717	59,1400	53,2250	54,7456
Nitrogen foliar spray.	53,8433	62,1533	47,3217	54,4394
Phosphorus pre-planting.	53,6500	62,8233	51,4133	55,9622
Phosphorus basal leaf.	53,8967	59,1483	49,7817	54,2756
Phosphorus foliar spray.	58,2750	55,5650	53,8750	55,9050
Means	55,2739	59,1789	51,6900	55,3809

	Marginal means.	Body of Table.
L.S.D. (05)	5,4016	9,3558
(01)	7,3419	12,7165

C.V. = 14,11%

TABLE 13.

MEAN YIELDS OF FRUIT (kg/PLOT) FOR THE CYCLE FOLLOWING DIFFERENT PLACEMENTS OF N, P AND K. (INTERACTION TABLE).

Phosphorus.

	Preplanting	Basal leaf	Foliar spray	Means
Nitrogen pre-planting.	142,0500	137,8500	142,8667	140,9222
Nitrogen basal leaf.	143,8167	140,0500	145,1333	143,0000
Nitrogen foliar spray.	137,7000	139,4500	138,6167	138,5889
Means	141,1889	139,1167	142,2056	140,8370

Potassium.

	Preplanting	Basal leaf	Foliar spray	Means
Nitrogen pre-planting.	144,3333	139,6000	138,8333	140,9222
Nitrogen basal leaf.	139,9667	146,3167	142,7167	143,0000
Nitrogen foliar spray.	139,0833	144,4167	132,2667	138,5889
Phosphorus pre-planting.	138,4167	148,3333	136,8167	141,1889
Phosphorus basal leaf.	139,6333	141,5000	136,2167	139,1167
Phosphorus foliar spray.	145,3333	140,5000	140,7833	142,2056
Means	141,1278	143,4444	137,9389	140,8370

		Marginal means.	Body of Table.
L.S.D.	(05)	6,0911	10,5500
	(01)	8,2790	14,3397

C.V. = 6,26%

TABLE 14.

MEAN NUMBER OF SUCKERS PER PLOT FOLLOWING DIFFERENT PLACEMENTS OF N, P AND K. (INTERACTION TABLE).

Phosphorus.

	Preplanting	Basal leaf	Foliar spray	Means
Nitrogen pre-planting.	119,0000	119,6667	117,0000	118,5556
Nitrogen basal leaf.	118,1667	115,3333	114,5000	116,0000
Nitrogen foliar spray.	117,0000	116,0000	118,0000	117,0000
Means	118,0556	117,0000	116,5000	117,1852

Potassium.

	Preplanting	Basal leaf	Foliar spray	Means
Nitrogen pre-planting.	121,5000	117,0000	117,1667	118,5556
Nitrogen basal leaf.	119,6667	115,8333	112,5000	116,0000
Nitrogen foliar spray.	113,0000	124,0000	114,0000	117,0000
Phosphorus pre-planting.	120,3333	121,3333	112,5000	118,0556
Phosphorus basal leaf.	119,6667	118,3333	113,0000	117,0000
Phosphorus foliar spray.	114,1667	117,1667	118,1667	116,5000
Means	118,0556	118,9444	114,5556	117,1852

	Marginal means.	Body of Table.
L.S.D. (05)	7,7604	13,4413
(01)	10,5479	18,2696

C.V. = 9,58%

TABLE 15.

MEAN NUMBER OF SLIPS PER PLOT FOLLOWING DIFFERENT PLACEMENTS OF N, P AND K. (INTERACTION TABLE).

Phosphorus.

	Preplanting	Basal leaf	Foliar spray	Means
Nitrogen pre-planting.	72,0000	79,1667	72,3333	74,5000
Nitrogen basal leaf.	86,5000	69,0000	77,3333	77,6111
Nitrogen foliar spray.	73,8333	73,0000	78,6667	75,1667
Means	77,4444	73,7222	76,1111	75,7592

Potassium.

	Preplanting	Basal leaf	Foliar spray	Means
Nitrogen pre-planting.	73,8333	78,5000	77,1667	76,5000
Nitrogen basal leaf.	72,6667	77,8333	76,3333	75,6111
Nitrogen foliar spray.	76,5000	80,6667	68,3333	75,1667
Phosphorus pre-planting.	71,6667	78,5000	67,1667	72,4444
Phosphorus basal leaf.	76,1667	81,0000	79,0000	78,7222
Phosphorus foliar spray.	75,1667	77,5000	75,6667	76,1111
Means	74,3333	79,0000	73,9444	75,7592

	Marginal means.	Body of Table.
L.S.D. (05)	8,5073	14,7351
(01)	11,5632	20,0281

C.V. = 15,76%

TABLE 16.

MEAN YIELDS OF FRUIT (t/ha) AFTER THE APPLICATION OF DIFFERENT SOIL FUMIGANTS.

	Treatments	Plant Crop	Ratoon Crop	Cycle Total
A	D-D 449,3 l/ha.	77,27 ± 2,82	63,13 ± 2,89	140,40 ± 3,79
B	EDB 67,4 l in 269,6 l diesoline/ha.	67,68	43,00	110,68
C	EDB 89,8 l in 359,5 l diesoline/ha.	69,36	43,54	112,90
D	EDB 112,3 l in 449,3 l diesoline/ha.	72,79	51,39	124,18
E	EDB 89,8 l in 395,5 l water/ha.	68,28	46,26	114,54
F	DBCP 22,5 l in 202,2 l diesoline/ha.	69,79	41,06	110,85
G	DBCP 33,7 l in 181,0 l diesoline/ha.	72,93	44,46	117,39
H	DBCP 22,5 l in 337,0 l D-D/ha.	73,64	64,05	137,69
X	No fumigation	69,98	37,56	107,54
L.S.D.	(05)	5,78	8,36	10,89
	(01)	7,73	11,23	14,66
C.V.	%	4,4	13,4	7,2
Means:	No post planting.	66,41 ± 0,67	43,84 ± 0,89	110,25 ± 1,25
	post planting.	72,82	52,72	125,54
L.S.D.	(05)	1,84	2,60	3,58
	(01)	2,58	3,47	4,82
C.V.	%	4,6	12,6	7,1

TABLE 17.

MEAN NUMBER OF SUCKERS AND SLIPS PRODUCED PER PLOT AFTER THE APPLICATION OF SOIL FUMIGANTS.

Treatment		Number of Suckers	Number of Slips
A	D-D 449,3 l/ha.	110,9 ± 7,8	34,6 ± 7,8
B	EDB 67,4 l in 269,6 l diesoline/ha.	94,7	19,0
C	EDB 89,8 l in 359,5 l diesoline/ha.	95,7	14,3
D	EDB 112,3 l in 449,3 l diesoline/ha.	101,0	20,5
E	EDB 89,8 l in 395,5 l water/ha.	100,0	12,9
F	DBCP 22,5 l in 202,2 l diesoline/ha.	93,1	15,7
G	DBCP 33,7 l in 181,0 l diesoline/ha.	98,8	24,0
H	DBCP 22,5 l in 337,0 l D-D/ha.	123,4	27,7
X	No fumigation.	83,6	22,6
L.S.D.	(05)	15,9	22,5
	(01)	21,3	30,2
C.V.	%	9,4	45,7
Means	No post planting.	94,2	24,7
	post planting.	90,8	27,4
L.S.D.	(05)	5,3	7,2
	(01)	7,1	10,1
C.V.	%	11,3	50,7

TABLE 18.

MEAN NUMBER OF PLANT PARASITIC NEMATODES PER 100 ml SOIL SAMPLED 24 MONTHS AFTER THE APPLICATION OF DIFFERENT NEMATOCIDES.

Treatments		Meloidogyne sp.	Helicotylenchus sp.	Total
A. D-D 449,3 l/ha.	(a)	288	1276	1564
	(b)	190	16	206
H. DBCP 22,5 l in 337,0 l D-D/ha.	(a)	689	192	881
	(b)	72	8	80
X. No fumigation.	(a)	348	552	900
	(b)	160	48	208

(a) = no post planting application.

(b) = post planting application of DBCP.

TABLE 19.

MEAN YIELDS OF FRUIT (t/ha) AFTER TREATMENT WITH DIFFERENT SOIL FUMIGANTS.

Treatment	Plant crop	Ratoon crop	Cycle total
A DBCP 44,9 l in 179,7 l water/ha.	77,77 ± 1,68	88,95 ± 2,76	166,72 ± 3,72
B DBCP 56,2 l in 168,5 l water/ha.	76,65	94,94	171,59
C DBCP 67,4 l in 157,3 l water/ha.	77,25	88,97	166,22
D D-D 359,4 l/ha.	78,49	90,79	169,28
E D-D 449,3 l/ha.	82,16	94,78	176,94
F D-D 539,2 l/ha.	79,56	97,13	176,69
G DBCP 22,5 l in 179,7 l D-D/ha.	81,91	93,93	175,84
H DBCP 22,5 l in 269,6 l D-D/ha.	83,42	96,91	180,33
I DBCP 33,7 l in 269,6 l D-D/ha.	82,95	100,05	183,00
X CONTROL	77,41	76,11	153,52
L.S.D. (05)	4,86	8,00	10,80
(01)	6,57	10,80	14,59
C.V. %	4,2	6,0	4,3
Means no post planting.	78,84	96,93	175,77
post planting.	80,08	94,82	174,90
L.S.D. (05)	6,43	7,71	11,74
(01)	8,65	10,40	15,80
C.V. %	4,0	4,1	3,3

TABLE 20.

MEAN NUMBER OF SUCKERS AND SLIPS PRODUCED PER PLOT AFTER TREATMENT WITH DIFFERENT SOIL FUMIGANTS.

Treatment		Number of Suckers	Number of Slips
A	DBCP 44,9 l in 179,7 l water/ha.	122,4 ± 3,2	73,2 ± 7,0
B	DBCP 56,2 l in 168,5 l water/ha.	125,6	62,5
C	DBCP 67,4 l in 157,3 l water/ha.	130,2	78,1
D	D-D 359,4 l/ha.	124,5	50,5
E	D-D 449,3 l/ha.	122,9	62,8
F	D-D 539,2 l/ha.	120,7	60,5
G	DBCP 22,5 l in 179,7 l D-D/ha.	126,1	54,0
H	DBCP 22,5 l in 269,6 l D-D/ha.	129,2	50,6
I	DBCP 33,7 l in 269,6 l D-D/ha.	126,8	65,5
X	CONTROL	116,5	48,0
L.S.D.	(05)	9,5	20,3
	(01)	12,6	27,4
C.V.	%	5,2	23,1
Means	no post planting.	124,7	77,1
	post planting.	124,2	44,1
L.S.D.	(05)	18,9	36,0
	(01)	25,5	48,5
C.V.	%	7,4	29,1

TABLE 21.

MEAN NUMBER OF PLANT PARASITIC NEMATODES PER 100 ml SOIL SAMPLED SIX MONTHS AFTER PREPLANTING TREATMENT WITH DIFFERENT SOIL FUMIGANTS.

TREATMENTS*		NUMBER OF NEMATODES
A	DBCP 44,9 l in 179,7 l water/ha.	0
B	DBCP 56,2 l in 168,5 l water/ha.	0
C	DBCP 67,4 l in 157,3 l water/ha.	0
D	D-D 359,4 l/ha.	0
E	D-D 449,3 l/ha.	0
F	D-D 539,2 l/ha.	0
G	DBCP 22,5 l in 179,7 l D-D/ha.	0
H	DBCP 22,5 l in 269,6 l D-D/ha.	0
I	DBCP 33,7 l in 269,6 l D-D/ha.	0
X	CONTROL	124

*At the time of sampling the post planting application of DBCP had not yet been applied.

TABLE 22.

MEAN NUMBER OF PLANT PARASITIC NEMATODES PER 100 ml SOIL SAMPLED EIGHTEEN MONTHS AFTER PREPLANTING TREATMENT WITH DIFFERENT SOIL FUMIGANTS.

Treatments		Meloidogyne sp.	Helicotylenchus sp.	Trichodorus sp.	Total
A DBCP 44,9 l in 179,7 l water/ha.	(a)	425	25	5	455
	(b)	0	0	10	10
B DBCP 56,2 l in 168,5 l water/ha.	(a)	55	10	15	80
	(b)	0	0	15	15
C DBCP 67,4 l in 157,3 l water/ha.	(a)	20	40	10	70
	(b)	30	10	0	40
D D-D 359,4 l/ha.	(a)	0	75	10	85
	(b)	0	0	5	5
E D-D 449,3 l/ha.	(a)	0	5	15	20
	(b)	0	0	0	0
F D-D 539,2 l/ha.	(a)	0	0	0	0
	(b)	5	10	15	30
G DBCP 22,5 l in 179,7 l D-D/ha.	(a)	145	90	0	235
	(b)	0	15	10	25
H DBCP 22,5 l in 269,6 l D-D/ha.	(a)	15	25	10	50
	(b)	0	0	5	5
I DBCP 33,7 l in 269,6 l D-D/ha.	(a)	55	30	0	85
	(b)	0	0	5	5
X CONTROL	(a)	260	980	0	1240
	(b)	5	35	0	40

(a) = no post planting application.

(b) = post planting application of DBCP.

TABLE 23.

MEAN ROOT WEIGHT (g) OF ONE YEAR OLD PLANTS AFTER THE APPLICATION OF FERTILIZERS AND SOIL FUMIGANTS : SIGNIFICANT MAIN EFFECT AND INTERACTION TABLES AS REFLECTED BY ANALYSIS OF VARIANCE.

(a) Main effect of fumigation.

No fumigation	37,96	C.V. =	11,4%	
Fumigation	51,13	L.S.D.	(0,05)	2,57
	13,17**		(0,01)	3,46

TABLE 24.

MEAN ROOT WEIGHT (g) OF TWO YEAR OLD PLANTS AFTER THE APPLICATION OF FERTILIZERS AND SOIL FUMIGANTS : SIGNIFICANT MAIN EFFECT AND INTERACTION TABLES AS REFLECTED BY ANALYSIS OF VARIANCE.

(a) Main effect of fumigation.

No fumigation	51,0	C.V. =	15,7%	
Fumigation	74,1	L.S.D.	(0,05)	4,9
	23,1**		(0,01)	6,6

(b) Main effect of iron.

No iron	59,9
Iron	65,2
	5,3*

(c) Interaction : high nitrogen (N) X phosphorus (P).

	(i)	N	mean	N-(i)
(i)	59,4	69,4	64,4	10,0**
P	63,9	57,6	60,8	-6,3
mean	61,6	63,5	62,6	1,9
P-(i)	4,5	-11,8**	-3,6	-16,3**

		Marginal means.	Body of table.	Interaction.
L.S.D.	(0,05)	4,9	7,0	9,9
	(0,01)	6,6	9,4	13,3

Plate I. Roots of two year old pineapple plants. Plant on right from fumigated plot. Other four plants indicating variations in effects of nematodes on roots in unfumigated plots.

Plate II. Roots of plants after harvesting the ratoon crop. Plant on left from fumigated plot. Other three from unfumigated plots.

Plate I. Roots of two year old pineapple plants. Plant on right from fumigated plot. Other four plants indicating variations in effects of nematodes on roots in unfumigated plots.

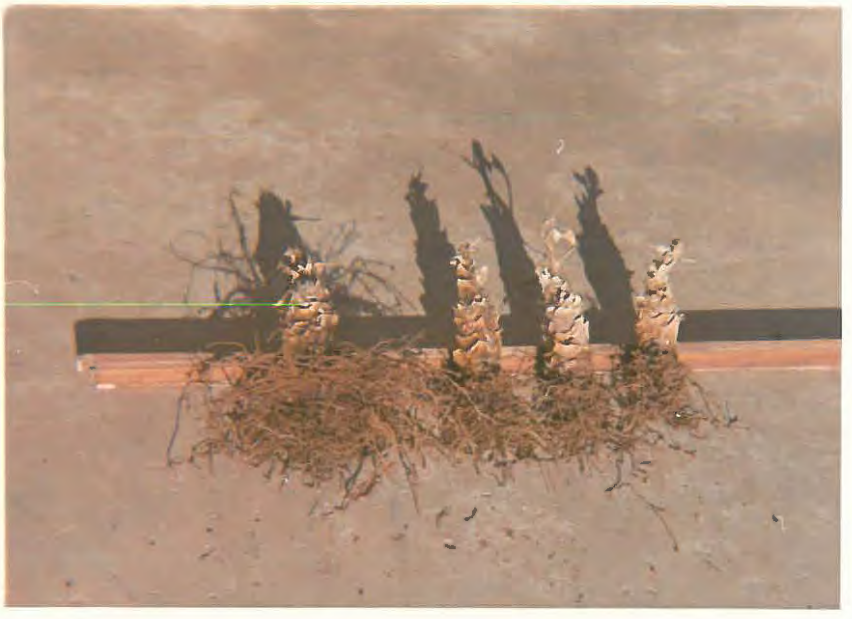

Plate II. Roots of plants after harvesting the ratoon crop. Plant on left from fumigated plot. Other three from unfumigated plots.

TABLE 25.

MEAN D-LEAF WEIGHT (g) OF ONE YEAR OLD PLANTS AFTER THE APPLICATION OF FERTILIZERS AND SOIL FUMIGANTS : SIGNIFICANT MAIN EFFECT AND INTERACTION TABLES AS REFLECTED BY ANALYSIS OF VARIANCE.

(a) Main effect of potassium.

No potassium	51,80	C.V. =	10,1%
Potassium	55,03	L.S.D.	(0,05) 2,76
	3,23*		(0,01) 3,81

(b) Interaction : fumigation (F) X iron (Fe).

	(i)	Fe	mean	Fe-(i)
(i)	43,38	47,13	45,26	3,75
F	63,14	60,01	61,58	-3,13
mean	53,26	53,57	53,42	0,31
F-(i)	19,76**	12,88**	16,32**	-6,88*

		Marginal means.	Body of table.	Interaction.
L.S.D.	(0,05)	2,76	3,88	5,49
	(0,01)	3,81	5,21	7,36

TABLE 26.

MEAN D-LEAF WEIGHT (g) OF TWO YEAR OLD PLANTS AFTER THE APPLICATION OF FERTILIZERS AND SOIL FUMIGANTS : SIGNIFICANT MAIN EFFECT AND INTERACTION TABLES AS REFLECTED BY ANALYSIS OF VARIANCE.

(a) Main effect of fumigation.

No fumigation	66,2	C.V. =	5,4%
Fumigation	72,0	L.S.D.	(0,05) 1,9
	5,8**		(0,01) 2,5

(b) Main effect of potassium.

No potassium	66,9
Potassium	73,1
	6,2**

(c) Main effect of iron.

No iron	67,7
Iron	70,4
	2,7**

(d) Interaction : fumigation (F) X high nitrogen (N).

	(i)	N	mean	N-(i)
(i)	67,4	64,9	66,2	-2,5
F	69,7	74,3	72,0	4,6**
mean	68,6	69,6	69,1	1,0
F-(i)	2,3	9,4**	5,8**	7,1**

		Marginal means.	Body of table.	Interaction.
L.S.D.	(0,05)	1,9	2,7	3,8
	(0,01)	2,5	3,6	5,8

TABLE 27.

MEAN NUMBER OF SUCKERS PER PLOT AFTER THE APPLICATION OF FERTILIZERS AND SOIL FUMIGANTS : SIGNIFICANT MAIN EFFECT AND INTERACTION TABLES AS REFLECTED BY ANALYSIS OF VARIANCE.

(a) Main effect of fumigation.

No fumigation	51,8281	C.V. =	12,5%
Fumigation	111,7188	L.S.D.	(0,05) 3,6307
	59,8907**		(0,01) 4,8417

(b) Main effect of potassium.

No potassium	86,2188
Potassium	77,3281
	- 8,8907**

(c) Main effect of iron.

No iron	79,0000
Iron	84,5469
	5,5469**

(d) Main effect of zinc.

No zinc	78,3594
Zinc	85,1875
	6,8281**

(e) Interaction : fumigation (F) X high nitrogen (N).

	(i)	F	mean	F-(i)
(i)	55,7812	110,3750	83,0781	54,5938**
N	47,8750	113,0625	80,4687	65,1875**
mean	51,8281	111,7188	81,7734	59,8907**
N-(i)	- 7,9062**	2,6875	- 2,6094	10,5937**

(f) Interaction : iron (Fe) X zinc (Zn).

	(i)	Fe	mean	Fe-(i)
(i)	73,2812	83,4375	78,3594	10,1563**
Zn	84,7187	85,6563	85,1875	0,9376
mean	79,0000	84,5469	81,7734	5,5469**
Zn-(i)	11,4375**	2,2188	6,8281	- 9,2187*

		Marginal means.	Body of table.	Interaction.
L.S.D.	(0,05)	3,6307	5,1345	7,2612
	(0,01)	4,8417	6,8473	9,6834

TABLE 28.

MEAN NUMBER OF SLIPS PER PLOT FOLLOWING THE APPLICATION OF FERTILIZERS AND SOIL FUMIGANTS : SIGNIFICANT MAIN EFFECT AND INTERACTION TABLES AS REFLECTED BY ANALYSIS OF VARIANCE.

(a) Main effect of fumigation.

No fumigation	66,2812	C.V.	=	30,8%
Fumigation	55,7812	L.S.D.	(0,05)	6,6839
	-10,5000**		(0,01)	8,9136

(b) Main effect of potassium.

No potassium	44,5156
Potassium	77,5469
	33,0313**

(c) Main effect of zinc.

No zinc	66,3594
Zinc	56,7031
	- 9,6563**

(d) Interaction : fumigation (F) X iron (Fe).

	(i)	F	mean	F-(i)
(i)	63,3750	60,4375	61,9062	- 2,9375
Fe	69,1875	51,1250	60,1562	-18,0625**
mean	66,2812	55,7812	61,0313	-10,5000**
Fe-(i)	5,8125	- 9,3125	- 1,7500	-15,1250*

(e) Interaction : phosphorus (P) X potassium (K).

	(i)	P	mean	P-(i)
(i)	46,6250	42,4063	44,5156	- 4,2187
K	71,6875	83,4062	77,5469	11,7187*
mean	59,1562	62,9062	61,0312	3,7500
K-(i)	25,0625**	40,9999**	33,0313**	15,9374*

		Marginal means.	Body of table.	Interaction.
L.S.D.	(0,05)	6,6839	9,4525	13,3677
	(0,01)	8,9135	12,6055	17,8267

Plate III. Eighteen month old plants having had the same fertilizer treatments. Plant on left from fumigated plot. Plant on right with severe Meloidogyne infestation from unfumigated plot.

Plate IV. Two year old plants. Left, fumigation plus all nutrients (a b c d e f); centre, fumigation plus low nitrogen (i); right, not fumigated but given all nutrients (b c d e f).

Plate V. Four and a half year old plants after harvesting of the ratoon crop. Left, fumigation plus all nutrients; right no fumigation but given all nutrients.

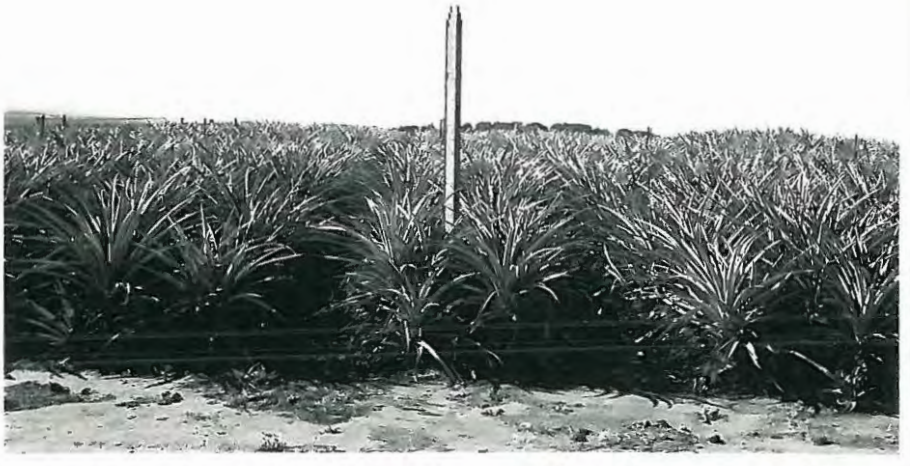

Plate VI. View of field trial. Plot in centre given all nutrients but not fumigated. Extreme right fumigation plus all nutrients.

Plate VII. Two year old plants showing the effects of different applied treatments. Left to right: fumigation; phosphorus; high nitrogen; potassium; iron; zinc; control; fumigation plus P high N K Fe Zn.

TABLE 29.

MEAN WEIGHTS (kg) OF ONE YEAR OLD PLANTS FOLLOWING THE APPLICATION OF FERTILIZERS AND SOIL FUMIGANTS : SIGNIFICANT MAIN EFFECT AND INTERACTION TABLES AS REFLECTED BY ANALYSIS OF VARIANCE.

(a) Main effect of fumigation.

No fumigation	0,912	C.V. =	10,7%
Fumigation	1,367	L.S.D.	(0,05) 0,063
	0,455**		(0,01) 0,082

(b) Interaction : fumigation (F) X iron (Fe).

	(i)	Fe	mean	Fe-(i)
(i)	0,862	0,962	0,912	0,100*
F	1,424	1,311	1,367	-0,113*
mean	1,143	1,136	1,140	-0,007
F-(i)	0,562**	0,349**	0,455**	-0,213**

(c) Interaction : iron (Fe) X zinc (Zn).

	(i)	Zn	mean	Zn-(i)
(i)	1,184	1,102	1,143	-0,082
Fe	1,093	1,179	1,136	0,086*
mean	1,139	1,141	1,140	0,002
Fe-(i)	-0,091*	0,077	0,007	0,168**

		Marginal means.	Body of table.	Interaction.
L.S.D.	(0,05)	0,063	0,086	0,122
	(0,01)	0,082	0,118	0,168

TABLE 30.

MEAN WEIGHTS (kg) OF TWO YEAR OLD PLANTS FOLLOWING THE APPLICATION OF FERTILIZERS AND SOIL FUMIGANTS : SIGNIFICANT MAIN EFFECT AND INTERACTION TABLES AS REFLECTED BY ANALYSIS OF VARIANCE.

(a) Main effect of fumigation.

No fumigation	2,628	C.V. =	9,5%
Fumigation	3,491	L.S.D.	(0,05) 0,148
	0,863**		(0,01) 0,198

(b) Main effect of phosphorus.

No phosphorus	2,984
Phosphorus	3,134
	0,150*

(c) Main effect of potassium.

No potassium	2,964
Potassium	3,155
	0,191*

(d) Interaction : iron (Fe) X zinc (Zn).

	(i)	Zn	mean	Zn-(i)
(i)	3,193	2,896	3,045	-0,297**
Fe	3,031	3,117	3,074	0,086
mean	3,112	3,006	3,060	-0,106
Fe-(i)	-0,162	0,221*	0,029	0,383*

	Marginal means.	Body of table.	Interaction.
L.S.D. (0,05)	0,148	0,202	0,296
(0,01)	0,198	0,280	0,397

TABLE 31.

MEAN PLANT WEIGHT (kg) AT THE END OF THE GROWTH CYCLE FOLLOWING THE APPLICATION OF FERTILIZERS AND SOIL FUMIGANTS : SIGNIFICANT MAIN EFFECT AND INTERACTION TABLES AS REFLECTED BY ANALYSIS OF VARIANCE.

(a) Main effect of fumigation.

No fumigation	4,3511	C.V. = 10,7%	
Fumigation	6,0287	L.S.D. (0,05)	0,1981
	1,6776**	(0,01)	0,2641

(b) Main effect of high nitrogen.

Low nitrogen	4,9852
High nitrogen	5,3947
	0,4095**

(c) Main effect of potassium.

No potassium	5,0820
Potassium	5,2978
	0,2158*

(d) Main effect of iron.

No iron	5,0767
Iron	5,3031
	0,2264*

(e) Main effect of zinc.

No zinc	5,0756
Zinc	5,3042
	0,2286*

(f) Interaction : fumigation (F) X high nitrogen (N).

	(i)	F	mean	F-(i)
(i)	4,2916	5,6787	4,9852	1,3871**
N	4,4106	6,3788	5,3947	1,9682**
mean	4,3511	6,0287	5,1899	1,6776**
N-(i)	0,1190	0,7001**	0,4095**	0,5811**

TABLE 31 CONTINUED.

(g) Interaction : nitrogen (N) X iron (Fe).

	(i)	N	mean	N-(i)
(i)	4,7616	5,3919	5,0767	0,6303**
Fe	5,2087	5,3975	5,3031	0,1888
mean	4,9852	5,3947	5,1899	0,4095**
Fe-(i)	0,4471**	0,0056	0,2264*	-0,4415*

		Marginal means.	Body of table.	Interaction .
L.S.D.	(0,05)	0,1981	0,2801	0,3961
	(0,01)	0,2641	0,3736	0,5283

TABLE 32.

PLANT CROP YIELDS (kg/PLOT) FOLLOWING THE APPLICATION OF FERTILIZERS AND SOIL FUMIGANTS : SIGNIFICANT MAIN EFFECT AND INTERACTION TABLES AS REFLECTED BY ANALYSIS OF VARIANCE.

(a) Main effect of fumigation.

No fumigation	83,7959	C.V. =	6,4%
Fumigation	105,0172	L.S.D.	(0,05) 2,1536
	21,2213**		(0,01) 2,8719

(b) Main effect of phosphorus.

No phosphorus	95,5686
Phosphorus	93,2443
	- 2,3243*

(c) Main effect of iron.

No iron	93,0967
Iron	95,7164
	2,6197*

(d) Main effect of zinc.

No zinc	93,0500
Zinc	95,7635*
	2,7135*

(e) Interaction : phosphorus (P) X zinc (Zn).

	(i)	P	mean	P-(i)
(i)	92,9922	93,1075	93,0498	0,1153
Zn	93,4969	98,0297	95,7633	4,5328**
mean	93,2445	95,5686	94,4066	2,3241*
Zn-(i)	0,5047	4,9222**	2,7135*	4,4175*

		Marginal means.	Body of table.	Interaction.
L.S.D.	(0,05)	2,1536	3,0456	4,3070
	(0,01)	2,8719	4,0615	5,7437

TABLE 33.

RATOON CROP YIELDS (kg/PLOT) FOLLOWING THE APPLICATION OF FERTILIZERS AND SOIL FUMIGANTS : SIGNIFICANT MAIN EFFECT AND INTERACTION TABLES AS REFLECTED BY ANALYSIS OF VARIANCE.

(a) Main effect of fumigation.

No fumigation	80,6797	C.V. = 13,2%	
Fumigation	119,0617	L.S.D. (0,05)	4,6954
	38,3820**	(0,01)	6,2617

(b) Main effect of high nitrogen.

Low nitrogen	97,0648
High nitrogen	102,6766
	5,6118*

(c) Main effect of zinc.

No zinc	97,1500
Zinc	102,5914
	5,4414*

TABLE 34.

TOTAL YIELDS FOR CYCLE (kg/PLOT) FOLLOWING THE APPLICATION OF FERTILIZERS AND SOIL FUMIGANTS : SIGNIFICANT MAIN EFFECT AND INTERACTION TABLES AS REFLECTED BY ANALYSIS OF VARIANCE.

(a) Main effect of fumigation.

No fumigation	164,0638	C.V. = 9,2%
Fumigation	222,4398	L.S.D. (0,05) 6,2866
	58,3760**	(0,01) 8,3836

(b) Main effect of high nitrogen.

Low nitrogen	188,5436
High nitrogen	197,9600
	9,4164**

(c) Main effect of iron.

No iron	188,7788
Iron	197,7248
	8,9460**

(d) Main effect of zinc.

No zinc	188,6373
Zinc	197,8663
	9,2290**

TABLE 35.

MEAN NUMBER OF MONTHS TO HARVESTING OF PLANT CROP FOLLOWING THE APPLICATION OF FERTILIZERS AND SOIL FUMIGANTS : SIGNIFICANT MAIN EFFECT AND INTERACTION TABLES AS REFLECTED BY ANALYSIS OF VARIANCE.

(a) Main effect of fumigation.

No fumigation	30,0547	C.V. = 2,7%
Fumigation	28,0156	L.S.D. (0,05) 0,2775
	- 2,0391**	(0,01) 0,3701

(b) Main effect of nitrogen.

Low nitrogen	28,4063
High nitrogen	29,6641
	1,2578**

(c) Main effect of zinc.

No zinc	29,4313
Zinc	28,6391
	- 0,7922**

(d) Interaction fumigation (F) X high nitrogen (N).

	(i)	F	mean	F-(i)
(i)	29,2313	27,5813	28,4063	-1,6500**
N	30,8781	28,4500	29,6641	-2,4281**
mean	30,0547	28,0156	29,0352	-2,0391**
N-(i)	1,6468**	0,8687**	1,2578**	-0,7781**

	Marginal means.	Body of table.	Interaction.
L.S.D. (0,05)	0,2775	0,3924	0,4252
(0,01)	0,3701	0,5234	0,5672

TABLE 36.

MEAN NUMBER OF MONTHS TO HARVESTING OF RATOON CROP FOLLOWING THE APPLICATION OF FERTILIZERS AND SOIL FUMIGANTS : SIGNIFICANT MAIN EFFECT AND INTERACTION TABLES AS REFLECTED BY ANALYSIS OF VARIANCE.

(a) Main effect of fumigation.

No fumigation	52,7531	C.V.	= 1,2%
Fumigation	51,1047	L.S.D.	(0,05) 0,2127
	- 1,6484**		(0,01) 0,2836

(b) Main effect of nitrogen.

Low nitrogen	51,5310
High nitrogen	52,3266
	0,7956**

(c) Main effect of potassium.

No potassium	51,6656
Potassium	52,1922
	0,5266**

(d) Main effect of zinc.

No zinc	52,2828
Zinc	51,5750
	- 0,7078**

(e) Interaction : phosphorus (P) X iron (Fe).

	(i)	P	mean	P-(i)
(i)	51,9031	52,0156	51,9594	0,1125
Fe	52,1031	51,6937	51,8984	-0,4094**
mean	52,0031	51,8547	51,9289	-0,1484
Fe-(i)	0,2000	- 0,3219*	- 0,0610	-0,5219*

		Marginal means.	Body of table.	Interaction .
L.S.D.	(0,05)	0,2127	0,3007	0,4252
	(0,01)	0,2836	0,4011	0,5672

TABLE 37.

TOTAL SOLUBLE SOLIDS IN FRUIT HARVESTED IN MID SEASON OF PLANT CROP FOLLOWING THE APPLICATION OF FERTILIZERS AND SOIL FUMIGANTS : SIGNIFICANT MAIN EFFECT AND INTERACTION TABLES AS REFLECTED BY ANALYSIS OF VARIANCE.

(a) Main effect of fumigation.

No fumigation	15,2234	C.V. =	3,6%
Fumigation	14,4672	L.S.D.	(0,05) 0,1907
	- 0,7562**		(0,01) 0,2543

(b) Main effect of phosphorus.

No phosphorus	14,7109
Phosphorus	14,9797
	0,2688**

(c) Main effect of high nitrogen.

Low nitrogen	14,9641
High nitrogen	14,7266
	- 0,2375*

(d) Main effect of iron.

No iron	14,7156
Iron	14,9750
	0,2594**

(e) Interaction : fumigation (F) X zinc (Zn).

	(i)	F	mean	F-(i)
(i)	15,0719	14,5125	14,7922	-0,5594**
Zn	15,3750	14,4219	14,8984	-0,9531**
mean	15,2234	14,4672	14,8453	-0,7562**
Zn-(i)	0,3031*	- 0,0906	0,1062	0,3937*

		Marginal means.	Body of table.	Interaction.
L.S.D.	(0,05)	0,1907	0,2697	0,3814
	(0,01)	0,2543	0,3597	0,5087

TABLE 38.

DENSITY OF FRUIT HARVESTED IN MID SEASON OF PLANT CROP FOLLOWING THE APPLICATION OF FERTILIZERS AND SOIL FUMIGANTS : SIGNIFICANT MAIN EFFECT AND INTERACTION TABLES AS REFLECTED BY ANALYSIS OF VARIANCE.

(a) Main effect of fumigation.

No fumigation	0,9775	C.V. = 2,1%	
Fumigation	0,9989	L.S.D. (0,05)	0,0075
	0,0214**	(0,01)	0,0100

TABLE 39.

SUGAR (Brix) OF FRUIT HARVESTED IN MID SEASON OF PLANT CROP FOLLOWING THE APPLICATION OF FERTILIZERS AND SOIL FUMIGANTS : SIGNIFICANT MAIN EFFECT AND INTERACTION TABLES AS REFLECTED BY ANALYSIS OF VARIANCE.

(a) Main effect of fumigation.

No fumigation	17,9453	C.V. =	3,8%
Fumigation	17,1250	L.S.D.	(0,05) 0,2375
	- 0,8203**		(0,01) 0,3168

(b) Main effect of iron.

No iron	17,3594
Iron	17,7109
	0,3515**

(c) Interaction : fumigation (F) X phosphorus (P).

	(i)	F	mean	F-(i)
(i)	17,8750	17,2969	17,5859	-0,5781**
P	18,0156	16,9531	17,4844	-1,0625**
mean	17,9453	17,1250	17,5352	-0,8203**
P-(i)	0,1406	- 0,3438*	- 0,1015	-0,4844*

(d) Interaction : fumigation (F) X iron (Fe).

	(i)	F	mean	F-(i)
(i)	17,8906	16,8281	17,3594	-1,0625**
Fe	18,0000	17,4219	17,7109	-0,5781**
mean	17,9453	17,1250	17,5352	-0,8203**
Fe-(i)	0,1094	0,5938**	0,3515**	-0,4844*

(e) Interaction : potassium (K) X zinc (Zn).

	(i)	K	mean	K-(i)
(i)	17,4219	17,6875	17,5547	0,2656
Zn	17,6250	17,4062	17,5156	-0,2188
mean	17,5234	17,5469	17,5352	0,0235
Zn-(i)	0,2031	- 0,2813	- 0,0391	-0,4844*

		Marginal means.	Body of table.	Interaction.
L.S.D.	(0,05)	0,2375	0,3359	0,4750
	(0,01)	0,3168	0,4480	0,6336

TABLE 40.

ACIDITY (%) OF FRUIT IN MID SEASON OF PLANT CROP FOLLOWING THE APPLICATION OF FERTILIZERS AND SOIL FUMIGANTS : SIGNIFICANT MAIN EFFECT AND INTERACTION TABLES AS REFLECTED BY ANALYSIS OF VARIANCE.

(a) Main effect of potassium.

No potassium	0,9312	C.V.	= 7,8%
Potassium	0,9806	L.S.D.	(0,05) 0,0267
	0,0494**		(0,01) 0,0356

(b) Interaction : fumigation (F) X iron (Fe).

	(i)	F	mean	F-(i)
(i)	0,9741	0,9381	0,9561	-0,0360
Fe	0,9447	0,9669	0,9558	0,0222
mean	0,9594	0,9525	0,9559	-0,0069
Fe-(i)	-0,0294	0,0288	-0,0003	0,0582*

(c) Interaction : potassium (K) X zinc (Zn).

	(i)	K	mean	K-(i)
(i)	0,9528	0,9681	0,9605	0,0153
Zn	0,9097	0,9931	0,9514	0,0834**
mean	0,9312	0,9806	0,9559	0,0494**
Zn-(i)	-0,0431*	0,0250	0,0091	0,0681*

		Marginal means.	Body of table.	Interaction.
L.S.D.	(0,05)	0,0267	0,0377	0,0533
	(0,01)	0,0356	0,0503	0,0711

TABLE 41.

AVAILABLE PHOSPHORUS IN THE SOIL AFTER RATOON CROP FOLLOWING THE APPLICATION OF FERTILIZERS AND SOIL FUMIGANTS : SIGNIFICANT MAIN EFFECT AND INTERACTION TABLES AS REFLECTED BY ANALYSIS OF VARIANCE.

(a) Main effect of soil fumigation.

No fumigation	13,7344	C.V. =	46,6%
Fumigation	9,8437	L.S.D.	(0,05) 1,9532
	- 3,8907**		(0,01) 2,6048

(b) Main effect of iron.

No iron	12,7969
Iron	10,7812
	- 2,0157*

(c) Main effect of phosphorus.

No phosphorus	8,8906
Phosphorus	14,6875
	5,7969**

(d) Interaction : fumigation (F) X potassium (K).

	(i)	F	mean	F-(i)
(i)	11,8125	10,6875	11,2500	-1,1250
K	15,6563	9,0000	12,3281	-6,6563**
mean	13,7344	9,8437	11,7891	-3,8907**
K-(i)	3,8438**	- 1,6875	1,0781	-5,5313**

(e) Interaction : phosphorus (P) X iron (Fe).

	(i)	P	mean	P-(i)
(i)	8,9062	16,6875	12,7969	7,7813**
Fe	8,8750	12,6875	10,7812	3,8125**
mean	8,8906	14,6875	11,7891	5,7969**
Fe-(i)	-0,0312	- 4,0000**	- 2,0157*	-3,9688*

		Marginal means.	Body of table.	Interaction.
L.S.D.	(0,05)	1,9532	2,7623	3,9064
	(0,01)	2,6048	3,6837	5,2095

TABLE 42.

AVAILABLE POTASSIUM IN THE SOIL AFTER RATOON CROP FOLLOWING THE APPLICATION OF FERTILIZERS AND SOIL FUMIGANTS : SIGNIFICANT MAIN EFFECT AND INTERACTION TABLES AS REFLECTED BY ANALYSIS OF VARIANCE.

(a) Main effect of fumigation.

No fumigation	57,3594	C.V.	= 21,6
Fumigation	40,6406	L.S.D.	(0,05) 3,7564
	-16,7188**		(0,01) 5,0094

(b) Main effect of applied potassium.

No potassium	43,0781
Potassium	54,9219
	11,8438**

(c) Interaction : fumigation (F) X potassium (K).

	(i)	F	mean	F-(i)
(i)	48,7812	37,3750	43,0781	-11,4062**
K	65,9375	43,9063	54,9219	-22,0312**
mean	57,3594	40,6406	49,0000	-16,7188**
K-(i)	17,1563**	6,5313*	11,8438**	-10,6250**

		Marginal means.	Body of table.	Interaction.
L.S.D.	(0,05)	3,7564	5,3123	7,5126
	(0,01)	5,0094	7,0842	10,0186

TABLE 43.

AVAILABLE MAGNESIUM IN THE SOIL AFTER RATOON CROP FOLLOWING THE APPLICATION OF FERTILIZERS AND SOIL FUMIGANTS : SIGNIFICANT MAIN EFFECT AND INTERACTION TABLES AS REFLECTED BY ANALYSIS OF VARIANCE.

(a) Main effect of fumigation.

No fumigation	32,6562	C.V.	= 38,0%
Fumigation	28,1250	L.S.D.	(0,05) 4,1017
	- 4,5312*		(0,01) 5,4698

TABLE 44.

A COMPARISON OF AVAILABLE NUTRIENTS IN THE SOIL BEFORE PLANTING AND AFTER COMPLETION OF THE FERTILIZER/FUMIGATION TRIAL.

Nutrients	Levels before planting (p.p.m.)	Levels after cycle (p.p.m.)	
P	10	14,6875*	8,8969**
K	210	54,9219*	43,0781**
Ca	228	55,0781	
Mg	154	30,3906	
pH(N-KCl)	4,1	3,4773	

* Samples from plots where P and K had been applied.

** Samples from plots where P and K were not applied.

TABLE 45.

LEAF-N CONCENTRATION (%) AFTER FLOWER DIFFERENTIATION FOR PLANT CROP FOLLOWING THE APPLICATION OF FERTILIZERS AND SOIL FUMIGANTS : SIGNIFICANT MAIN EFFECT AND INTERACTION TABLES AS REFLECTED BY ANALYSIS OF VARIANCE.

(a) Main effect of fumigation.

No fumigation	1,2306	C.V. = 15,5%
Fumigation	1,3250	L.S.D. (0,05) 0,0704
	0,0944**	(0,01) 0,0939

(b) Main effect of high nitrogen.

Low nitrogen	1,2083
High nitrogen	1,3473
	0,1390**

TABLE 46.

LEAF-P CONCENTRATION (%) AFTER FLOWER DIFFERENTIATION FOR PLANT CROP FOLLOWING THE APPLICATION OF FERTILIZERS AND SOIL FUMIGANTS : SIGNIFICANT MAIN EFFECT AND INTERACTION TABLES AS REFLECTED BY ANALYSIS OF VARIANCE.

(a) Main effect of fumigation.

No fumigation	0,1380	C.V. = 14,9%
Fumigation	0,1572	L.S.D. (0,05) 0,0078
	0,0192**	(0,01) 0,0104

(b) Main effect of applied phosphorus.

No phosphorus	0,1416
Phosphorus	0,1536
	0,0120**

(c) Main effect of high nitrogen.

Low nitrogen	0,1519
High nitrogen	0,1433
	-0,0086*

TABLE 47.

LEAF-K CONCENTRATION (%) AFTER FLOWER DIFFERENTIATION FOR PLANT CROP FOLLOWING THE APPLICATION OF FERTILIZERS AND SOIL FUMIGANTS : SIGNIFICANT MAIN EFFECT AND INTERACTION TABLE AS REFLECTED BY ANALYSIS OF VARIANCE.

(a) Main effect of applied potassium.

No potassium	1,5319	C.V. =	9,3%
Potassium	1,7664	L.S.D.	(0,05) 0,0544
	0,2345**		(0,01) 0,0725

(b) Interaction : fumigation (F) X potassium (K).

	(i)	F	mean	F-(i)
(i)	1,5631	1,5006	1,5319	-0,0625
K	1,7191	1,8137	1,7664	0,0946*
mean	1,6411	1,6572	1,6491	0,0161
K-(i)	0,1560**	0,3131**	0,2345**	0,1571**

		Marginal means.	Body of table.	Interaction.
L.S.D.	(0,05)	0,0544	0,0769	0,1087
	(0,01)	0,0725	0,1026	0,1450

TABLE 48.

LEAF-Ca CONCENTRATION (%) AFTER FLOWER DIFFERENTIATION FOR THE PLANT CROP FOLLOWING THE APPLICATION OF FERTILIZERS AND SOIL FUMIGANTS : SIGNIFICANT MAIN EFFECT AND INTERACTION TABLES AS REFLECTED BY ANALYSIS OF VARIANCE.

(a) Main effect of fumigation.

No fumigation	0,0414	C.V. = 22,8%	
Fumigation	0,0767	L.S.D. (0,05)	0,0048
	0,0353**	(0,01)	0,0064

(b) Main effect of applied phosphorus.

No phosphorus	0,0559
Phosphorus	0,0622
	0,0063*

(c) Main effect of applied iron.

No iron	0,0566
Iron	0,0616
	0,0050*

(d) Main effect of applied potassium.

No potassium	0,0700
Potassium	0,0481
	-0,0219**

(e) Interaction : fumigation (F) X potassium (K).

	(i)	F	mean	F-(i)
(i)	0,0494	0,0906	0,0700	0,0412**
K	0,0334	0,0628	0,0481	0,0294**
mean	0,0414	0,0767	0,0591	0,0353**
K-(i)	-0,0160**	-0,0278**	-0,0219**	-0,0118*

		Marginal means.	Body of table.	Interaction.
L.S.D.	(0,05)	0,0048	0,0068	0,0096
	(0,01)	0,0064	0,0090	0,0127

TABLE 49.

LEAF-Mg CONCENTRATION (%) AFTER FLOWER DIFFERENTIATION FOR THE PLANT CROP FOLLOWING THE APPLICATION OF FERTILIZERS AND SOIL FUMIGANTS : SIGNIFICANT MAIN EFFECT AND INTERACTION TABLES AS REFLECTED BY ANALYSIS OF VARIANCE.

(a) Main effect of fumigation.

No fumigation	0,1272	C.V.	= 16,1%
Fumigation	0,1370	L.S.D.	(0,05) 0,0076
	0,0098*		(0,01) 0,0101

(b) Main effect of potassium.

No potassium	0,1359
Potassium	0,1283
	-0,0076*

TABLE 50.

LEAF-Mn CONCENTRATION (p.p.m.) AFTER FLOWER DIFFERENTIATION FOR THE PLANT CROP FOLLOWING THE APPLICATION OF FERTILIZERS AND SOIL FUMIGANTS : SIGNIFICANT MAIN EFFECT AND INTERACTION TABLES AS REFLECTED BY ANALYSIS OF VARIANCE.

(a) Interaction : fumigation (F) X potassium (K).

	(i)	F	mean	F-(i)
(i)	172	136	154	-36**
K	168	188	178	20
mean	170	162	166	-8
K-(i)	- 4	52**	24	56*

C.V. = 42,3%

		Marginal means.	Body of table.	Interaction.
L.S.D.	(0,05)	25	35	49
	(0,01)	33	47	66

TABLE 51.

LEAF-Fe CONCENTRATION (p.p.m.) AFTER FLOWER DIFFERENTIATION FOR THE PLANT CROP FOLLOWING THE APPLICATION OF FERTILIZERS AND SOIL FUMIGANTS : SIGNIFICANT MAIN EFFECT AND INTERACTION TABLES AS REFLECTED BY ANALYSIS OF VARIANCE.

(a) Interaction : phosphorus (P) X high nitrogen (N).

	(i)	P	mean	P-(i)
(i)	35,3125	33,7500	34,5312	-1,5625
N	27,8125	42,5000	35,1563	14,6875**
mean	31,5625	38,1250	34,8438	6,5625
N-(i)	- 7,5000	8,7500	0,6251	16,2500*

(b) Interaction : phosphorus (P) X zinc (Zn).

	(i)	P	mean	P-(i)
(i)	35,3125	32,5000	33,9062	-2,8125
Zn	27,8125	43,7500	35,7813	15,9375**
mean	31,5625	38,1250	34,8438	6,5625
Zn-(i)	-7,5000	11,2500*	1,8751	18,7500**

C.V. = 55,2%

		Marginal means.	Body of table.	Interaction.
L.S.D.	(0,05)	6,8301	9,6592	13,6600
	(0,01)	9,1084	12,8812	18,2166

TABLE 52.

LEAF-Zn CONCENTRATION (p.p.m.) AFTER FLOWER DIFFERENTIATION FOR THE PLANT CROP FOLLOWING THE APPLICATION OF FERTILIZERS AND SOIL FUMIGANTS : SIGNIFICANT MAIN EFFECT AND INTERACTION TABLE AS REFLECTED BY ANALYSIS OF VARIANCE.

(a) Main effect of applied zinc.

No zinc	17,8594	C.V. = 28,4%	
Zinc	21,1719	L.S.D.	(0,05) 1,9722
	3,3125**		(0,01) 2,6300

TABLE 53.

LEAF-N CONCENTRATION (%) AFTER FLOWER DIFFERENTIATION FOR THE RATOON CROP FOLLOWING THE APPLICATION OF FERTILIZERS AND SOIL FUMIGANTS : SIGNIFICANT MAIN EFFECT AND INTERACTION TABLES AS REFLECTED BY ANALYSIS OF VARIANCE.

(a) Main effect of fumigation.

No fumigation	1,1683	C.V. = 7,9%
Fumigation	1,1142	L.S.D. (0,05) 0,0321
	-0,0541**	(0,01) 0,0428

(b) Main effect of high nitrogen.

Low nitrogen	1,0697
High nitrogen	1,2128
	0,1431**

TABLE 54.

LEAF-P CONCENTRATION (%) AFTER FLOWER DIFFERENTIATION FOR THE RATOON CROP FOLLOWING THE APPLICATION OF FERTILIZERS AND SOIL FUMIGANTS : SIGNIFICANT MAIN EFFECT AND INTERACTION TABLES AS REFLECTED BY ANALYSIS OF VARIANCE.

(a) Main effect of high nitrogen.

Low nitrogen	0,1408	C.V. = 15,6%
High nitrogen	0,1192	L.S.D. (0,05) 0,0072
	-0,0216**	(0,01) 0,0096

(b) Main effect of applied phosphorus.

No phosphorus	0,1228
Phosphorus	0,1372
	0,0144**

(c) Main effect of applied iron.

No iron	0,1348
Iron	0,1252
	-0,0096**

(d) Main effect of applied zinc.

No zinc	0,1381
Zinc	0,1219
	-0,0162**

TABLE 55.

LEAF-K CONCENTRATION (%) AFTER FLOWER DIFFERENTIATION FOR THE RATOON CROP FOLLOWING THE APPLICATION OF FERTILIZERS AND SOIL FUMIGANTS : SIGNIFICANT MAIN EFFECT AND INTERACTION TABLES AS REFLECTED BY ANALYSIS OF VARIANCE.

(a) Main effect of fumigation.

No fumigation	2,1272	C.V. = 13,7%
Fumigation	1,9923	L.S.D. (0,05) 0,1000
	-0,1349**	(0,01) 0,1334

(b) Main effect of applied zinc.

No zinc	2,1228
Zinc	1,9967
	-0,1261*

(c) Main effect of applied potassium.

No potassium	1,8692
Potassium	2,2503
	0,3811**

(d) Interaction : fumigation (F) X high nitrogen (N).

	(i)	F	mean	F-(i)
(i)	2,0734	2,0928	2,0831	0,0194
N	2,1809	1,8919	2,0364	-0,2890**
mean	2,1272	1,9923	2,0598	-0,1349**
N-(i)	0,1075	-0,2009**	-0,0467	-0,3084**

(e) Interaction : potassium (K) X zinc (Zn).

	(i)	K	mean	K-(i)
(i)	1,9850	2,2606	2,1228	0,2756**
Zn	1,7534	2,2400	1,9967	0,4866**
mean	1,8692	2,2503	2,0598	0,3811**
Zn-(i)	-0,2316**	-0,0206	-0,1261*	0,2110*

	Marginal means.	Body of table.	Interaction.
L.S.D. (0,05)	0,1000	0,1415	0,2001
(0,01)	0,1334	0,1887	0,2668

TABLE 56.

LEAF-Ca CONCENTRATION (%) AFTER FLOWER DIFFERENTIATION FOR THE RATOON CROP FOLLOWING THE APPLICATION OF FERTILIZERS AND SOIL FUMIGANTS : SIGNIFICANT MAIN EFFECT AND INTERACTION TABLES AS REFLECTED BY ANALYSIS OF VARIANCE.

(a) Main effect of fumigation.

No fumigation	0,2291	C.V. = 17,0%	
Fumigation	0,3108	L.S.D. (0,05)	0,0163
	0,0817**	(0,01)	0,0217

(b) Main effect of applied potassium.

No potassium	0,2875
Potassium	0,2523
	-0,0352**

(c) Main effect of applied zinc.

No zinc	0,2783
Zinc	0,2616
	-0,0167*

(d) Interaction : potassium (K) X zinc (Zn).

	(i)	K	mean	K-(i)
(i)	0,3050	0,2516	0,2783	-0,0534**
Zn	0,2700	0,2531	0,2616	-0,0169
mean	0,2875	0,2523	0,2699	-0,0352**
Zn-(i)	-0,0350**	0,0015	-0,0167*	0,0365*

		Marginal -means.	Body of table.	Interaction.
L.S.D.	(0,05)	0,0163	0,0230	0,0325
	(0,01)	0,0217	0,0307	0,0434

TABLE 57.

LEAF-Mg CONCENTRATION (%) AFTER FLOWER DIFFERENTIATION FOR THE RATOON CROP FOLLOWING THE APPLICATION OF FERTILIZERS AND SOIL FUMIGANTS : SIGNIFICANT MAIN EFFECT AND INTERACTION TABLES AS REFLECTED BY ANALYSIS OF VARIANCE.

(a) Main effect of fumigation.

No fumigation	0,1783	C.V. = 15,0%	
Fumigation	0,2272	L.S.D.	(0,05) 0,0108
	0,0489**		(0,01) 0,0144

(b) Main effect of applied potassium.

No potassium	0,2128
Potassium	0,1927
	-0,0201**

(c) Main effect of high nitrogen.

Low nitrogen	0,2095
High nitrogen	0,1959
	-0,0136*

(d) Interaction : potassium (K) X zinc (Zn).

	(i)	K	mean	K-(i)
(i)	0,2228	0,1912	0,2070	-0,0316**
Zn	0,2028	0,1941	0,1984	-0,0087
mean	0,2128	0,1927	0,2027	-0,0201**
Zn-(i)	-0,0200*	0,0029	-0,0086	0,0229*

		Marginal means.	Body of table.	Interaction.
L.S.D.	(0,05)	0,0108	0,0152	0,0214
	(0,01)	0,0143	0,0203	0,0287

TABLE 58.

LEAF-Mn CONCENTRATION (p.p.m.) AFTER FLOWER DIFFERENTIATION FOR THE RATOON CROP FOLLOWING THE APPLICATION OF FERTILIZERS AND SOIL FUMIGANTS : SIGNIFICANT MAIN EFFECT AND INTERACTION TABLES AS REFLECTED BY ANALYSIS OF VARIANCE.

(a) Main effect of fumigation.

No fumigation	397	C.V. = 19,5%
Fumigation	531	L.S.D. (0,05) 32
	134**	(0,01) 43

(b) Main effect of high nitrogen.

Low nitrogen	420
High nitrogen	508
	88**

(c) Main effect of phosphorus.

No phosphorus	481
Phosphorus	447
	- 34*

(d) Interaction : fumigation (F) X iron (Fe).

	(i)	F	mean	F-(i)
(i)	374	549	462	175**
Fe	419	514	467	95**
mean	397	531	464	134**
Fe-(i)	45	-35	5	-80*

	Marginal means.	Body of table.	Interaction.
L.S.D. (0,05)	32	46	55
(0,01)	43	61	86

TABLE 59.

LEAF-Fe CONCENTRATION (p.p.m.) AFTER FLOWER DIFFERENTIATION FOR THE RATOON CROP FOLLOWING THE APPLICATION OF FERTILIZERS AND SOIL FUMIGANTS : SIGNIFICANT MAIN EFFECT AND INTERACTION TABLES AS REFLECTED BY ANALYSIS OF VARIANCE.

(a) Main effect of high nitrogen.

Low nitrogen	18,6563	C.V. = 11,5%	
High nitrogen	17,8125	L.S.D. (0,05)	0,7472
	-0,8438*	(0,01)	0,9964

(b) Main effect of applied iron.

No iron	17,4062
Iron	19,0625
	1,6563**

(c) Main effect of applied potassium.

No potassium	17,8125
Potassium	18,6563
	0,8438*

(d) Interaction : high nitrogen (N) X potassium (K).

	(i)	N	mean	N-(i)
(i)	18,6875	16,9375	17,8125	-1,7500**
K	18,6250	18,6875	18,6563	0,0625
mean	18,6563	17,8125	18,2344	-0,8438*
K-(i)	-0,0625	1,7500**	0,8438*	1,8125*

		Marginal means.	Body of table.	Interaction.
L.S.D.	(0,05)	0,7471	1,0566	1,4942
	(0,01)	0,9964	1,4091	1,9927

TABLE 60.

LEAF-Zn CONCENTRATION (p.p.m.) AFTER FLOWER DIFFERENTIATION FOR THE RATOON CROP FOLLOWING THE APPLICATION OF FERTILIZERS AND SOIL FUMIGANTS : SIGNIFICANT MAIN EFFECT AND INTERACTION TABLES AS REFLECTED BY ANALYSIS OF VARIANCE.

(a) Main effect of zinc.

No zinc	22,1875	C.V. = 18,9%	
Zinc	26,3281	L.S.D. (0,05)	1,6319
	4,1406**	(0,01)	2,1763

(b) Interaction : phosphorus (P) X zinc (Zn).

	(i)	P	mean	P-(i)
(i)	22,6250	21,7500	22,1875	-0,8750
Zn	24,5312	28,1250	26,3281	3,5938**
mean	23,5781	24,9375	24,2578	1,3594
Zn-(i)	1,9062	6,3750**	4,1406**	4,4688**

		Marginal means.	Body of table.	Interaction.
L.S.D.	(0,05)	1,6319	2,3079	3,2639
	(0,01)	2,1763	3,0777	4,3524

TABLE 61.

MEAN COUNTS OF PLANT PARASITIC NEMATODES PER 100 ml SOIL IN SAMPLES TAKEN ON DIFFERENT DATES FOLLOWING THE APPLICATION OF SOIL FUMIGANTS IN THE FERTILIZER/FUMIGATION TRIAL.

Sampling dates.		Helicotylenchus.	Meloidogyne.	Trichodorus.	Total
20.8.65	Initial count	312	48	16	376
19.3.66	Treated	3±3	Nil	1±1	4±3
	Untreated	259±97	3±3	4±3	266±85
30.3.67	Treated	6±4	Nil	4±3	10±4
	Untreated	695±119	96±42	2±2	793±98
3.2.69	Treated	26±13	48±10	3±3	77±8
	Untreated	312±69	184±62	2±2	498±104
18.2.70	Treated	290±88	207±71	6±4	503±119
	Untreated	259±78	247±66	6±3	512±115

TABLE 62.

MEAN COUNTS OF PLANT PARASITIC NEMATODES PER 100 ml SOIL IN SAMPLES TAKEN ON 3/2/69 IN THE FERTILIZER/FUMIGATION TRIAL : SIGNIFICANT MAIN EFFECT AND INTERACTION TABLES AS REFLECTED BY ANALYSIS OF VARIANCE.

(a) Main effect of fumigation.

No fumigation	504,6875	C.V.	= 90,7%	
Fumigation	77,5000	L.S.D.	(0,05)	93,7930
	-427,1875**		(0,01)	125,0794

TABLE 63.

MEAN WEIGHTS (kg) OF TWENTY PLANTS SAMPLED MONTHLY IN THREE PLANTATIONS - C 11, W1 AND W6.

Month	C 11	W1	W6
Jan.	-	-	0,37
Feb.	0,31	0,34	0,52
March	0,56	0,52	0,62
April	0,78	0,52	0,72
May	0,92	0,78	1,09
June	1,10	0,78	1,11
July	1,00	0,84	1,14
Aug.	1,02	0,98	1,35
Sept.	1,21	1,06	1,22
Oct.	1,21	1,10	1,34
Nov.	1,50	1,18	1,49
Dec.	1,53	1,48	1,63
Jan.	1,62	1,81	1,90
Feb.	2,39	2,44	2,11
March	2,45	2,56	2,62
April	3,04	2,76	2,71
May	3,32	3,40	3,10
June	3,21	3,40	3,09

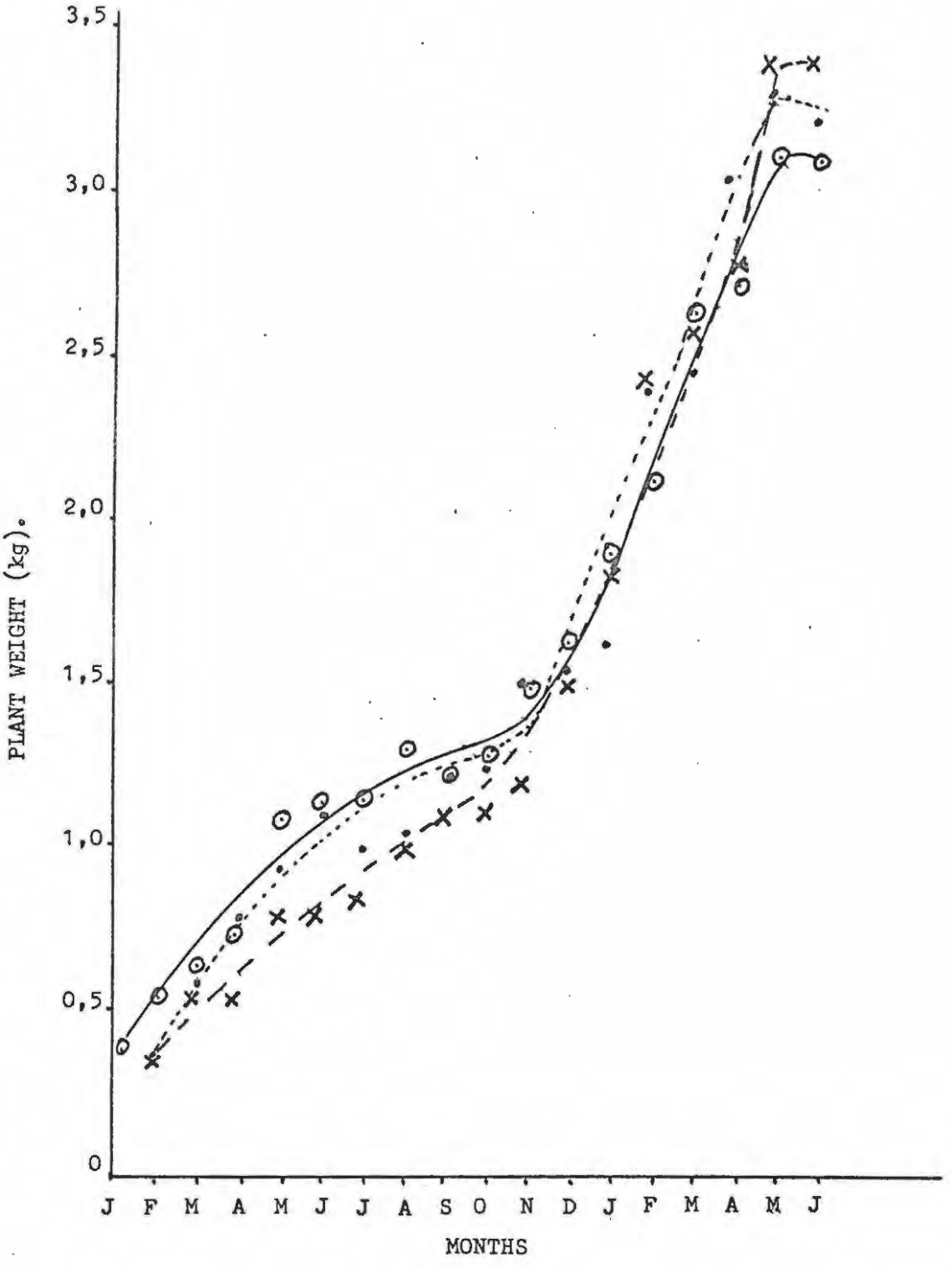

Fig. IV. Mean plant weights from samples taken monthly from plantations C11, W1 and W6.

.------. C11

x— — —x W1

o——— o W6

Plate VIII. Nine month old plants showing leaf die back which occurs during the winter months.

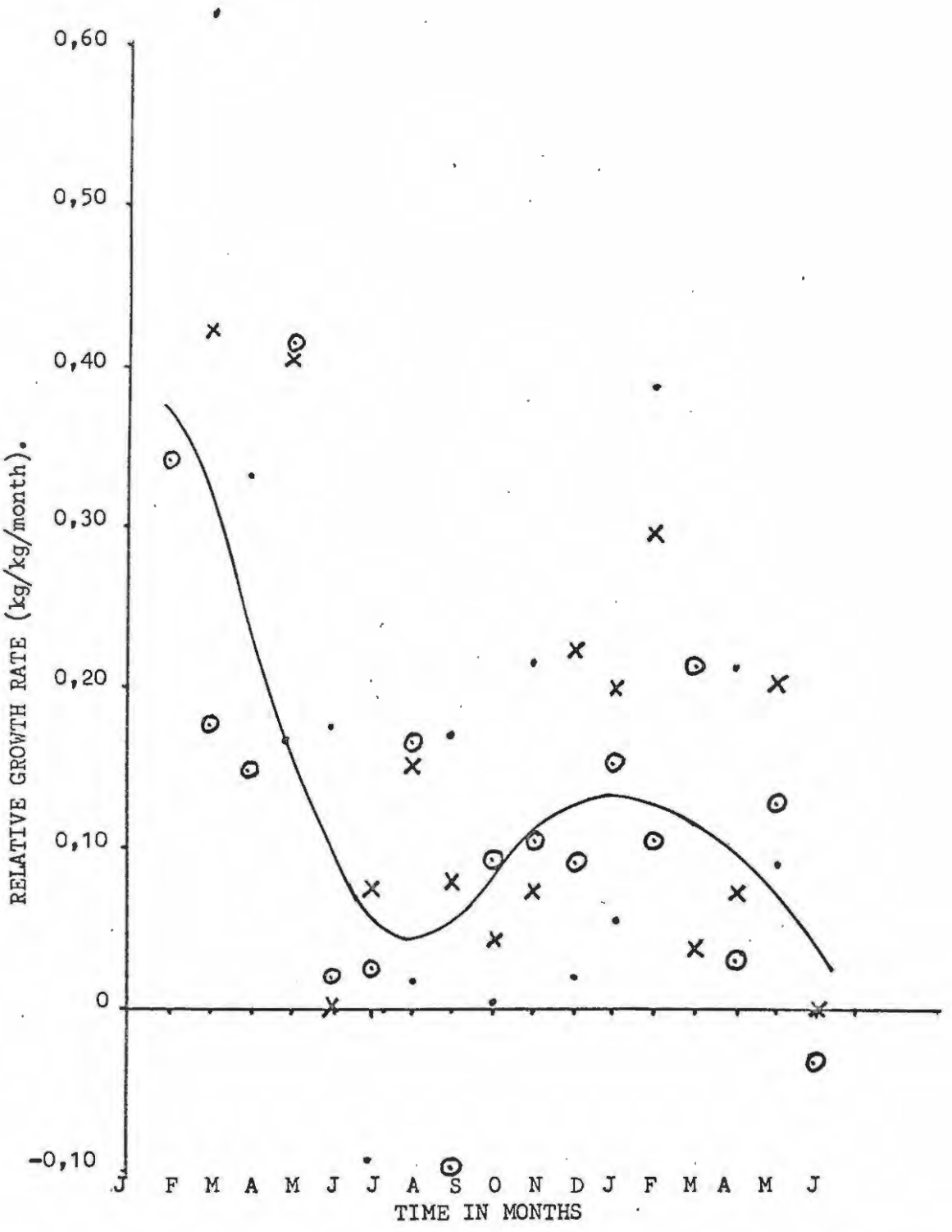

Fig. V. Mean relative growth rate for the three plantations C11, W1 and W6.

. C11

x W1

o W6

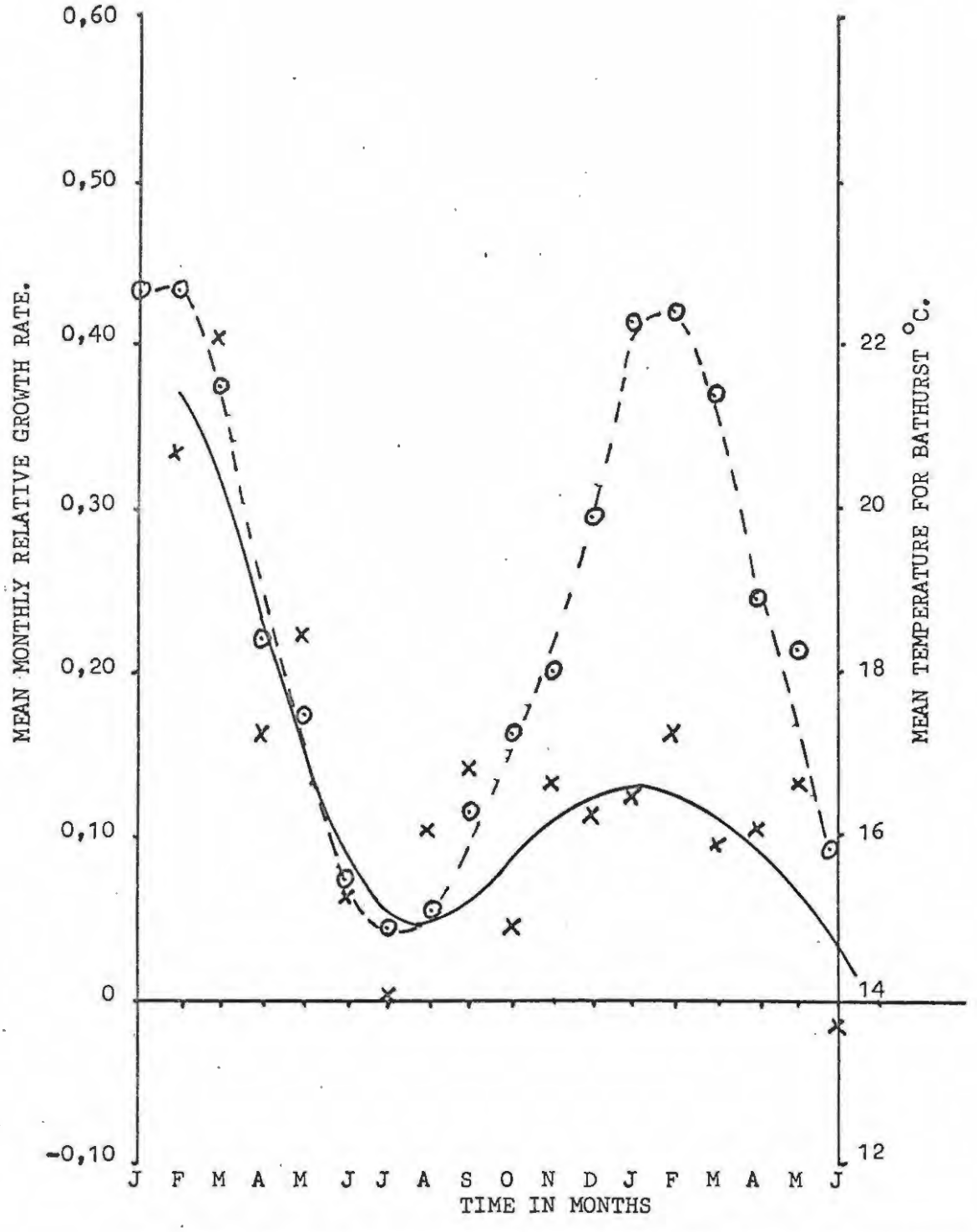

Fig. VI. Mean relative growth rate for the three plantations C11, W1 and W6 and mean monthly temperatures for Bathurst.

o— — —o Mean monthly temperature °C Bathurst.

x———x Mean monthly relative growth rate.

TABLE 64.

MEAN TEMPERATURES (°C) BATHURST FOR THE PERIODS OF GROWTH FROM PLANTING TO FLOWER DIFFERENTIATION OF PLANTS PLANTED IN PLANTATIONS C11, W1 AND W6.

	Nov. 1968 – June 1970	Nov. 1969 – June 1971
Nov.	23,0	18,9
Dec.	20,5	20,9
Jan.	22,1	23,2
Feb.	22,8	22,6
March	21,3	21,6
April	17,5	19,3
May	17,3	18,1
June	14,7	16,3
July	15,3	14,5
Aug.	17,3	14,8
Sept.	16,3	16,3
Oct.	18,3	16,3
Nov.	18,9	17,0
Dec.	20,9	18,9
Jan.	23,2	21,4
Feb.	22,6	22,0
March	21,6	21,2
April	19,3	18,4
May	18,1	17,0
June	16,3	15,5
Means first 6 months	19,9°C	20,0°C
Means latter 12 months	19,0°C	17,8°C

TABLE 65.

MEAN D-LEAF WEIGHTS (g) TAKEN MONTHLY FROM SAMPLING AREAS IN PLANTATIONS C11, W1 AND W6.

Month	C11	W1	W6
Jan.	–	--	11
Feb.	15	14	14
March	28	26	25
April	32	24	28
May	43	34	41
June	54	35	42
July	50	38	46
Aug.	51	44	55
Sept.	56	50	45
Oct.	60	50	56
Nov.	58	51	59
Dec.	49	48	55
Jan.	47	54	55
Feb.	57	65	54
March	60	68	62
April	73	64	69
May	71	74	72
June	74	76	77

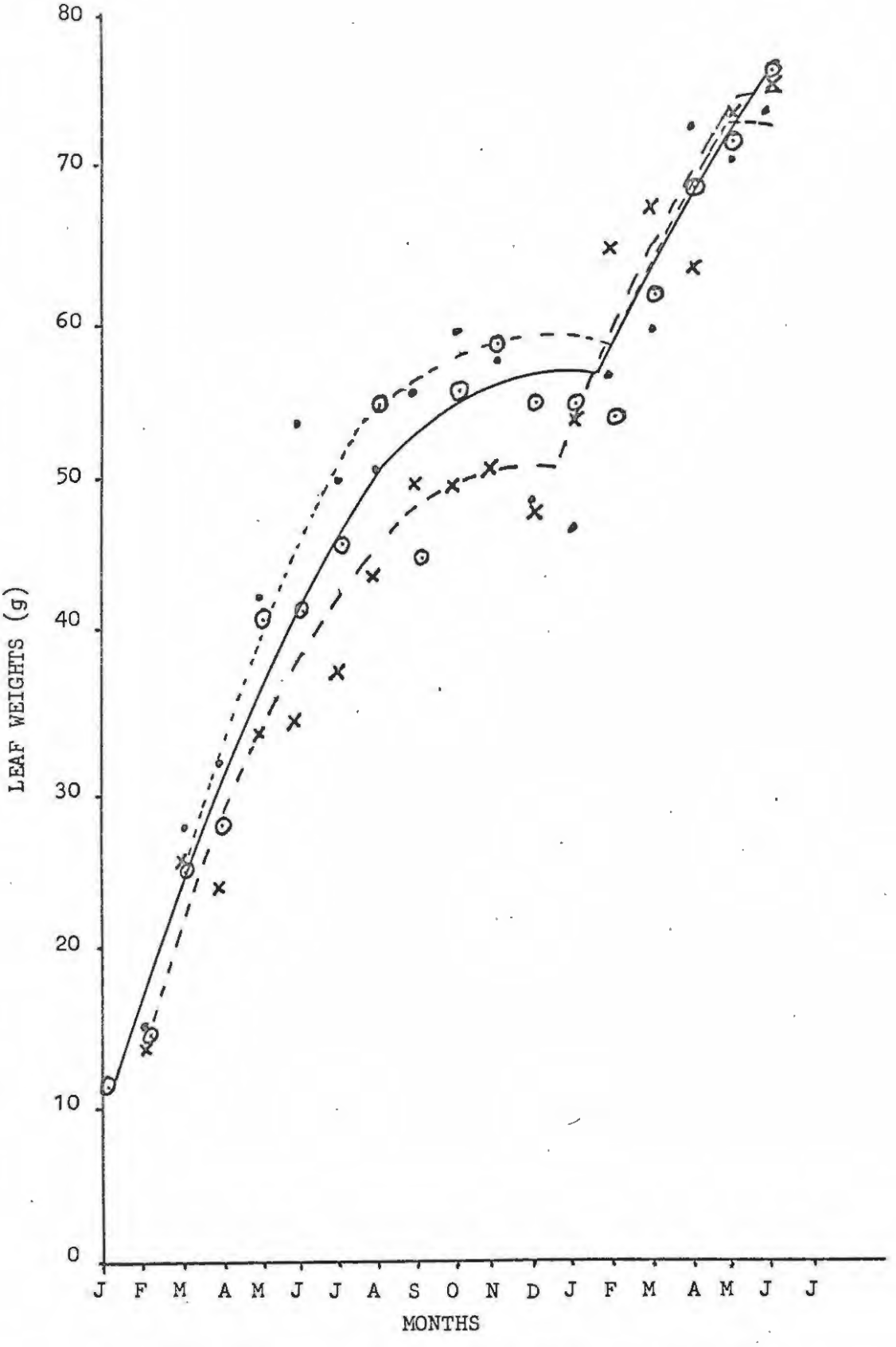

Fig. VII. Mean D-leaf weights of 80 leaves sampled monthly from plantations C11, W1 and W6.

.-----. C11

x— —x W1

o——— o W6

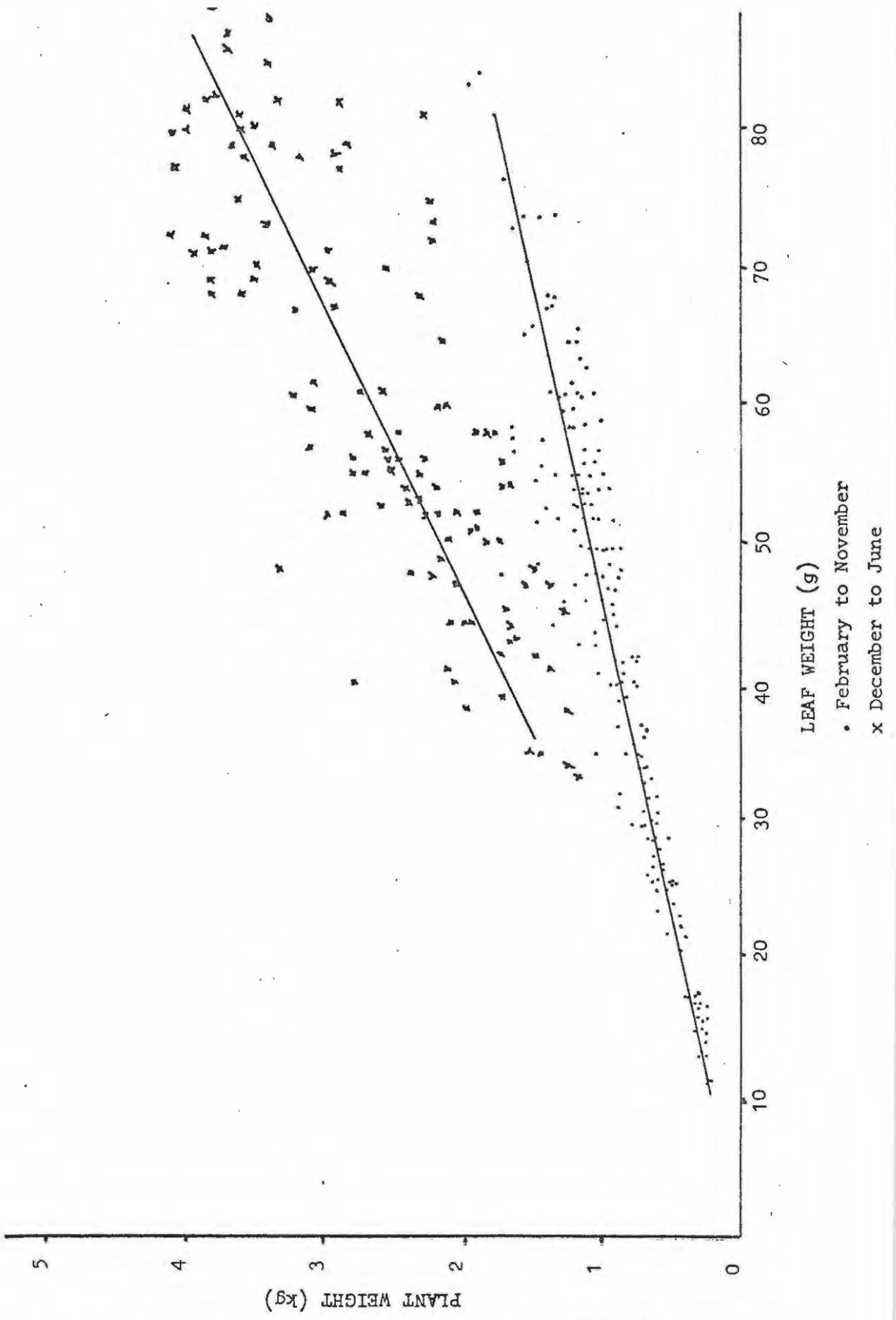

Fig. VIII. Scatter plot illustrating correlation between D-leaf weight and plant weight: Plantation C11

Correlation Coefficient: Feb. - Nov. +0,8908
Dec. - June +0,6483

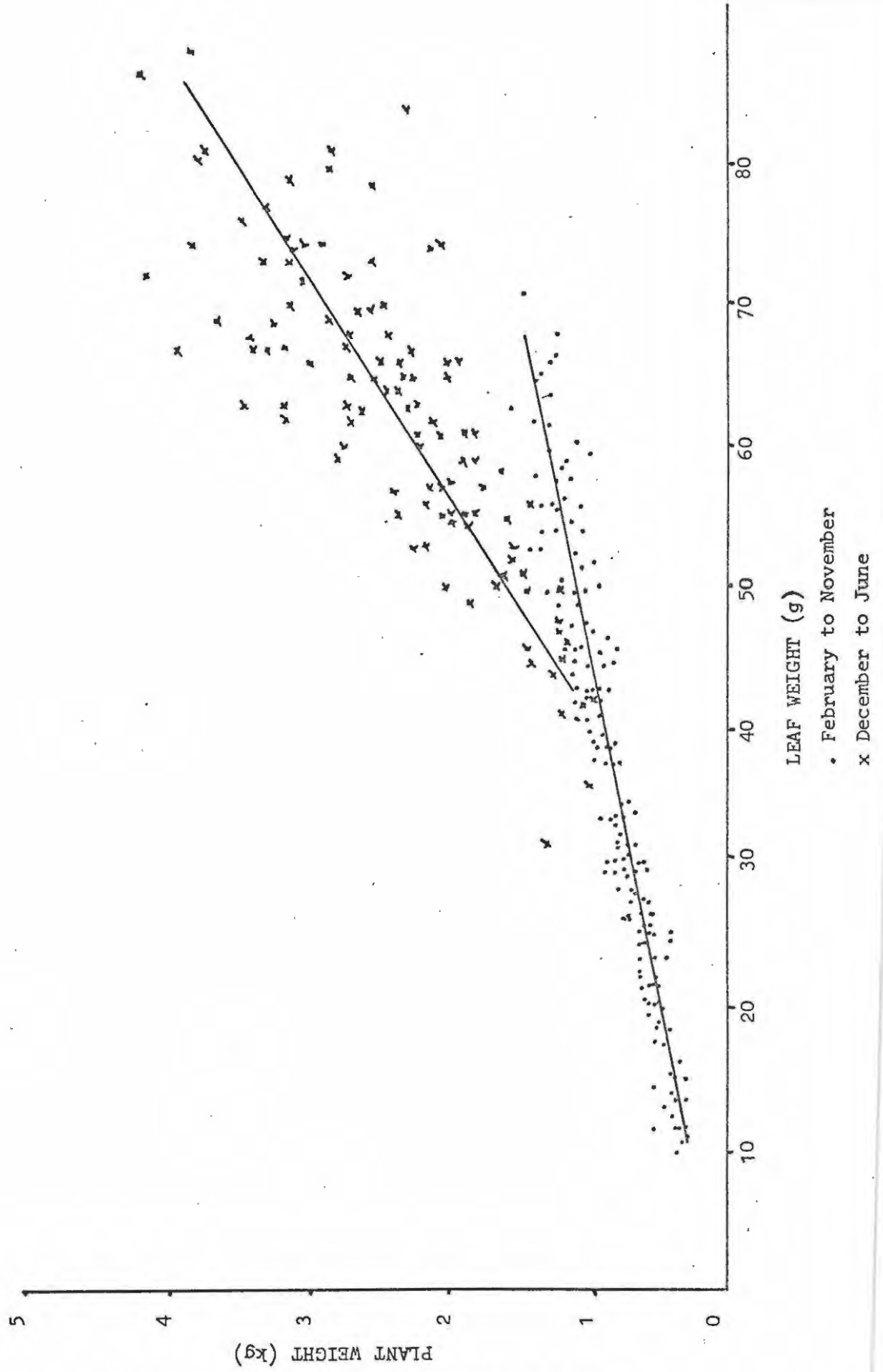

Fig. IX. Scatter plot illustrating correlation between D-leaf weight and plant weight: Plantation W1

Correlation Coefficient: Feb. - Nov. +0,8908
Dec. - June +0,6038

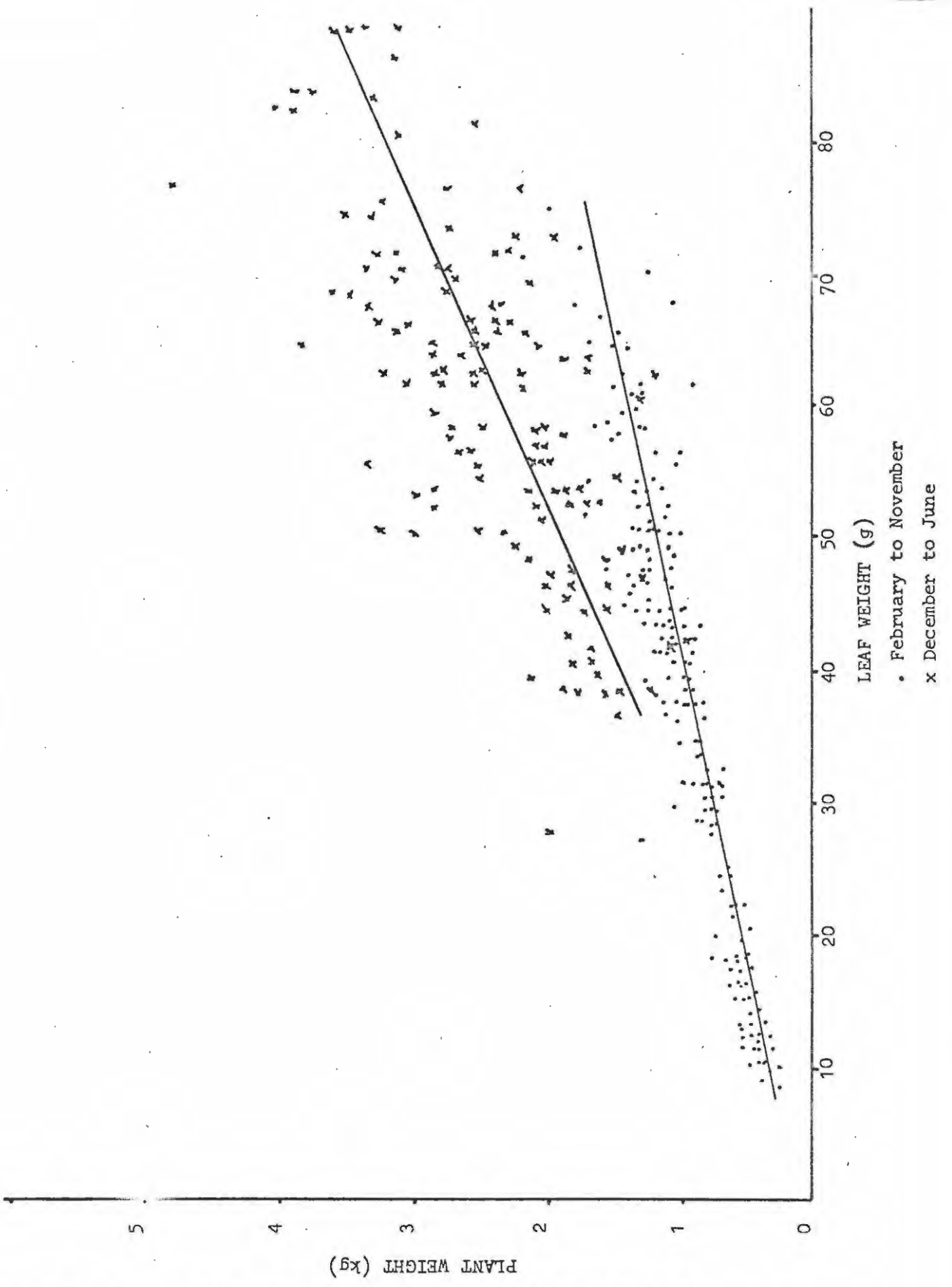

Fig. X. Scatter plot illustrating correlation between D-leaf weight and plant weight: Plantation W6.

Correlation Coefficient Feb. - Nov. +0,8403
Dec. - June +0,5546

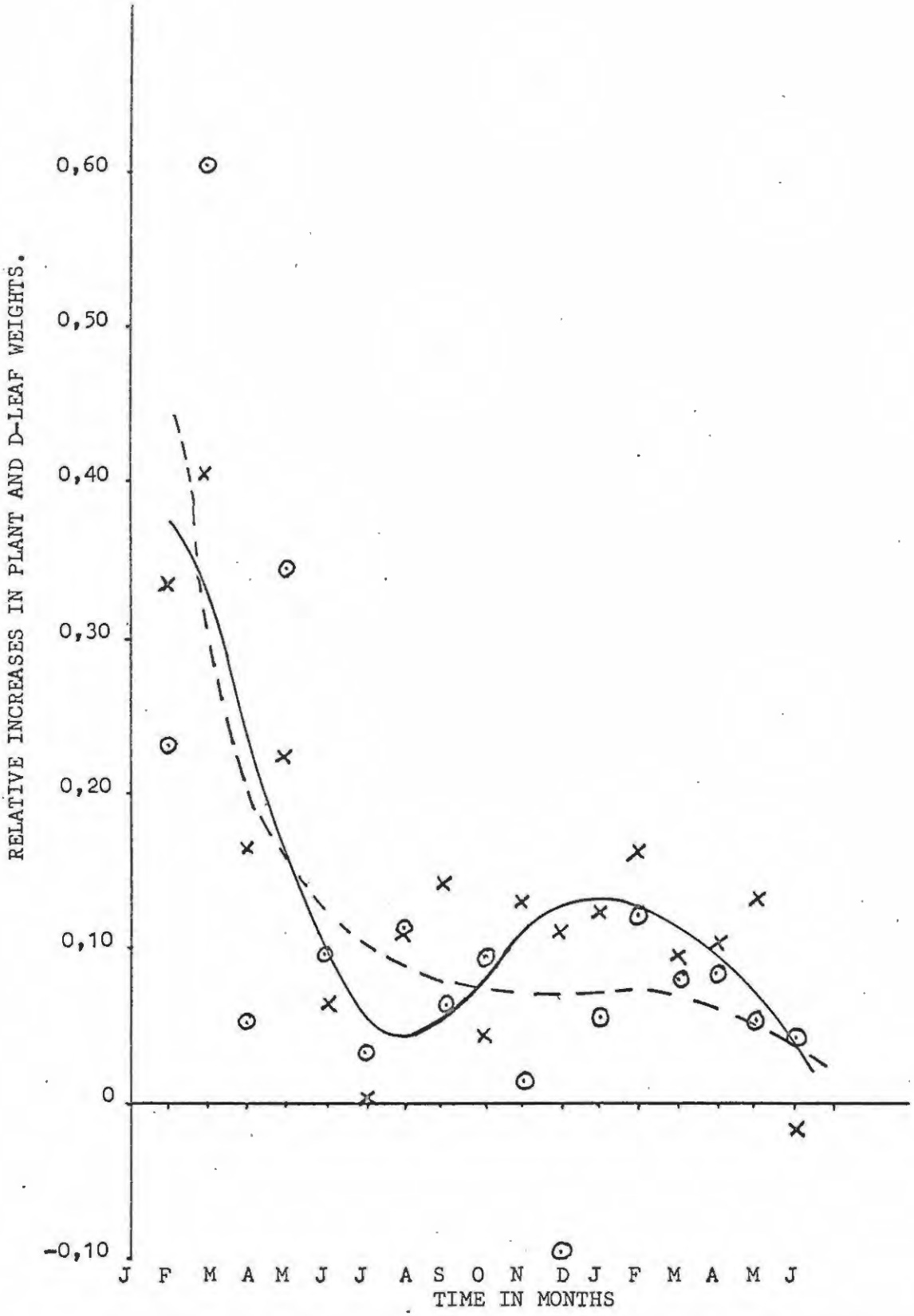

Fig. XI. Mean relative growth rates of plants in plantations C11, W1 and W6 as determined by plant weight and D-leaf weight.

x———x Relative increase in plant weight.

o— ——o Relative increase in D-leaf weight.

TABLE 66.

MEAN NUTRIENT CONCENTRATIONS IN BASAL PORTION OF D-LEAVES SAMPLED MONTHLY IN PLANTATION C11.

	Percentage dry weight.					Parts per million dry weight.				
Month	N	P	K	Ca	Mg	Mn	Fe	Zn	Cu	Na
Feb.	2,18	0,159	4,08	1,080	0,374	52	26,5	13,7	8,1	0,053
March	2,39	0,245	5,53	0,849	0,397	69	24,5	19,1	14,1	0,030
April	1,81	0,201	4,39	0,617	0,354	70	31,3	14,3	13,6	0,033
May	1,84	0,209	3,18	0,543	0,295	87	24,1	15,0	9,1	0,029
June	1,53	0,187	3,29	0,350	0,228	65	20,8	14,0	9,3	0,013
July	1,37	0,172	2,32	0,296	0,179	51	23,5	14,7	4,6	0,007
Aug.	1,10	0,122	1,89	0,188	0,144	41	14,1	9,4	4,5	0,009
Sept.	1,12	0,153	1,84	0,218	0,148	47	13,8	11,9	5,4	0,012
Oct.	1,19	0,115	1,95	0,207	0,137	26	13,2	12,2	5,5	0,011
Nov.	1,38	0,205	2,61	0,215	0,233	76	17,2	15,0	8,8	0,008
Dec.	1,19	0,192	1,99	0,341	0,230	53	18,8	21,0	13,6	0,007
Jan.	1,83	0,229	3,02	0,410	0,317	31	19,5	31,4	17,5	0,006
Feb.	2,13	0,255	3,23	0,700	0,457	68	24,7	29,5	16,3	0,007
March	1,92	0,235	3,48	0,555	0,422	76	26,1	21,6	9,9	0,013
April	1,79	0,257	4,03	0,683	0,622	116	23,1	25,6	12,6	0,008
May	1,91	0,226	5,14	0,673	0,640	93	20,2	19,2	10,9	0,005
June	1,50	0,179	2,10	0,484	0,305	82	18,5	19,0	12,0	0,006

TABLE 67.

MEAN NUTRIENT CONCENTRATION IN BASAL PORTION OF D-LEAVES SAMPLED MONTHLY IN PLANTATION W1.

	Percentage dry weight.					Parts per million dry weight.				
Month	N	P	K	Ca	Mg	Mn	Fe	Zn	Cu	Na
Feb.	1,93	0,161	5,36	0,970	0,434	302	28,6	15,0	10,0	0,041
March	2,28	0,170	6,32	0,897	0,346	461	30,0	21,5	15,5	0,039
April	1,79	0,140	5,27	0,780	0,360	204	26,8	14,2	10,5	0,045
May	2,01	0,224	4,30	0,499	0,233	176	26,9	17,9	10,5	0,022
June	1,78	0,226	4,25	0,397	0,216	118	22,2	14,4	10,6	0,012
July	1,66	0,194	3,00	0,382	0,180	158	25,6	14,5	6,9	0,010
Aug.	1,56	0,171	2,38	0,349	0,194	112	16,0	10,8	10,2	0,009
Sept.	1,46	0,144	2,56	0,272	0,158	95	14,2	11,0	8,0	0,010
Oct.	1,52	0,171	2,63	0,313	0,192	116	22,8	14,1	15,1	0,011
Nov.	1,63	0,240	3,46	0,344	0,229	102	19,6	20,8	14,9	0,010
Dec.	1,44	0,274	3,74	0,459	0,298	57	28,2	33,5	21,2	0,010
Jan.	1,67	0,275	3,18	0,496	0,343	95	19,0	32,0	19,1	0,006
Feb.	1,50	0,244	2,90	0,529	0,376	101	21,2	30,6	13,4	0,006
March	1,34	0,223	2,58	0,512	0,458	101	19,6	26,4	13,0	0,009
April	1,70	0,230	3,53	0,673	0,511	159	23,6	24,9	13,7	0,008
May	1,18	0,171	4,75	0,491	0,695	122	16,2	18,6	12,9	0,007
June	1,27	0,155	2,10	0,319	0,262	128	17,8	21,0	12,9	0,008

TABLE 68.

MEAN NUTRIENT CONCENTRATION IN BASAL PORTION OF D-LEAVES SAMPLED MONTHLY IN PLANTATION W6.

	Percentage dry weight.					Parts per million dry weight.				
Month	N	P	K	Ca	Mg	Mn	Fe	Zn	Cu	Na
Jan	1,93	0,180	5,84	0,466	0,593	482	21,8	42,6	19,2	0,031
Feb.	2,65	0,254	6,28	0,980	0,728	986	40,0	72,7	12,2	0,024
March	2,58	0,307	6,16	0,612	0,598	664	33,7	38,4	16,1	0,046
April	2,40	0,301	4,30	0,449	0,617	955	37,5	33,1	13,8	0,028
May	1,90	0,256	3,38	0,482	0,476	498	23,8	24,4	14,9	0,014
June	1,62	0,224	2,63	0,391	0,351	423	20,4	20,8	13,7	0,017
July	1,33	0,192	1,86	0,203	0,313	294	18,0	16,1	10,5	0,013
Aug.	1,25	0,176	1,84	0,165	0,222	261	23,3	17,5	9,8	0,015
Sept.	1,20	0,142	1,47	0,120	0,197	398	17,5	12,3	9,7	0,013
Oct.	1,28	0,159	1,53	0,118	0,181	324	17,2	14,5	9,4	0,010
Nov.	1,28	0,158	2,03	0,073	0,156	177	13,5	12,3	8,5	0,010
Dec.	1,46	0,175	2,25	0,068	0,211	166	22,5	21,2	12,1	0,009
Jan.	1,41	0,252	2,88	0,205	0,227	421	28,7	19,5	13,8	0,010
Feb.	1,28	0,243	2,48	0,257	0,303	805	24,1	22,5	17,1	0,009
March	1,28	0,251	2,33	0,325	0,296	712	28,4	25,1	11,2	0,007
April	1,35	0,254	3,10	0,382	0,392	452	26,2	21,6	16,8	0,010
May	1,22	0,231	2,54	0,316	0,257	372	18,4	18,8	15,7	0,010
June	1,21	0,215	2,54	0,341	0,264	474	17,3	20,0	15,4	0,009

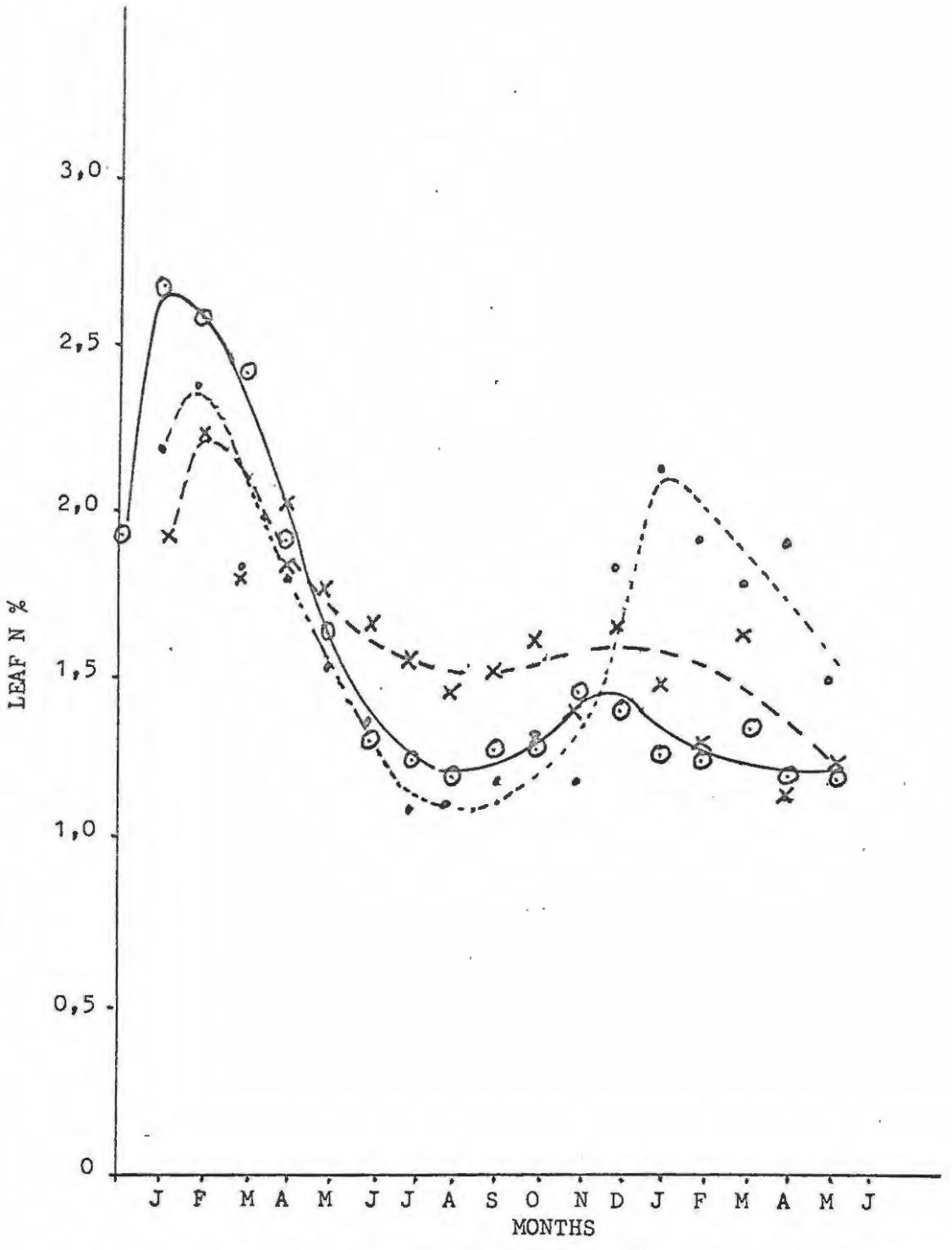

Fig. XII. Seasonal variation in nitrogen concentration of D-leaves sampled in plantations C11, W1 and W6.

•- - - - • C11

x— — —x W1

o———o W6

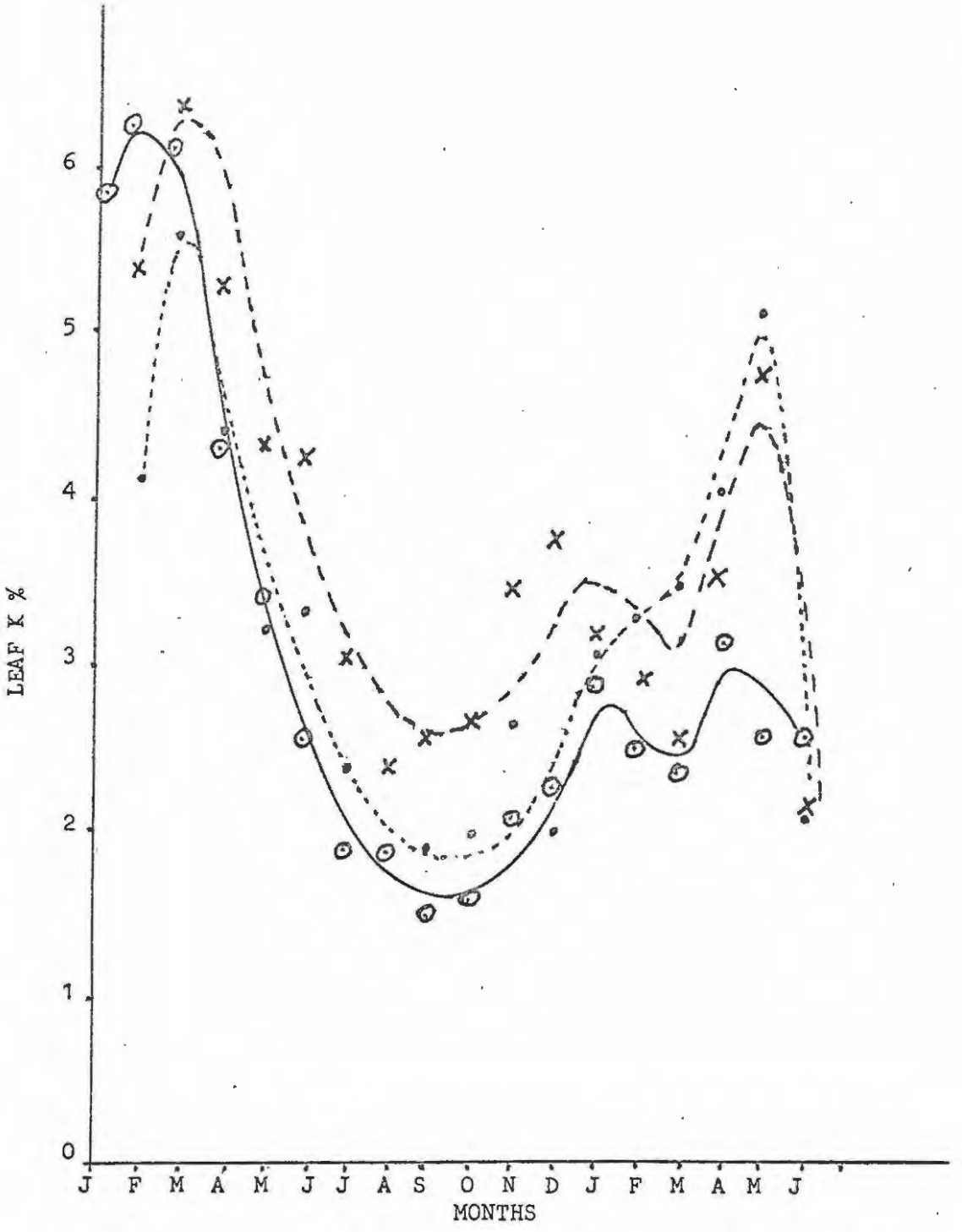

Fig. XIII. Seasonal variation in potassium concentration of D-leaves in plantations C11, W1 and W6.

.- - - - - . C11

x — — x W1

o ——— o W6

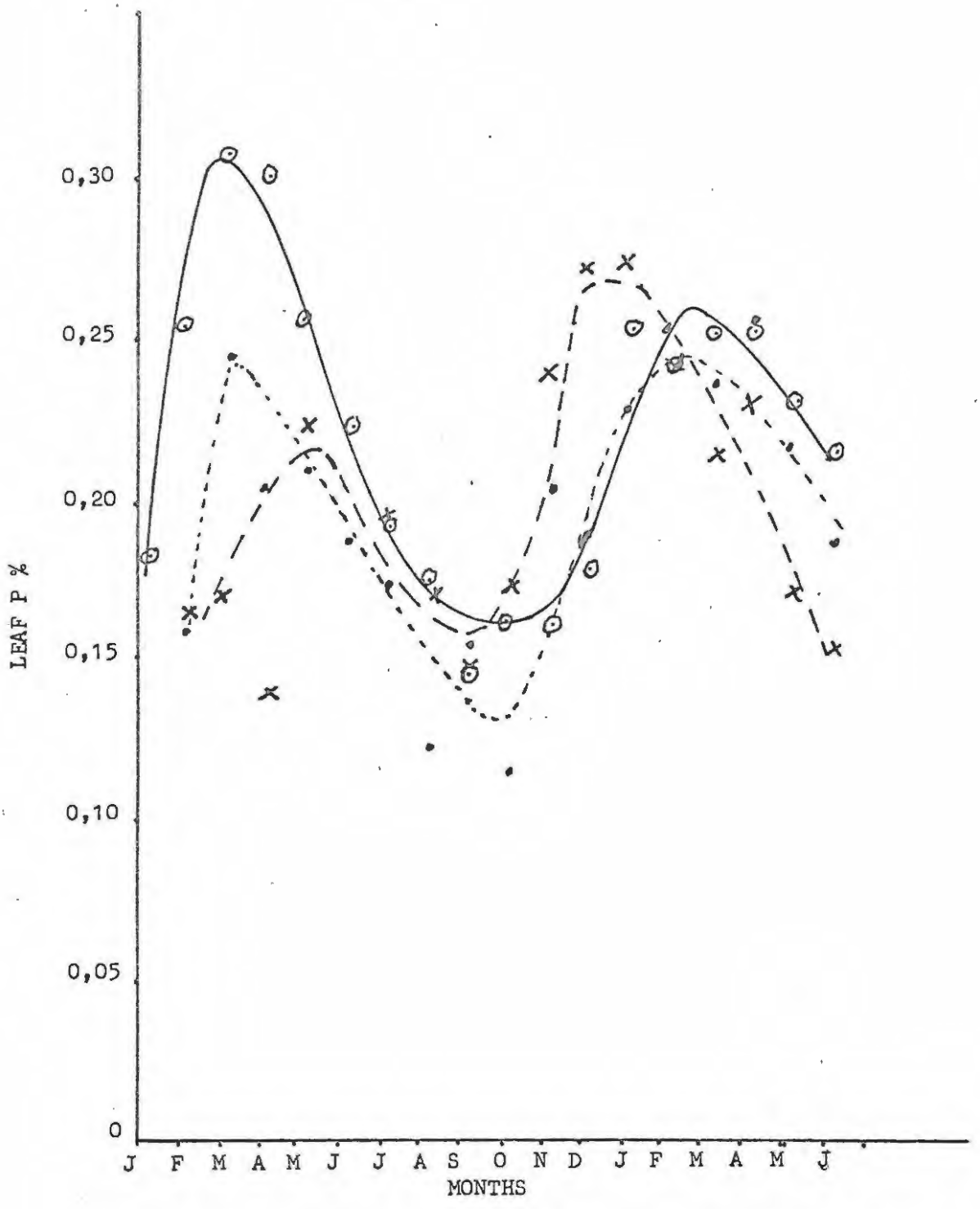

Fig. XIV. Seasonal variation in phosphorus concentration of D-leaves in plantations C11, W1 and W6.

.------. C11

x— —x W1

o———o W6

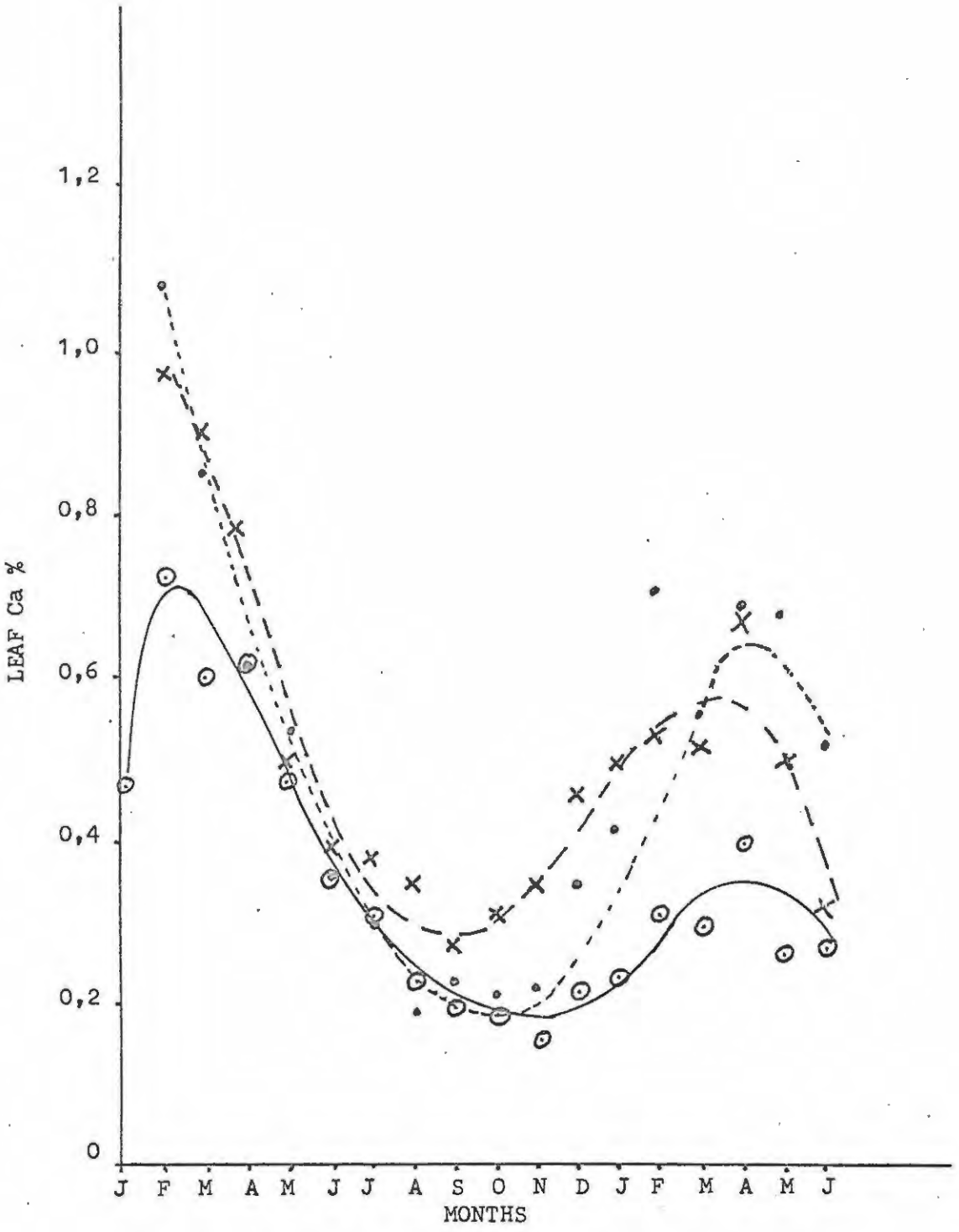

Fig. XV. Seasonal variation in calcium concentration of D-leaves in plantations C11, W1 and W6.

C11
W1
W6

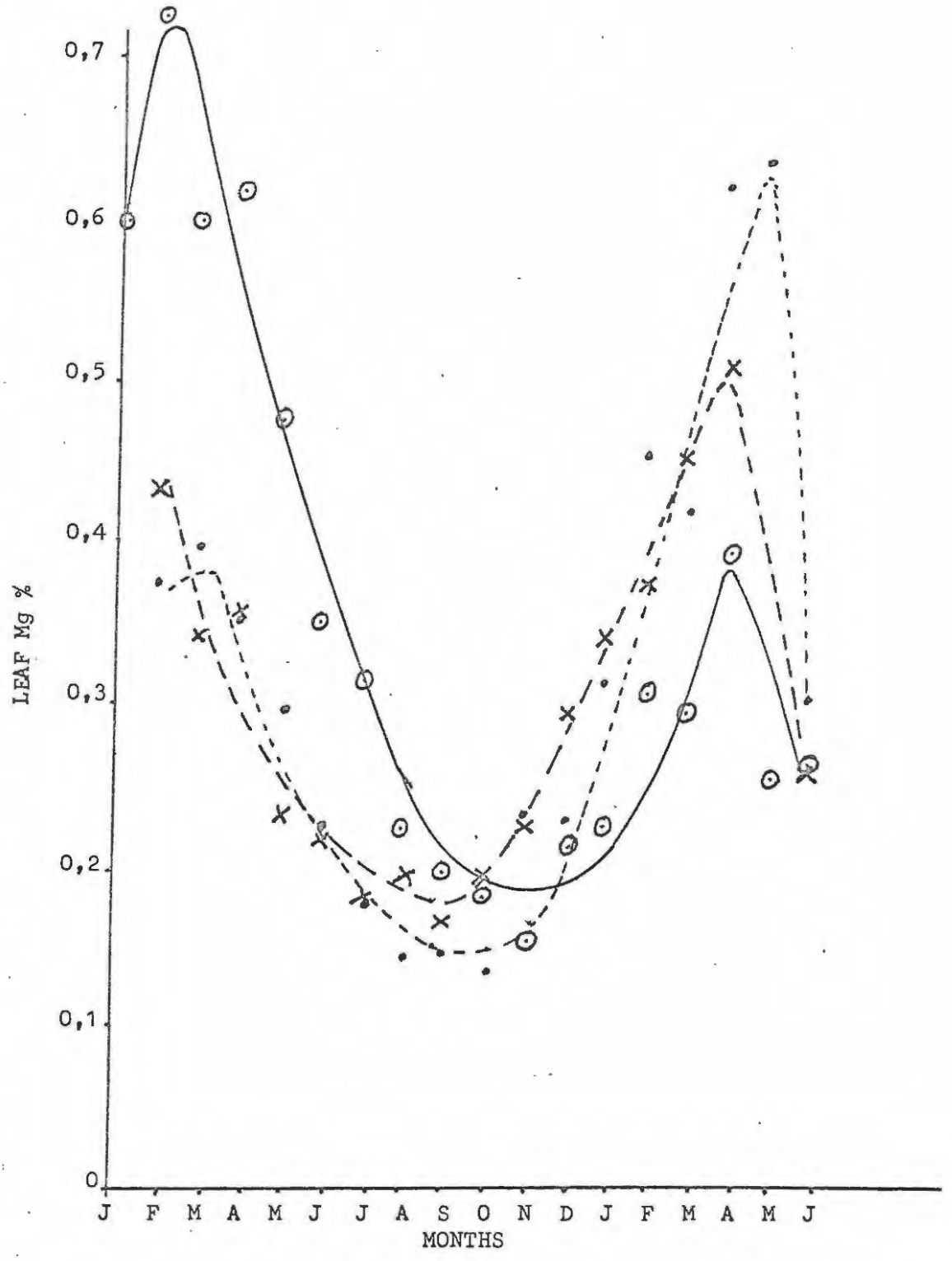

Fig. XVI. Seasonal variations in magnesium concentration of D-leaves in plantations C11, W1 and W6.

.-----. C11

x— —x W1

o——— o W6

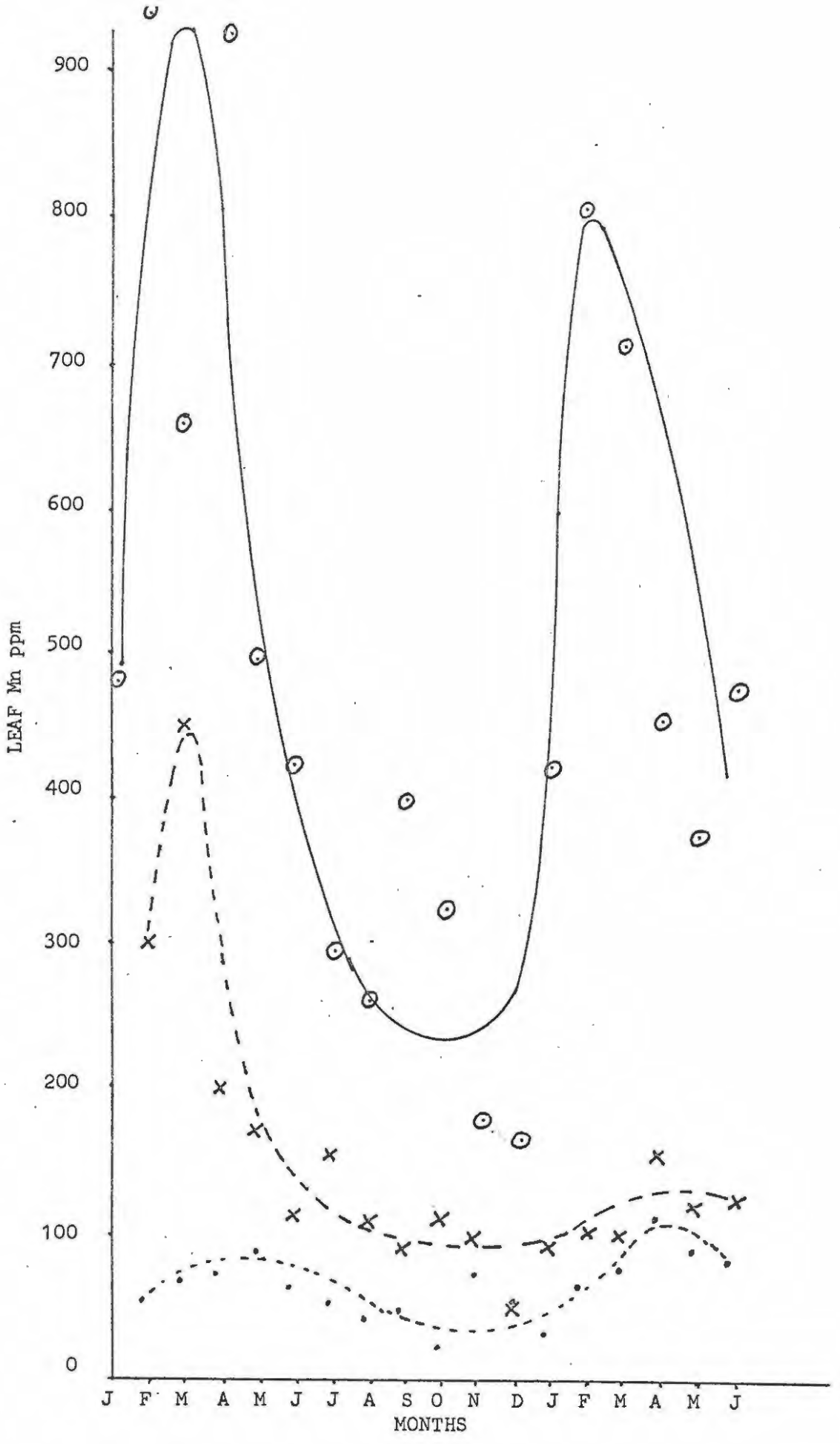

Fig. XVII. Seasonal variations in manganese concentration of D-leaves in plantations C11, W1 and W6.

•------• C11

x— —x W1

o———o W6

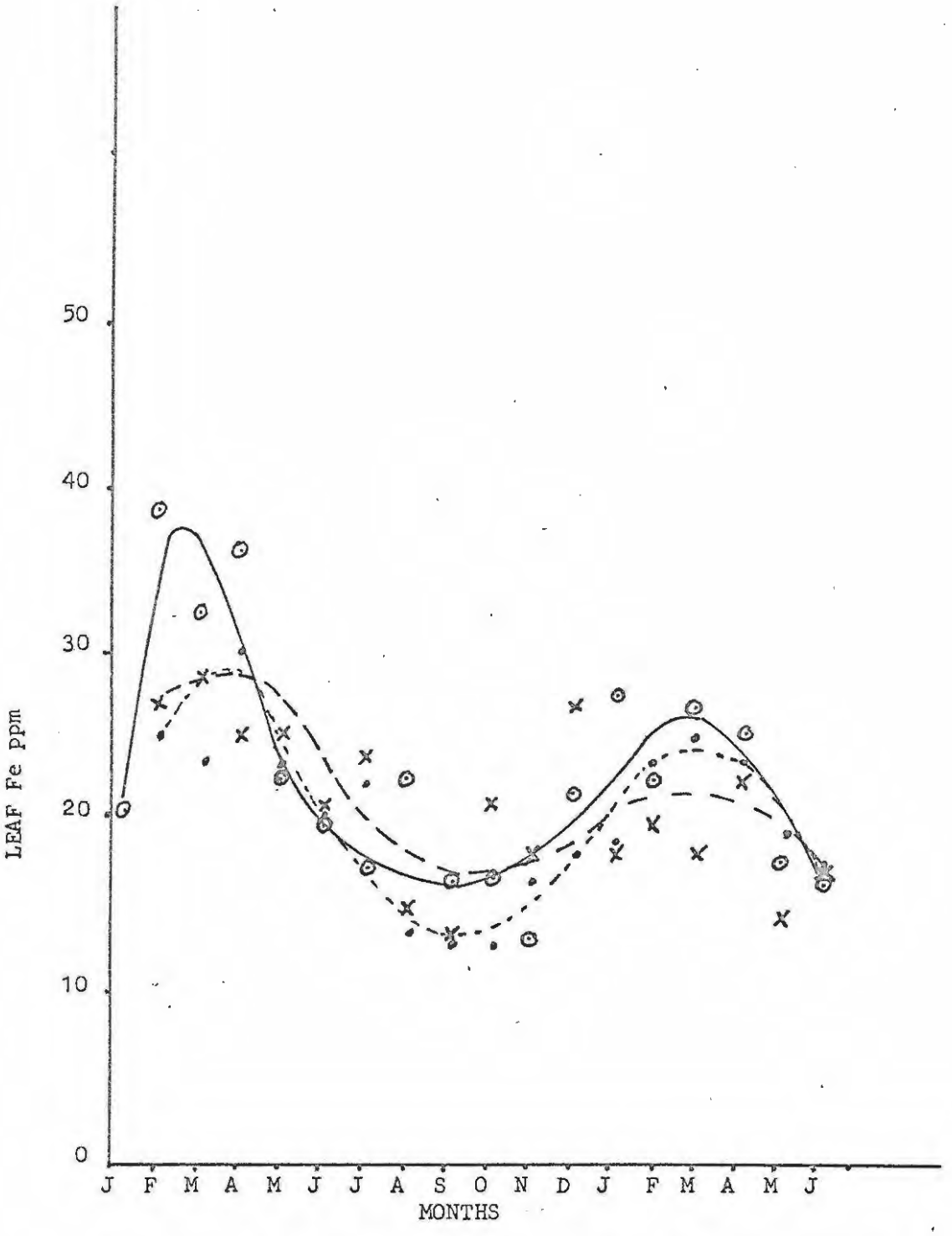

Fig. XVIII. Seasonal variations in iron concentration of D-leaves in plantations C11, W1 and W6.

•- - - - -• C11

x— — —x W1

o———o W6

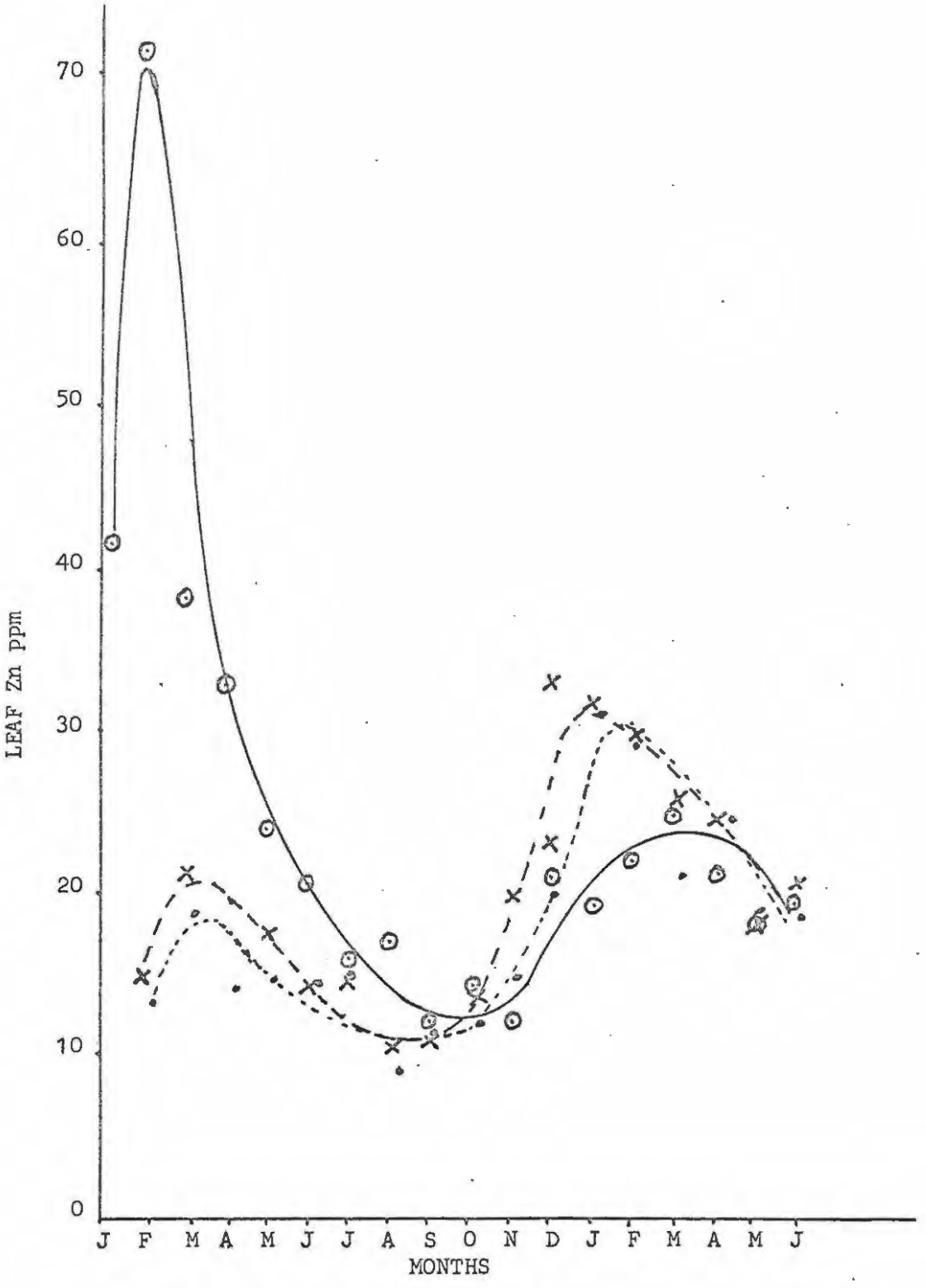

Fig. XIX. Seasonal variations in zinc concentration of D-leaves in plantations C11, W1 and W6.

.- - - - - . C11

x— —x W1

o———o W6

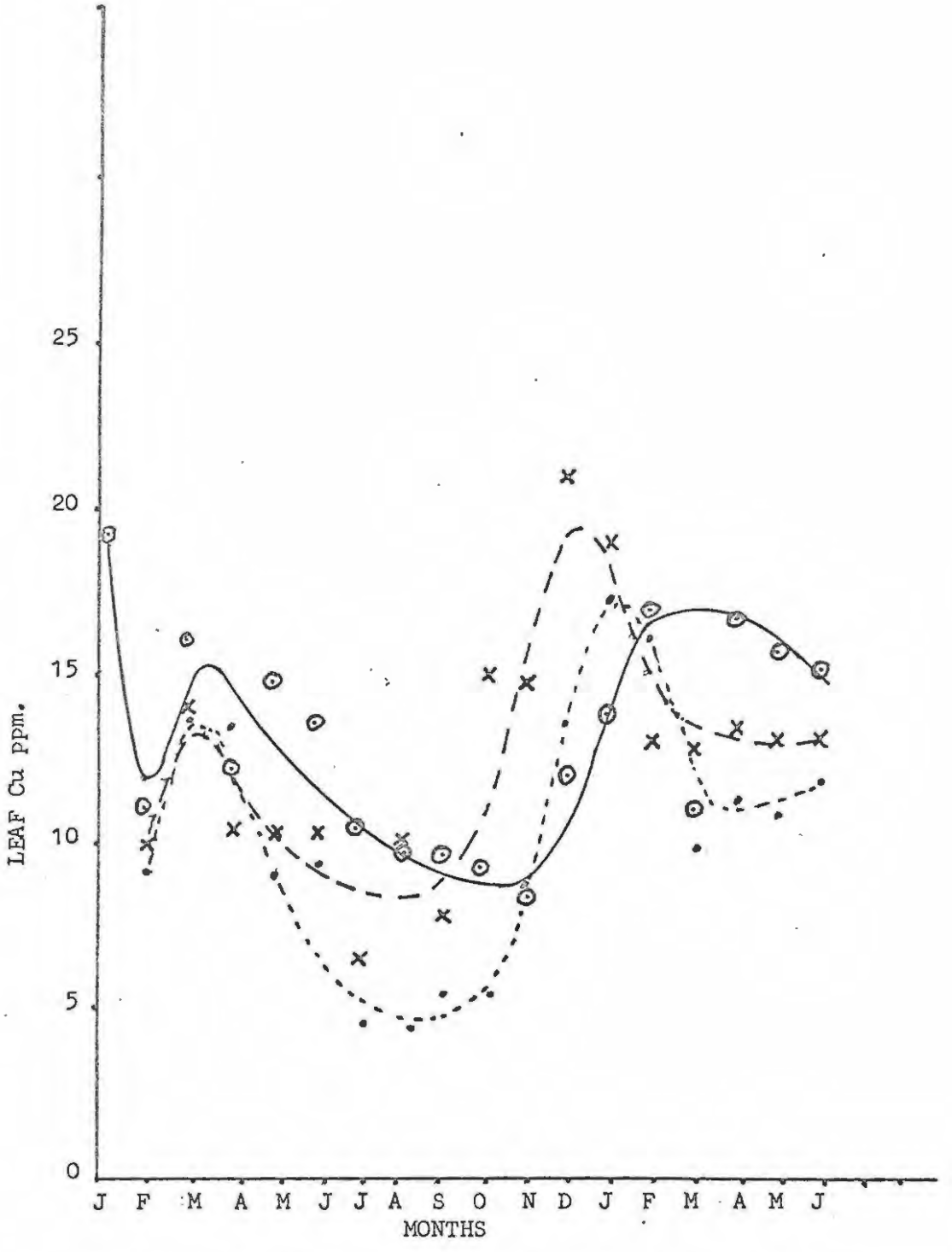

Fig. XX. Seasonal variations in copper concentration of D-leaves in plantations C11, W1 and W6.

.------. C11

x— —x W1

o——— o W6

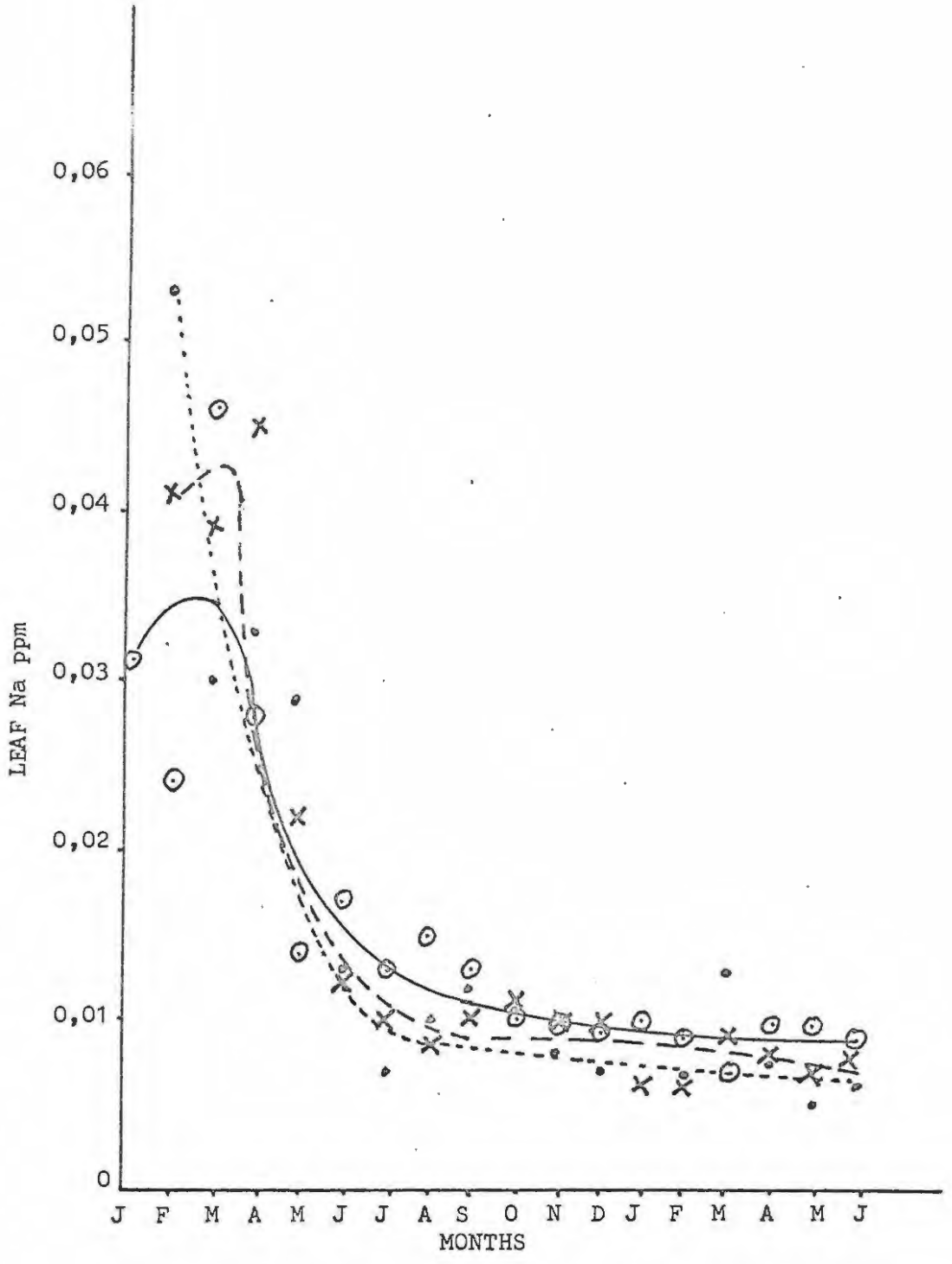

Fig. XXI. Seasonal variations in sodium concentration of D-leaves in plantations C11, W1 and W6.

•------• C11

x— — -x W1

o———o W6

TABLE 69.

FERTILIZER/FUMIGATION TRIAL.

SAMPLE SHEET FROM COMPUTER DATA.

LEAF ANALYSIS PLANT CROP POTASSIUM.

ANALYSIS OF VARIANCE.

SOURCE	DF	SUMS OF SQUARES
BLOCKS	15	0,9320
A	1	0,0083
B	1	0,0155
AB	1	0,0524
C	1	0,0297
A C	1	0,0020
BC	1	0,0006
ABC	1	0,0285
D	1	1,7601 **
A D	1	0,1976 **
B D	1	0,0532
AB D	1	0,0056
CD	1	0,0169
A CD	1	0,0027
BCD	1	0,0354
ABCD	1	0,0021
E	1	0,0009
A E	1	0,0202
B E	1	0,0002
AB E	1	0,0001
C E	1	0,0453
A C E	1	0,0765
BC E	1	0,0003
ABC E	1	0,1345 *
DE	1	0,0000
A DE	1	0,0004
B DE	1	0,0500
AB DE	1	0,0001
CDE	1	0,0054
A CDE	1	0,0016
BCDE	1	0,2652 **
ABCDE	1	0,0403
F	1	0,0012
A F	1	0,0002
B F	1	0,0142
AB F	1	0,0153
C F	1	0,0103
A C F	1	0,0315
BC F	1	0,0020
ABC F	1	0,0001
D F	1	0,0122
A D F	1	0,1319 *
B D F	1	0,0812

TABLE 69 CONTINUED.

Sample Sheet From Computer Data Continued.

SOURCE	DF	SUMS OF SQUARES
AB D F	1	0,0002
CD F	1	0,0791
A CD F	1	0,0565
BCD F	1	0,0765
ABCD F	1	0,0178
EF	1	0,0020
A EF	1	0,0020
B EF	1	0,0143
AB EF	1	0,0785
C EF	1	0,0588
A C EF	1	0,0141
BC EF	1	0,0005
ABC EF	1	0,0086
DEF	1	0,0035
A DEF	1	0,0451
B DEF	1	0,0045
AB DEF	1	0,0016
CDEF	1	0,0322
A CDEF	1	0,0018
BCDEF	1	0,0039
ABCDEF	1	0,1158 *
ERROR	49	1,1480
TOTAL	127	5,8490

SE = 0,1531 MEAN = 1,6491 C.V. = 9,2818%

A = applied fumigation. a

B = applied phosphorus. b

C = applied high nitrogen. c

D = applied potassium. d

E = applied iron. e

F = applied zinc f

TABLE 70.

FERTILIZER/FUMIGATION TRIAL.

MEAN PLANT WEIGHT (kg), D-LEAF WEIGHTS (g) AND ROOT WEIGHT (g) RECORDED ONE AND TWO YEARS FROM PLANTING.

2^6 FACTORIAL

Replication III ABC BDE ADF CEF ACDE BCDF ABEF confounded.

		At one year			At two years		
		Plant wt. (kg)	D-leaf wt. (g)	Root wt. (g)	Plant wt. (kg)	D-leaf wt. (g)	Root wt. (g)
	abf	1,49	48,0	62,4	3,37	70	78
	abde	1,41	49,7	61,3	3,42	75	108
	df	72	33,9	36,7	2,18	73	56
1	acef	1,25	55,2	50,7	3,25	71	85
	e	90	47,4	37,6	2,36	68	50
	bc	74	36,1	36,1	3,50	61	41
	bcdef	99	44,6	41,5	2,76	67	51
	acd	1,45	69,2	51,2	4,01	75	67
	aef	1,27	59,4	57,1	3,15	69	60
	abcf	1,30	60,9	50,5	3,40	70	67
	cdf	62	38,5	28,7	2,49	66	51
	ce	75	41,1	34,1	2,37	65	52
2	b	97	44,3	32,8	2,79	62	37
	abcde	1,20	60,9	42,9	3,64	77	61
	bdef	92	47,2	32,8	2,64	66	45
	ad	1,46	65,6	47,7	3,62	71	71
	bcd	85	39,4	40,0	2,20	62	51
	bcef	70	35,5	40,0	2,01	63	46
	de	71	39,3	37,5	2,18	69	55
	abe	1,23	64,2	52,0	3,36	67	62
3	acdef	1,25	58,9	45,3	3,80	76	110
	ac	1,26	57,1	43,0	3,01	70	78
	f	67	36,2	31,4	2,18	60	43
	abdf	1,55	69,1	46,3	3,55	72	87
	ace	1,22	60,0	45,9	3,37	69	67
	ef	93	46,8	34,1	2,66	59	39
	d	94	50,0	35,2	2,53	62	42
4	abdef	1,37	68,1	44,2	3,45	67	65
	acdf	1,44	67,8	47,5	3,68	74	70
	ab	1,44	69,9	44,6	3,44	70	55
	bcde	80	40,5	28,5	2,55	66	50
	bcf	74	37,1	32,1	2,15	58	38

TABLE 70 CONTINUED.

Plant weight, D-leaf weight and Root weight at 1 and 2 years continued.

Replication III continued.

		At one year			At two years		
		Plant wt. (kg)	D-leaf wt. (g)	Root wt. (g)	Plant wt. (kg)	D-leaf wt. (g)	Root wt. (g)
	c	86	43,0	34,0	2,19	59	43
	af	1,58	67,2	50,7	3,17	67	54
	cdef	1,08	52,4	35,5	2,76	70	51
	abcd	1,47	61,6	42,7	3,75	75	57
5	ade	1,49	63,9	40,0	3,68	71	53
	bdf	1,11	51,5	35,2	2,93	67	43
	abcef	1,49	63,5	50,02	3,58	75	57
	be	1,10	56,1	36,5	2,56	71	50
	abce	1,07	51,6	50,0	3,28	73	67
	a	1,19	52,9	47,2	3,13	69	66
	bd	1,00	49,8	36,5	3,00	74	53
	bcf	91	48,2	45,4	2,74	69	59
6	adef	1,52	67,9	59,7	3,33	74	73
	abcdf	1,35	63,4	55,7	3,85	79	62
	cf	77	42,3	37,2	1,85	56	48
	cde	1,03	51,6	40,9	2,39	64	54
	bcdf	66	46,0	46,0	2,55	63	51
	abd	1,51	66,5	60,1	3,63	71	69
	def	1,16	53,5	50,0	3,23	74	58
	(1)	1,04	45,0	54,6	2,94	64	56
7	bce	1,04	42,2	50,6	3,08	70	57
	abef	1,37	48,8	59,2	3,44	68	102
	acf	1,38	61,6	56,5	3,20	68	94
	acde	1,20	58,0	55,8	3,67	82	87
	cd	1,06	51,8	44,2	3,37	77	80
	abcdef	1,54	67,6	60,6	3,92	83	86
	bde	1,20	53,3	38,4	3,08	74	60
	cef	1,14	52,4	39,8	3,15	72	73
8	abc	1,69	70,1	63,9	3,97	71	80
	bf	1,05	49,1	30,7	2,69	66	49
	ae	1,12	62,4	48,2	3,49	70	93
	adf	1,21	59,3	43,1	3,08	64	81

TABLE 71.

FERTILIZER FUMIGATION TRIAL.

NUMBER OF SLIPS AND SUCKERS PRODUCED PER PLOT AND THE NUMBER OF MONTHS TO HARVESTING THE PLANT CROP AND THE RATOON CROP.

2^6 FACTORIAL

Replication I ABE BDF ACD CEF ADEF BCDE ABCF confounded.

		No. Slips	No. Suckers	Months to Plant Crop	Months to Ratoon Crop
	acde	56	102	26,8	50,3
	d	81	46	28,4	52,5
	cf	50	55	29,6	52,3
1	bdef	88	52	28,1	52,6
	ab	48	116	28,2	51,0
	bce	71	66	29,4	52,8
	abcdf	81	106	29,1	52,0
	aef	51	104	27,7	50,0
	adef	30	106	27,0	51,2
	abcf	50	118	27,4	51,3
	cdf	120	61	29,8	53,2
	ace	66	116	29,1	52,2
2	(1)	88	41	29,9	52,8
	bef	76	73	28,2	51,0
	abd	117	97	27,5	51,5
	bcde	104	29	30,4	53,6
	df	74	81	28,1	51,3
	abcd	81	104	28,5	52,7
	acdef	40	131	28,0	51,5
3	ae	36	130	28,1	51,6
	abf	30	131	25,8	50,1
	c	36	41	32,5	52,8
	bde	121	59	28,6	52,5
	bcef	39	64	29,9	52,2
	bc	43	57	30,4	52,4
	abdf	87	93	28,5	51,8
	abc	47	107	29,6	51,9
4	ade	92	102	27,9	51,7
	bcdef	116	39	30,2	53,4
	f	54	66	28,5	51,8
	acef	30	115	27,3	50,9
	cd	104	60	30,1	53,0

TABLE 71 CONTINUED.

Replication I continued.

		No. Slips	No. Suckers	Months to Plant Crop	Months to Ratoon Crop
	acd	73	90	30,1	52,4
	af	33	101	27,3	49,5
	bc	64	44	30,5	53,7
5	abcdef	34	126	26,5	50,6
	cef	66	60	30,5	52,6
	bdf	100	78	27,4	52,4
	abe	54	124	27,5	50,7
	de	143	65	28,2	52,5
	def	39	50	29,2	52,5
	abcde	97	105	30,7	52,4
	acdf	80	114	28,5	52,4
	bcf	75	73	29,7	52,6
6	bd	147	43	29,3	53,0
	abef	35	124	27,4	50,0
	ce	51	58	30,6	52,4
	a	83	114	29,4	51,3
	abcef	21	107	27,7	51,1
	e	72	67	29,3	52,5
	ac	53	91	29,0	51,8
7	abde	91	107	28,0	51,6
	bcd	92	27	32,4	53,4
	bf	36	51	29,7	52,0
	cdef	67	30	32,3	53,9
	adf	87	95	27,8	50,8
	ad	81	77	27,6	51,1
	bcdf	34	85	32,3	54,2
	abdef	71	104	28,2	49,1
8	b	49	63	29,0	52,4
	acf	48	126	28,0	51,2
	abce	40	113	29,7	51,4
	ef	55	66	29,9	51,9
	cde	62	43	31,2	53,8

TABLE 71 CONTINUED.

Replication II ABF CDF ADE BCE ABCD BDEF ACEF confounded.

		No. Slips	No. Suckers	Months to Plant Crop	Months to Ratoon Crop
	af	25	115	27,8	49,5
	bef	74	83	29,0	50,6
	abde	77	113	28,5	51,4
1	abc	20	115	29,3	53,4
	acdef	84	128	29,6	52,4
	bcdf	72	53	30,1	53,0
	d	60	54	29,6	53,0
	ce	39	48	31,1	53,2
	bcd	55	26	32,5	54,1
	abcf	69	111	28,5	50,9
	be	29	44	30,4	52,8
	acde	55	108	29,2	52,4
2	cef	40	43	31,4	53,4
	df	47	36	29,5	52,9
	a	28	117	28,2	50,8
	abdef	84	121	26,6	51,3
	e	74	68	29,4	52,2
	ab	21	128	27,0	50,0
	acf	38	122	27,5	50,4
	cd	76	46	31,0	53,7
3	abcde	87	115	29,2	52,6
	bcef	28	66	29,6	52,3
	adef	73	87	28,5	51,6
	bdf	97	45	29,7	52,6
	abe	63	132	28,0	51,0
	abcd	116	102	28,2	51,1
	bdef	85	73	29,0	52,5
	bcf	48	48	30,1	51,2
4	acef	16	124	28,5	51,7
	(1)	74	44	29,6	52,9
	cde	65	47	31,3	53,5
	adf	59	101	28,0	48,9

TABLE 71 CONTINUED.

Replication II continued.

		No. Slips	No. Suckers	Months to Plant Crop	Months to Ratoon Crop
	abdf	41	105	26,9	49,6
	def	91	47	29,0	53,1
	b	39	53	30,1	52,8
5	cf	36	58	30,4	52,9
	acd	91	114	28,5	52,2
	ae	43	115	27,0	51,7
	abcef	8	117	26,9	50,8
	bcde	70	30	31,4	53,8
	bc	43	32	32,5	53,7
	abcdf	64	105	28,1	50,9
	abef	20	119	26,4	49,0
	bde	91	28	30,1	53,4
6	cdef	64	32	31,0	53,4
	ace	36	132	28,2	51,2
	f	44	50	29,8	52,3
	ad	83	106	28,1	51,8
	ade	45	116	28,1	51,1
	ac	26	92	30,3	51,6
	abcdef	52	111	26,9	50,4
	bce	57	57	31,0	52,2
7	ef	32	69	29,0	51,8
	cdf	46	36	30,7	53,1
	abf	21	121	26,7	50,0
	bd	38	39	30,3	52,5
	de	55	46	30,5	53,5
	c	33	21	32,9	53,6
	bf	16	48	28,2	52,2
	abce	23	128	27,7	50,7
8	abd	82	95	26,5	50,5
	bcdef	97	54	29,7	52,0
	aef	26	116	26,4	49,6
	acdf	71	123	27,8	51,1

TABLE 72.

FERTILIZER/FUMIGATION TRIAL.

PLOT YIELDS (kg) OF FRUIT HARVESTED IN THE PLANT CROP, RATOON CROP AND OVER THE CYCLE, AND MEAN PLANT WEIGHT (kg) AT END OF CYCLE.

2^6 FACTORIAL.

Replication I ABE BDF ACD CEF ADEF BCDE ABCF confounded.

		Plant Crop	Ratoon Crop	Cycle Yields	Plant Weight After Ratoon
	acdc	110,35	127,30	237,65	6,48
	d	82,60	61,60	144,20	4,04
	cf	72,00	79,25	151,25	4,41
1	bdef	92,40	69,65	162,05	4,89
	ab	100,75	109,90	210,65	6,02
	bce	91,65	61,35	153,00	4,16
	abcdf	100,15	122,20	222,35	6,07
	aef	105,40	129,90	235,30	5,41
	adef	115,45	115,20	230,65	7,11
	abcf	116,45	100,85	217,30	5,93
	cdf	85,80	111,15	196,95	5,23
	ace	99,55	122,95	222,50	7,66
2	(1)	89,90	92,70	182,60	4,16
	bef	94,30	106,45	200,75	5,20
	abd	115,35	111,00	226,35	6,20
	bcde	92,25	107,60	199,85	4,43
	df	98,50	93,05	191,55	3,91
	abcd	110,00	110,85	220,85	6,89
	acdef	112,60	137,00	249,60	7,36
3	ae	101,35	119,65	221,00	5,45
	abf	123,05	116,80	239,85	5,41
	c	70,45	94,45	164,90	4,16
	bde	90,80	93,45	184,25	6,09
	bcef	90,65	84,35	175,00	4,57
	be	78,20	89,05	167,25	4,84
	abdf	100,45	113,40	213,85	6,04
	abc	98,60	127,85	226,45	6,62
4	ade	107,10	122,00	229,10	5,80
	bcdef	91,30	105,70	197,00	5,50
	f	85,75	96,05	154,80	5,11
	acef	118,50	134,10	252,60	7,16
	cd	92,10	98,20	190,30	5,36

TABLE 72 CONTINUED.

Replication I continued.

		Plant Crop	Ratoon Crop	Cycle Yields	Plant Weight After Ratoon
	acd	107,60	110,50	218,10	5,43
	af	95,40	132,50	227,90	5,57
	bc	79,80	69,70	149,50	3,57
5	abcdef	122,90	115,50	238,40	5,93
	cef	86,05	90,25	176,30	4,66
	bdf	99,00	76,65	175,65	4,82
	abe	111,95	130,60	242,55	6,68
	de	98,45	80,30	178,75	5,23
	def	76,70	54,65	131,35	5,41
	abcde	102,60	118,90	221,50	5,40
	acdf	102,90	104,50	206,95	7,23
	bcf	98,35	105,00	203,35	5,20
6	bd	91,95	87,30	179,25	5,14
	abef	106,55	146,00	252,55	6,12
	ce	93,50	97,65	191,15	5,02
	a	92,60	101,50	194,10	5,50
	abcef	102,15	125,25	227,40	5,95
	e	87,10	81,05	168,15	3,93
	ac	103,15	121,55	224,70	6,27
7	abde	105,35	116,85	222,20	5,32
	bcd	80,54	75,15	155,69	5,04
	bf	79,05	72,35	151,40	3,73
	cdef	84,55	92,50	177,05	4,82
	adf	103,25	135,95	239,20	6,09
	ad	83,95	103,55	187,50	5,14
	bcdf	72,70	60,90	133,60	4,25
	abdef	102,10	110,55	212,65	5,61
8	b	79,50	88,20	167,70	3,27
	acf	105,20	126,60	231,80	6,36
	abce	100,90	108,40	209,30	5,93
	ef	85,10	85,30	170,04	5,34
	cde	96,05	87,40	183,45	4,91

TABLE 72 CONTINUED.

Replication II ABF CDF ADE BCE ABCD BDEF ACEF confounded.

		Plant Crop	Ratoon Crop	Cycle Yields	Plant Weight After Ratoon
	af	99,95	111,70	211,65	6,27
	bef	94,60	109,45	204,05	4,54
	abde	99,00	116,55	215,55	5,73
1	abc	101,50	128,65	230,15	6,25
	acdef	106,40	116,50	222,90	6,13
	bcdf	83,05	81,05	164,10	4,78
	d	79,50	83,95	163,45	4,25
	ce	82,00	80,45	162,45	3,29
	bcd	79,50	66,80	146,30	3,36
	abcf	107,45	128,50	235,95	5,84
	be	73,50	67,60	141,10	2,93
	acde	101,70	105,25	206,95	5,22
2	cef	81,55	84,35	165,90	3,34
	df	79,60	66,85	146,45	3,30
	a	96,05	117,70	213,75	4,77
	abdef	102,85	117,20	220,05	5,60
	e	85,30	86,30	171,60	4,48
	ab	114,05	122,15	236,20	6,61
	acf	110,85	120,00	230,85	6,64
	cd	89,50	86,80	176,30	4,39
3	abcde	103,80	129,00	232,80	5,92
	bcef	85,05	93,65	178,70	4,82
	adef	101,05	118,40	219,45	5,59
	bdf	86,60	104,20	190,80	4,32
	abe	96,75	126,00	222,75	6,86
	abcd	116,15	111,20	227,35	7,34
	bdef	92,35	91,05	183,40	5,45
	bcf	86,40	97,85	184,25	4,18
4	acef	99,25	130,00	229,25	6,82
	(1)	77,45	62,75	140,20	3,70
	cde	79,60	81,70	161,30	4,18
	adf	98,95	112,60	211,55	4,50

TABLE 72 CONTINUED.

Replication II continued.

		Plant Crop	Ratoon Crop	Cycle Yields	Plant Weight After Ratoon
	abdf	103,15	120,45	223,60	5,04
	def	80,30	61,80	143,10	3,00
	b	72,40	62,05	134,45	3,48
5	cf	83,60	87,20	170,80	3,91
	acd	109,30	121,65	230,95	6,89
	ae	113,45	107,00	220,45	5,48
	abcef	108,25	116,25	224,50	5,84
	bcde	73,80	72,45	146,25	4,09
	bc	72,40	56,25	129,65	3,68
	abcdf	114,00	115,10	229,10	8,02
	abef	105,80	112,45	218,35	5,16
	bde	77,50	65,45	142,95	4,84
6	cdef	82,65	71,45	154,10	3,84
	ace	107,25	137,20	244,45	5,45
	f	74,45	71,10	145,55	4,18
	ad	96,05	103,65	199,70	5,00
	ade	102,40	92,45	194,85	5,11
	ac	98,65	114,95	213,60	5,20
	abcdef	109,00	126,80	235,80	7,05
	bce	89,50	89,65	179,15	5,00
7	ef	80,05	60,20	140,25	4,00
	cdf	78,55	77,95	156,50	4,20
	abf	101,95	117,15	209,10	5,23
	bd	67,50	44,60	112,10	3,20
	de	69,05	53,85	122,90	3,32
	c	72,70	52,30	125,00	3,27
	bf	76,75	54,55	131,30	3,23
	abce	98,90	133,00	231,90	5,27
8	abd	112,00	109,75	221,75	5,14
	bcdef	88,15	89,45	177,60	5,52
	aef	101,20	118,05	219,25	6,16
	acdf	100,35	133,45	233,80	5,57

TABLE 73.

FERTILIZER FUMIGATION TRIAL.

MEASUREMENTS OF T.S.S., FRUIT DENSITY, SUGAR AND ACIDITY OF PLANT CROP FRUIT SAMPLED MID SEASON.

2^6 FACTORIAL

Replication I ABE BDF ACD CEF ADEF BCDE ABCF confounded.

		T.S.S.	Fruit Density	Sugar Brix	Acid %
	acde	15,2	1,00	19,0	0,78
	d	15,6	1,00	19,5	0,94
	cf	15,6	0,98	17,0	0,77
1	bdef	15,6	0,98	18,5	0,77
	ab	14,8	1,02	18,0	1,05
	bce	14,7	0,98	18,5	1,12
	abcdf	13,4	1,01	16,0	0,85
	aef	15,5	0,99	17,5	0,84
	adef	13,8	1,03	16,0	1,00
	abcf	13,2	1,02	16,5	0,86
	cdf	14,7	1,00	17,5	0,86
	ace	13,3	1,03	16,0	0,88
2	(1)	14,9	1,01	18,0	0,91
	bef	14,9	0,98	18,5	0,86
	abd	13,7	1,04	16,0	0,92
	bcde	14,8	1,00	18,5	0,90
	df	14,8	0,98	16,5	0,92
	abcd	13,8	1,04	16,0	0,99
	acdef	13,8	1,04	16,0	1,06
3	ae	13,7	1,02	18,0	1,00
	abf	14,0	1,01	16,5	0,86
	c	14,5	0,97	18,0	1,07
	bde	13,9	0,99	18,5	1,07
	bcef	13,6	0,96	17,5	0,75
	be	15,1	1,00	17,0	0,92
	abdf	13,5	1,01	17,0	1,00
	abc	14,2	1,02	16,5	0,89
4	ade	13,3	0,99	17,5	1,05
	bcdef	15,5	0,99	18,0	1,05
	f	14,3	0,99	17,5	0,99
	acef	14,3	0,99	19,5	0,99
	cd	15,1	0,99	19,0	0,99

TABLE 73 CONTINUED.

Replication I continued.

		T.S.S.	Fruit Density	Sugar Brix	Acid %
	acd	13,1	1,00	17,5	0,89
	af	12,7	0,98	17,0	0,88
	bc	14,0	1,02	19,0	0,92
5	abcdef	12,3	0,99	16,0	0,94
	cef	15,1	0,98	19,0	0,89
	bdf	14,0	0,99	18,5	0,91
	abe	14,4	0,98	17,0	0,90
	de	15,5	0,96	18,0	0,92
	def	15,6	0,96	19,0	0,98
	abcde	13,4	1,00	17,0	1,12
	acdf	13,5	1,01	18,0	1,27
	bcf	14,4	1,01	18,5	1,04
6	bd	13,9	1,00	17,5	0,99
	abef	13,9	0,97	16,5	0,90
	ce	14,9	1,00	18,5	0,97
	a	14,6	1,00	16,5	1,00
	abcef	15,3	1,03	18,5	0,95
	e	14,6	0,99	17,0	0,89
	ac	12,6	0,99	15,5	0,88
7	abde	14,3	0,99	17,0	0,98
	bcd	14,2	0,97	18,0	1,01
	bf	14,9	0,96	18,0	0,95
	cdef	14,3	0,96	18,0	1,05
	adf	14,9	1,00	16,0	0,88
	ad	15,7	0,96	17,0	0,79
	bcdf	16,7	0,96	18,5	1,11
	abdef	13,7	1,00	17,5	0,98
8	b	14,1	0,95	18,5	0,77
	acf	14,2	1,04	17,0	0,88
	abce	14,0	1,00	17,5	0,99
	ef	15,2	0,95	17,0	0,95
	cde	15,2	0,97	18,0	0,95

TABLE 73 CONTINUED.

Replication II ABF CDF ADE BCE ABCD BDEF ACEF confounded.

		T.S.S.	Fruit Density	Sugar Brix	Acid %
	af	16,1	1,00	17,5	0,93
	bef	17,1	1,04	18,0	0,99
	abde	16,1	0,99	17,0	1,12
1	abc	15,1	0,96	17,0	1,00
	acdef	16,1	0,98	17,5	1,04
	bcdf	16,9	0,99	18,0	1,12
	d	17,0	0,95	18,0	1,13
	ce	18,0	1,11	17,0	0,96
	bcd	15,9	0,96	17,5	0,95
	abcf	14,6	0,98	16,5	1,00
	be	15,5	0,96	17,0	0,96
	acde	16,1	0,98	17,5	1,07
2	cef	16,0	0,98	18,0	0,91
	df	17,1	0,94	17,0	0,94
	a	15,6	1,01	16,0	0,93
	abdef	15,5	0,99	17,0	1,07
	e	14,6	0,95	18,0	1,05
	ab	15,0	0,99	17,0	0,84
	acf	15,8	0,99	18,0	0,84
	cd	15,0	0,99	17,5	1,08
3	abcde	15,6	0,98	18,0	0,99
	bcef	14,8	0,98	17,0	0,77
	adef	15,1	0,96	18,5	1,11
	bdf	15,3	0,97	18,0	0,99
	abe	15,3	1,00	17,5	0,94
	abcd	15,2	1,00	17,0	0,99
	bdef	15,5	0,97	16,5	0,90
	bcf	14,8	0,97	18,5	0,98
4	acef	14,7	0,98	17,5	0,90
	(1)	15,1	0,99	17,0	0,95
	cde	15,4	0,99	17,5	0,74
	adf	15,1	0,99	17,0	1,03

TABLE 73 CONTINUED.

Replication II continued.

		T.S.S.	Fruit Density	Sugar Brix	Acid %
	abdf	15,0	1,03	16,5	1,09
	def	16,3	0,93	18,0	0,87
	b	16,9	0,98	18,0	0,87
5	cf	16,3	0,99	17,5	0,87
	acd	15,0	0,99	17,0	0,84
	ae	15,5	1,03	17,5	0,87
	abcef	15,2	1,04	17,0	0,80
	bcde	15,1	0,98	17,5	0,89
	bc	13,7	0,95	18,0	1,07
	abcdf	13,6	0,99	16,5	0,89
	abef	14,9	1,00	17,5	0,84
	bde	15,7	1,04	18,0	1,00
6	cdef	15,2	0,96	18,5	1,23
	ace	13,2	1,04	18,0	0,79
	f	15,1	0,97	17,0	0,98
	ad	15,7	0,93	18,0	0,82
	ade	13,4	1,01	17,5	1,15
	ac	13,0	1,01	16,5	0,96
	abcdef	13,5	0,98	17,5	1,05
	bce	15,1	0,98	17,5	1,03
7	ef	16,0	0,95	19,0	0,97
	cdf	14,5	0,98	17,0	0,95
	abf	13,0	0,98	16,5	1,08
	bd	13,0	0,98	18,0	1,08
	de	16,9	0,97	19,0	0,94
	c	15,4	0,95	17,5	1,02
	bf	14,4	0,97	18,5	1,04
	abce	15,4	1,00	17,5	0,99
8	abd	15,1	0,97	17,0	0,90
	bcdef	17,5	0,96	19,0	0,88
	aef	16,4	0,97	18,0	0,85
	acdf	14,9	0,98	17,5	0,99

TABLE 74.

FERTILIZER FUMIGATION TRIAL.

RESULTS OF ANALYSIS OF SOIL SAMPLES TAKEN IN MAY 1970 AFTER COMPLETION OF THE TRIAL.

2^6 FACTORIAL

Replication I ABE BDF ACD CEF ADEF BCDE ABCF confounded.

		P p.p.m.	K p.p.m.	Ca p.p.m.	Mg p.p.m.	pH
	acde	9	40	50	20	3,6
	d	9	80	50	30	3,5
	cf	11	50	50	30	3,6
1	bdef	6	60	50	30	3,8
	ab	7	38	50	50	3,6
	bce	13	50	50	40	3,4
	abcdf	10	38	100	20	3,4
	aef	6	50	100	40	3,7
	adef	5	40	50	30	3,6
	abcf	13	40	50	30	3,4
	cdf	14	90	50	40	3,5
	ace	11	38	50	20	3,8
2	(1)	9	60	50	50	3,6
	bef	17	50	50	40	3,4
	abd	16	38	50	30	3,4
	bcde	10	90	150	50	3,5
	df	9	80	50	30	3,6
	abcd	8	40	50	30	3,4
	acdef	6	38	50	30	3,5
3	ae	4	38	50	20	3,8
	abf	7	38	50	40	3,6
	c	8	38	50	30	3,4
	bde	13	50	50	20	3,3
	bcef	10	75	100	50	3,4
	be	16	50	50	40	3,6
	abdf	16	60	100	30	3,5
	abc	15	38	50	40	3,5
4	ade	4	38	100	30	3,9
	bcdef	5	50	50	40	3,5
	f	4	38	50	40	3,5
	acef	8	38	50	20	3,3
	cd	17	60	50	40	3,4

TABLE 74 CONTINUED.

Soil Analysis at end of cycle continued.

Replication I continued.

		P p.p.m.	K p.p.m.	Ca p.p.m.	Mg p.p.m.	pH
	acd	5	80	50	30	3,6
	af	8	40	50	20	3,5
	bc	15	50	50	40	3,5
5	abcdef	4	38	50	20	3,8
	cef	7	50	50	40	3,5
	bdf	27	75	50	20	3,5
	abe	12	25	50	20	3,4
	de	13	75	100	50	3,4
	def	9	80	50	30	3,5
	abcde	16	50	50	20	3,4
	acdf	6	38	50	30	3,5
	bcf	15	50	50	30	3,8
6	bd	24	50	50	30	3,5
	abef	13	25	100	20	3,5
	ce	10	38	50	20	3,3
	a	9	50	100	40	3,4
	abcef	8	50	50	30	3,4
	e	4	50	50	20	3,5
	ac	8	50	50	20	3,5
7	abde	7	50	50	30	3,8
	bcd	24	75	50	40	3,5
	bf	8	50	100	30	3,5
	cdef	13	50	50	20	3,2
	adf	4	50	50	40	3,4
	ad	3	50	50	30	3,5
	bcdf	20	80	50	30	3,4
	abdef	12	38	50	20	3,6
8	b	14	50	50	30	3,9
	acf	4	25	50	40	3,5
	abce	9	38	50	20	3,5
	ef	9	50	50	20	3,3
	cde	10	75	50	40	3,3

TABLE 74 CONTINUED.

Soil Analysis at end of cycle continued.

Replication II ABF CDF ADE BCE ABCD BDEF ACEF confounded.

		P p.p.m.	K p.p.m.	Ca p.p.m.	Mg p.p.m.	pH
	af	5	40	50	30	3,5
	bef	12	50	50	20	3,4
	abde	11	38	50	20	3,6
1	abc	25	50	50	40	3,7
	acdef	7	38	50	40	3,5
	bcdf	22	60	50	30	3,4
	d	19	60	50	20	3,3
	ce	10	60	50	50	3,3
	bcd	10	60	50	30	3,3
	abcf	9	40	50	20	3,4
	be	9	50	50	20	3,5
	acde	5	50	50	40	3,7
2	cef	7	38	50	40	3,4
	df	8	90	50	30	3,4
	a	12	25	50	20	3,3
	abdef	10	60	50	60	3,4
	e	12	50	50	20	3,4
	ab	25	40	50	20	3,4
	acf	17	50	50	20	3,5
	cd	15	90	50	50	3,7
3	abcde	5	38	50	20	3,4
	bcef	15	50	50	20	3,3
	adef	16	38	50	20	3,3
	bdf	45	75	50	30	3,4
	abe	25	40	50	20	3,4
	abcd	32	50	50	20	3,4
	bdef	24	25	50	30	3,6
	bcf	23	50	50	50	3,6
4	acef	18	38	50	40	3,4
	(1)	10	50	100	30	3,4
	cde	19	50	50	20	3,2
	adf	6	50	50	30	3,4

TABLE 74 CONTINUED.

Soil Analysis at end of cycle continued.

Replication II continued.

		P p.p.m.	K p.p.m.	Ca p.p.m.	Mg p.p.m.	pH
	abdf	16	50	50	20	3,4
	def	14	60	50	20	3,5
	b	7	50	50	30	3,6
5	cf	14	50	50	50	3,6
	acd	5	38	50	30	3,4
	ae	8	38	50	30	3,4
	abcef	8	25	50	20	3,2
	bcde	16	75	50	40	3,4
	bc	13	50	50	20	3,4
	abcdf	7	25	50	20	3,5
	abef	14	38	50	10	3,6
	bde	17	75	50	50	3,6
6	cdef	11	60	50	40	3,3
	ace	5	38	50	20	3,3
	f	13	38	100	20	3,3
	ad	4	50	50	40	3,4
	ade	3	40	50	20	3,5
	ac	6	25	50	20	3,5
	abcdef	14	38	50	30	3,7
	bce	14	38	50	40	3,6
7	ef	9	50	50	40	3,4
	cdf	12	50	50	20	3,3
	abf	8	25	50	20	3,3
	bd	8	60	50	40	3,4
	de	8	50	50	20	3,5
	c	6	50	50	30	3,5
	bf	34	38	50	30	3,7
	abce	11	38	50	40	3,6
8	abd	11	38	50	30	3,4
	bcdef	30	50	50	20	3,3
	aef	4	25	50	40	3,3
	acdf	5	38	50	40	3,4

TABLE 75.

FERTILIZER/FUMIGATION TRIAL.

RESULTS OF ANALYSIS OF LEAF SAMPLES TAKEN IN JUNE 1967 AFTER FLOWER DIFFERENTIATION FOR THE PLANT CROP : N, P, K, Ca, Mg, Zn, Mn, Fe.

2^6 FACTORIAL

Replication I ABE BDF ACD CEF ADEF BCDE ABCF confounded.

		% N	% P	% K	% Ca	% Mg	p.p.m. Zn	Mn	Fe
	acde	1,41	0,16	2,17	0,05	0,12	21	190	60
	d	1,21	0,12	1,65	0,03	0,09	19	100	50
	cf	1,54	0,13	1,65	0,04	0,12	25	160	20
1	bdef	1,21	0,17	1,70	0,03	0,11	22	180	50
	ab	1,14	0,17	1,45	0,10	0,13	20	170	20
	bce	1,24	0,15	1,65	0,04	0,13	18	270	20
	abcdf	1,45	0,14	1,70	0,06	0,15	22	210	40
	aef	1,54	0,17	1,61	0,07	0,12	21	200	20
	adef	1,27	0,21	2,22	0,05	0,13	23	190	30
	abcf	1,41	0,16	1,74	0,09	0,15	24	90	60
	cdf	1,34	0,16	1,92	0,03	0,10	46	190	70
	ace	1,44	0,16	1,48	0,10	0,16	15	100	40
2	(1)	1,17	0,16	1,70	0,04	0,17	19	100	80
	bef	1,23	0,15	1,57	0,05	0,13	31	220	100
	abd	1,76	0,18	1,74	0,06	0,12	17	240	50
	bcde	1,27	0,12	1,80	0,03	0,13	12	200	50
	df	1,21	0,18	1,98	0,03	0,10	25	140	40
	abcd	0,87	0,21	2,10	0,07	0,15	20	240	60
	acdef	1,47	0,14	1,70	0,09	0,14	21	140	20
3	ae	1,34	0,17	1,52	0,11	0,17	19	90	20
	abf	1,11	0,16	1,52	0,10	0,12	27	80	20
	c	1,27	0,15	1,74	0,04	0,12	12	80	30
	bde	1,18	0,13	1,74	0,03	0,17	19	230	30
	bcef	1,16	0,13	1,80	0,04	0,12	21	160	40
	be	1,01	0,16	1,65	0,06	0,15	20	160	80
	abdf	1,27	0,18	1,98	0,05	0,12	26	240	40
	abc	1,34	0,16	1,52	0,10	0,13	16	60	80
4	ade	1,34	0,15	1,74	0,06	0,13	31	220	60
	bcdef	1,16	0,16	1,74	0,04	0,11	47	210	160
	f	1,11	0,13	1,48	0,04	0,11	16	70	20
	acef	1,38	0,14	1,52	0,09	0,17	16	240	20
	cd	1,31	0,13	1,85	0,04	0,11	13	220	20

TABLE 75 CONTINUED.

Leaf Analysis : Plant Crop : N, P, K, Ca, Mg, Zn, Mn, Fe, continued.

Replication I continued.

		% N	% P	% K	% Ca	% Mg	Zn	Mn	Fe
	acd	1,34	0,18	1,92	0,05	0,12	30	160	60
	af	1,21	0,14	1,41	0,09	0,15	26	110	50
	bc	1,34	0,16	1,57	0,04	0,12	13	190	30
5	abcdef	1,71	0,22	1,65	0,07	0,15	21	190	30
	cef	1,17	0,13	1,57	0,04	0,10	24	200	20
	bdf	1,05	0,12	1,61	0,04	0,16	14	190	20
	abe	0,96	0,16	1,52	0,12	0,12	19	80	30
	de	1,14	0,13	1,74	0,04	0,17	16	160	60
	def	0,94	0,15	1,74	0,03	0,09	25	120	40
	abcde	1,34	0,16	1,98	0,07	0,13	21	270	50
	acdf	1,54	0,15	1,98	0,06	0,12	21	180	30
	bcf	1,34	0,12	1,65	0,05	0,12	18	150	30
6	bd	1,15	0,16	1,74	0,04	0,11	19	210	40
	abef	1,09	0,18	1,42	0,10	0,13	19	200	50
	ce	1,22	0,10	1,65	0,05	0,10	13	170	20
	a	1,31	0,16	1,52	0,10	0,13	16	140	20
	abcef	1,54	0,14	1,57	0,10	0,15	22	40	40
	e	1,14	0,13	1,38	0,07	0,13	16	100	30
	ac	1,88	0,14	1,61	0,09	0,15	14	50	30
7	abde	1,27	0,16	1,70	0,07	0,13	20	160	30
	bcd	1,15	0,15	2,10	0,04	0,13	27	90	40
	bf	1,27	0,13	1,42	0,05	0,18	23	230	90
	cdef	1,26	0,10	1,98	0,03	0,13	18	20	20
	adf	1,24	0,14	1,70	0,05	0,11	20	210	30
	ad	1,14	0,15	2,10	0,06	0,15	22	110	30
	bcdf	1,47	0,12	1,92	0,03	0,09	20	180	80
	abdef	1,34	0,14	1,48	0,10	0,16	21	40	30
8	b	1,31	0,18	1,74	0,07	0,13	25	220	30
	acf	1,16	0,14	1,57	0,06	0,13	19	210	20
	abce	1,47	0,16	1,42	0,12	0,11	18	150	30
	ef	1,09	0,10	1,52	0,05	0,10	20	200	70
	cde	1,54	0,11	1,70	0,02	0,14	16	220	30

TABLE 75 CONTINUED.

Leaf Analysis : Plant Crop : N, P, K, Ca, Mg, Zn, Mn, Fe, continued.

Replication II ABF CDF ADE BCE ABCD BDEF ACEF confounded.

		% N	% P	% K	% Ca	% Mg	Zn	Mn	Fe
	af	1,27	0,18	2,05	0,05	0,14	30	130	30
	bcf	1,17	0,22	1,92	0,08	0,14	18	230	40
	abde	1,21	0,17	1,52	0,07	0,15	21	60	20
1	abc	1,14	0,15	1,32	0,06	0,15	15	160	20
	acdef	1,34	0,17	1,92	0,05	0,12	16	280	20
	bcdf	1,46	0,13	1,85	0,04	0,10	19	100	30
	d	1,05	0,11	1,65	0,02	0,17	15	180	30
	ce	1,47	0,11	1,57	0,05	0,14	14	230	40
	bcd	1,21	0,12	1,45	0,06	0,13	20	50	40
	abcf	1,34	0,18	1,61	0,08	0,14	26	1 0	110
	be	1,54	0,15	2,05	0,02	0,11	16	270	30
	acde	1,34	0,14	1,61	0,07	0,11	22	120	30
2	cef	1,31	0,14	1,57	0,04	0,16	14	80	20
	df	1,01	0,17	1,57	0,02	0,13	21	110	30
	a	0,90	0,14	1,38	0,10	0,15	22	110	70
	abdef	1,54	0,16	1,74	0,06	0,12	21	240	30
	e	1,27	0,16	1,61	0,04	0,13	21	220	20
	ab	1,17	0,22	1,52	0,08	0,15	20	210	20
	acf	1,44	0,15	1,52	0,09	0,16	29	90	30
	cd	1,49	0,13	1,70	0,04	0,12	19	220	20
3	abcde	1,20	0,17	2,10	0,07	0,19	17	70	20
	bcef	1,29	0,12	1,45	0,05	0,12	16	230	30
	adef	1,21	0,14	1,98	0,06	0,15	17	240	30
	bdf	1,21	0,12	1,61	0,04	0,15	19	220	30
	abe	1,27	0,18	1,65	0,08	0,17	22	50	20
	abcd	1,24	0,14	1,80	0,05	0,12	21	100	20
	bdcf	1,54	0,19	1,92	0,06	0,14	17	210	20
	bcf	1,23	0,13	1,48	0,05	0,12	26	210	40
4	acef	1,34	0,16	1,74	0,10	0,13	31	200	30
	(1)	1,14	0,12	1,32	0,04	0,15	15	200	30
	cde	1,21	0,16	1,74	0,03	0,16	13	210	30
	adf	1,14	0,14	1,65	0,07	0,11	21	250	20

TABLE 75 CONTINUED.

Leaf Analysis : Plant Crop : N, P, K, Ca, Mg, Zn, Mn, Fe, continued.

Replication II continued.

	% N	% P	% K	% Ca	% Mg	Zn	Mn	Fe
abdf	1,34	0,18	1,92	0,05	0,13	22	180	20
def	1,07	0,12	1,65	0,04	0,09	16	220	30
b	1,14	0,15	1,32	0,05	0,12	10	60	20
5 cf	1,14	0,12	1,42	0,05	0,10	18	200	20
acd	1,14	0,16	1,98	0,06	0,10	12	80	20
ae	1,35	0,12	1,35	0,08	0,15	19	250	20
abcef	1,31	0,12	1,35	0,10	0,12	18	100	40
bcde	1,94	0,10	1,52	0,03	0,13	9	230	20
bc	1,41	0,14	1,74	0,04	0,12	16	220	30
abcdf	1,61	0,17	1,45	0,11	0,16	16	100	30
abef	1,37	0,15	1,35	0,09	0,15	22	180	20
bde	1,07	0,13	1,52	0,03	0,13	20	190	20
6 cdef	1,23	0,13	1,57	0,02	0,14	17	200	20
ace	1,04	0,11	1,24	0,10	0,09	13	170	20
f	1,13	0,10	1,45	0,05	0,15	14	150	20
ad	1,68	0,12	1,61	0,06	0,11	15	230	20
ade	1,21	0,18	1,85	0,05	0,14	19	260	30
ac	1,41	0,16	1,42	0,09	0,15	18	190	30
abcdef	1,61	0,15	1,74	0,06	0,13	20	340	20
bce	1,01	0,12	1,20	0,07	0,15	19	100	30
7 ef	1,18	0,11	1,35	0,08	0,13	10	30	20
cdf	1,34	0,14	1,61	0,02	0,11	14	120	10
abf	1,04	0,15	1,42	0,07	0,16	20	150	20
bd	1,27	0,12	1,48	0,04	0,13	13	200	20
de	0,21	0,19	1,74	0,02	0,11	19	190	60
c	1,41	0,15	1,45	0,05	0,12	16	200	20
bf	1,14	0,16	1,28	0,05	0,13	19	190	20
abce	1,47	0,15	1,35	0,10	0,17	19	50	20
8 abd	1,10	0,15	1,70	0,05	0,13	17	250	20
bcdef	1,27	0,15	1,52	0,03	0,14	12	80	20
aef	1,64	0,10	1,35	0,09	0,18	17	160	20
acdf	1,31	0,12	1,61	0,05	0,13	15	210	20

TABLE 76.

FERTILIZER/FUMIGATION TRIAL.

RESULTS OF ANALYSIS OF LEAF SAMPLES TAKEN IN FEBRUARY 1969 AFTER FLOWER DIFFERENTIATION FOR THE RATOON CROP : N, P, K, Ca, Mg, Zn, Mn, Fe.

2^6 FACTORIAL

Replication I ABE BDF ACD CEF ADEF BCDE ABCF confounded.

		% N	% P	% K	% Ca	% Mg	p.p.m. Zn	Mn	Fe
	acde	1,23	0,12	2,21	0,20	0,16	19	71	24
	d	1,03	0,16	2,24	0,21	0,14	18	38	24
	cf	1,27	0,11	1,68	0,19	0,14	25	40	19
1	bdef	1,06	0,11	2,00	0,17	0,12	25	31	22
	ab	1,03	0,22	2,18	0,40	0,26	19	57	20
	bce	1,21	0,09	2,24	0,21	0,14	15	47	22
	abcdf	0,97	0,15	1,60	0,28	0,20	29	51	23
	aef	1,30	0,12	2,06	0,22	0,16	17	59	24
	adef	1,05	0,20	2,68	0,33	0,22	23	59	27
	abcf	1,18	0,12	1,86	0,29	0,18	17	60	18
	cdf	1,29	0,15	2,69	0,24	0,16	25	49	19
	ace	1,18	0,13	1,72	0,31	0,20	22	59	17
2	(1)	1,13	0,22	2,89	0,32	0,24	23	38	21
	bef	1,09	0,17	2,20	0,22	0,19	25	27	20
	abd	1,04	0,22	2,60	0,30	0,23	19	42	19
	bcde	1,40	0,19	3,46	0,27	0,25	20	51	18
	df	1,10	0,18	2,94	0,22	0,16	22	37	18
	abcd	1,11	0,15	2,10	0,30	0,19	15	69	14
	acdef	1,16	0,11	1,94	0,33	0,20	18	69	14
3	ae	1,02	0,19	2,42	0,43	0,30	18	53	20
	abf	0,93	0,15	1,88	0,32	0,23	19	45	16
	c	1,20	0,15	2,22	0,23	0,18	20	46	14
	bde	1,10	0,18	2,28	0,23	0,18	17	40	17
	bcef	1,28	0,15	2,54	0,26	0,21	22	46	20
	be	1,16	0,19	2,40	0,34	0,26	23	34	18
	abdf	1,10	0,20	2,75	0,35	0,26	27	62	18
	abc	1,22	0,16	2,00	0,36	0,24	16	52	14
4	ade	0,99	0,16	2,26	0,30	0,24	20	40	19
	bcdef	1,25	0,13	2,50	0,24	0,17	26	42	21
	f	1,08	0,11	1,40	0,18	0,14	24	24	20
	acef	1,23	0,12	1,65	0,24	0,18	20	47	20
	cd	1,19	0,13	2,22	0,20	0,17	16	36	17

TABLE 76 CONTINUED.

Leaf Analysis : Ratoon Crop : N, P, K, Ca, Mg, Zn, Mn, Fe, continued.

Replication I continued.

		% N	% P	% K	% Ca	% Mg	Zn	Mn	Fe
	acd	1,27	0,10	2,26	0,27	0,19	16	39	20
	af	0,95	0,13	1,84	0,34	0,24	32	38	17
	bc	1,23	0,11	1,98	0,18	0,13	17	28	16
5	abcdef	1,28	0,12	2,16	0,36	0,21	24	46	19
	cef	1,36	0,10	1,74	0,19	0,14	24	29	19
	bdf	1,03	0,13	2,10	0,18	0,13	28	22	20
	abe	1,03	0,20	2,23	0,40	0,26	20	37	24
	de	0,99	0,13	1,64	0,15	0,12	15	18	16
	def	1,16	0,12	1,58	0,27	0,18	14	49	13
	abcde	1,00	0,10	1,52	0,14	0,11	21	23	19
	acdf	1,20	0,11	1,56	0,20	0,14	20	55	13
	bcf	1,10	0,10	1,37	0,17	0,12	23	31	12
6	bd	1,06	0,19	1,92	0,21	0,15	22	31	17
	abef	1,01	0,13	1,48	0,28	0,19	26	34	16
	ce	1,13	0,08	1,50	0,17	0,16	19	32	12
	a	0,93	0,15	1,52	0,32	0,21	19	41	12
	abcef	1,21	0,09	1,00	0,28	0,17	25	40	14
	e	0,98	0,10	1,54	0,26	0,20	19	22	19
	ac	1,21	0,13	2,00	0,33	0,24	18	72	17
7	abde	0,98	0,13	2,10	0,30	0,22	19	42	20
	bcd	1,25	0,14	2,34	0,23	0,16	17	29	20
	bf	1,13	0,12	1,72	0,22	0,17	22	29	18
	cdef	1,26	0,09	2,34	0,19	0,16	20	50	22
	adf	0,98	0,12	2,08	0,31	0,24	20	56	15
	ad	1,12	0,07	2,45	0,30	0,18	17	47	15
	bcdf	1,27	0,09	2,14	0,19	0,14	30	36	16
	abdef	1,03	0,10	2,36	0,31	0,21	26	28	23
8	b	1,10	0,11	2,06	0,28	0,18	19	25	16
	acf	1,34	0,08	1,58	0,32	0,23	24	46	17
	abce	1,14	0,08	1,96	0,28	0,19	26	21	21
	ef	1,18	0,07	1,52	0,30	0,20	18	46	17
	cde	1,21	0,07	2,12	0,20	0,13	16	54	16

TABLE 76 CONTINUED.

Leaf Analysis : Ratoon Crop : N, P, K, Ca, Mg, Zn, Mn, Fe, continued.

Replication II ABF, CDF, ADE, BCE, ABCD, BDEF, ACEF confounded.

		% N	% P	% K	% Ca	% Mg	Zn	Mn	Fe
	af	1,06	0,10	1,96	0,30	0,24	23	74	24
	bef	1,02	0,14	1,70	0,26	0,16	25	38	24
	abde	1,00	0,12	2,29	0,34	0,19	22	54	20
1	abc	1,33	0,16	2,26	0,46	0,28	22	62	17
	acdef	1,29	0,11	2,57	0,32	0,23	28	66	22
	bcdf	1,26	0,13	3,00	0,21	0,17	29	40	20
	d	1,15	0,16	2,53	0,24	0,21	20	45	22
	ce	1,36	0,12	2,35	0,29	0,25	28	53	22
	bcd	1,20	0,12	2,25	0,17	0,16	28	60	18
	abcf	1,21	0,13	1,95	0,36	0,28	41	76	20
	be	1,10	0,13	1,68	0,24	0,21	38	44	24
	acde	1,01	0,16	2,40	0,34	0,27	41	53	24
2	cef	1,04	0,14	1,61	0,32	0,27	40	65	18
	df	1,16	0,13	2,36	0,17	0,17	40	35	20
	a	1,26	0,10	1,48	0,19	0,18	56	45	22
	abdef	1,23	0,11	1,66	0,29	0,24	44	55	21
	e	1,06	0,13	1,59	0,20	0,18	31	50	16
	ab	1,10	0,19	1,90	0,40	0,31	36	62	16
	acf	1,23	0,15	1,45	0,32	0,24	35	83	17
	cd	1,29	0,13	1,90	0,19	0,15	33	52	17
3	abcde	1,24	0,13	2,00	0,29	0,22	21	70	18
	bcef	1,24	0,10	1,76	0,22	0,19	46	40	19
	adef	1,16	0,15	2,35	0,26	0,29	28	84	17
	bdf	1,22	0,15	2,30	0,26	0,22	52	48	20
	abe	1,20	0,18	1,83	0,38	0,29	31	52	19
	abcd	1,27	0,16	2,01	0,28	0,20	38	62	17
	bdef	1,24	0,16	2,30	0,24	0,21	32	42	19
	bcf	1,37	0,12	1,92	0,23	0,17	45	45	16
4	acef	1,29	0,12	1,88	0,40	0,26	39	67	16
	(1)	1,12	0,14	2,00	0,29	0,23	24	41	18
	cde	1,32	0,12	2,54	0,23	0,19	45	65	18
	adf	0,96	0,12	2,10	0,28	0,23	30	51	16

TABLE 76 CONTINUED.

Leaf Analysis : Ratoon Crop : N, P, K, Ca Mg, Zn, Mn, Fe, continued.

Replication II continued.

		% N	% P	% K	% Ca	% Mg	Zn	Mn	Fe
	abdf	0,96	0,13	1,86	0,28	0,23	27	51	13
	def	1,07	0,11	2,28	0,23	0,19	25	40	19
	b	1,01	0,14	1,80	0,25	0,19	23	40	16
5	cf	1,29	0,10	2,00	0,23	0,19	21	42	15
	acd	0,91	0,12	1,70	0,33	0,27	17	47	18
	ae	1,22	0,13	2,42	0,35	0,27	27	65	16
	abcef	1,16	0,12	1,70	0,36	0,29	28	65	16
	bcde	1,29	0,10	2,20	0,22	0,19	18	54	15
	bc	1,19	0,13	2,13	0,27	0,21	29	57	16
	abcdf	1,19	0,10	2,00	0,28	0,22	31	67	14
	abef	0,94	0,12	1,80	0,31	0,26	30	44	17
	bde	1,08	0,14	2,47	0,26	0,21	23	37	19
6	cdef	1,17	0,11	2,50	0,21	0,18	24	44	27
	ace	1,20	0,10	1,92	0,36	0,27	20	57	17
	f	1,07	0,11	2,06	0,22	0,21	26	40	19
	ad	1,02	0,14	2,70	0,34	0,25	21	46	16
	ade	1,01	0,11	2,08	0,27	0,21	21	50	20
	ac	1,13	0,12	1,76	0,34	0,24	16	70	15
	abcdef	1,14	0,12	2,40	0,29	0,21	19	83	20
	bce	1,17	0,13	2,07	0,28	0,23	16	57	17
7	ef	1,08	0,10	1,50	0,25	0,19	20	26	16
	cdf	1,02	0,11	2,38	0,19	0,18	17	40	13
	abf	0,98	0,13	2,18	0,25	0,22	19	42	16
	bd	1,01	0,15	2,80	0,23	0,17	16	22	18
	de	1,18	0,11	2,55	0,18	0,15	15	28	16
	c	1,23	0,11	1,90	0,28	0,16	14	25	13
	bf	1,12	0,12	2,00	0,21	0,16	20	24	17
	abce	1,10	0,13	1,62	0,36	0,24	14	63	16
8	abd	0,91	0,18	2,20	0,33	0,26	16	52	16
	bcdef	1,16	0,09	2,20	0,17	0,14	18	41	19
	aef	0,89	0,10	1,66	0,29	0,27	24	25	20
	acdf	1,19	0,09	2,00	0,24	0,18	19	51	23

TABLE 77.

FERTILIZER/FUMIGATION TRIAL.

COUNTS OF PLANT PARASITIC NEMATODES PER 100 ml SOIL IN SAMPLES TAKEN ON 30/3/67.

2^6 FACTORIAL

Replication I ABE BDF ACD CEF ADEF BCDE ABCF confounded.

		Helicotylenchus	Meloidgyne	Trichodorus	Totals
	acde	0	0	0	0
	d	1260	220	0	1480
	cf	1080	140	0	1220
1	bdef	2040	540	0	2580
	ab	0	0	0	0
	bce	520	260	0	780
	abcdf	20	0	0	20
	aef	20	0	20	40
	adef	0	0	0	0
	abcf	20	0	0	20
	cdf	280	0	0	280
	ace	40	0	0	40
2	(1)	1680	0	0	1680
	bef	1640	0	0	1640
	abd	20	0	0	20
	bcde	340	0	0	340
	df	660	0	0	660
	abcd	0	0	0	0
	acdef	0	0	0	0
3	ae	20	0	0	20
	abf	60	0	20	80
	c	220	0	0	220
	bde	720	200	0	920
	bcef	300	0	0	300
	be	80	0	0	80
	abdf	0	0	20	20
	abc	0	0	0	0
4	ade	0	0	0	0
	bcdef	880	0	0	880
	f	1040	40	0	1080
	acef	0	0	0	0
	cd	120	0	0	120

TABLE 77 CONTINUED.

Replication I continued.

		Helicotylenchus	Meloidgyne	Trichodorus	Totals
	acd	0	0	40	40
	af	0	0	20	20
	bc	980	0	0	980
5	abcdef	0	0	0	0
	cef	380	120	0	500
	bdf	420	60	0	480
	abe	0	0	0	0
	de	820	0	0	820
	def	740	220	0	960
	abcde	0	0	0	0
	acdf	0	0	0	0
	bcf	1160	0	0	1160
6	bd	1260	40	60	1360
	abef	0	0	0	0
	ce	280	60	0	340
	a	0	0	20	20
	abcef	0	0	0	0
	e	1040	320	0	1360
	ac	60	0	0	60
7	abde	0	0	0	0
	bcd	620	40	0	660
	bf	1060	480	0	1540
	cdef	260	0	0	260
	adf	0	0	20	20
	ad	0	0	20	20
	bcdf	460	560	0	1020
	abdef	0	0	0	0
8	b	680	80	20	780
	acf	0	0	0	0
	abce	0	0	0	0
	ef	1520	0	0	1520
	cde	450	20	0	470

TABLE 77 CONTINUED.

Replication II ABF CDF ADE BCE ABCD BDEF ACEF confounded.

		Helicotylenchus	Meloidgyne	Trichodorus	Totals
	af	20	0	0	20
	bef	620	20	0	640
	abde	0	0	0	0
1	abc	0	0	40	40
	acdef	0	0	0	0
	bcdf	600	20	0	620
	d	1080	0	0	1080
	ce	260	140	0	400
	bcd	500	60	0	560
	abcf	0	0	0	0
	be	1480	240	0	1720
	acde	0	0	0	0
2	cef	600	40	0	640
	df	440	80	0	520
	a	20	0	40	60
	abdef	0	0	0	0
	e	700	80	0	780
	ab	40	0	0	40
	acf	0	0	0	0
	cd	260	0	0	260
3	abcde	0	0	0	0
	bcef	460	20	0	480
	adef	0	0	0	0
	bdf	960	80	0	1040
	abe	0	0	0	0
	abcd	0	0	0	0
	bdef	180	40	0	220
	bcf	480	0	0	480
4	acef	0	0	0	0
	(1)	1220	0	0	1220
	cde	120	0	0	120
	adf	0	0	0	0

TABLE 77 CONTINUED.

Replication II continued.

		Helicotylenchus	Meloidgyne	Trichodorus	Totals
	abdf	0	0	0	0
	def	660	40	0	700
	b	240	20	0	260
5	cf	140	0	0	140
	acd	0	0	0	0
	ae	0	0	0	0
	abcef	0	0	0	0
	bcde	220	20	0	240
	bc	300	0	0	300
	abcdf	40	0	0	40
	abef	0	0	0	0
	bde	1440	260	0	1700
6	cdef	360	260	0	620
	ace	0	0	0	0
	f	1500	120	0	1620
	ad	60	0	0	60
	ade	0	0	0	0
	ac	0	0	0	0
	abcdef	0	0	0	0
	bce	1100	0	0	1100
7	ef	360	120	0	480
	cdf	260	0	0	260
	abf	0	0	0	0
	bd	1180	320	0	1500
	de	500	20	20	540
	c	300	40	0	340
	bf	560	500	20	1080
	abce	20	0	0	20
8	abd	0	0	40	40
	bcdef	320	80	0	400
	aef	0	0	20	20
	acdf	0	0	0	0

TABLE 78.

FERTILIZER/FUMIGATION TRIAL.

COUNTS OF PLANT PARASITIC NEMATODES PER 100 ml SOIL IN SAMPLES TAKEN ON 3/2/69.

2^6 FACTORIAL.

Replication I ABE BDF ACD CEF ADEF BCDE ABCF confounded.

		Helicotylenchus	Meloidgyne	Trichodorus	Totals
	acde	210	0	0	210
	d	300	130	20	450
	cf	220	70	0	290
1	bdef	150	90	0	240
	ab	10	120	10	140
	bce	240	50	0	290
	abcdf	0	20	0	20
	aef	0	0	0	0
	adef	0	0	0	0
	abcf	120	90	0	210
	cdf	130	110	0	240
	ace	0	0	0	0
2	(1)	520	200	0	720
	bef	220	100	0	320
	abd	50	10	0	60
	bcde	50	50	0	100
	df	640	150	0	790
	abcd	0	20	20	40
	acdef	80	10	0	90
3	ae	30	0	0	30
	abf	20	50	10	80
	c	320	10	0	330
	bde	880	610	0	1490
	bcef	360	130	20	510
	be	390	60	0	450
	abdf	180	70	10	260
	abc	0	120	0	120
4	ade	100	0	10	110
	bcdef	310	10	0	320
	f	90	190	0	280
	acef	30	30	10	70
	cd	520	10	0	530

TABLE 78 CONTINUED.

Replication I continued.

		Helicotylenchus	Meloidgyne	Trichodorus	Totals
	acd	260	160	10	430
	af	0	30	0	30
	bc	310	320	0	630
5	abcdef	10	30	0	40
	cef	190	350	0	540
	bdf	390	120	0	510
	abe	30	40	10	80
	de	90	20	10	120
	def	500	120	10	630
	abcde	50	10	0	60
	acdf	0	10	10	20
	bcf	420	410	0	830
6	bd	550	700	10	1260
	abef	20	30	0	50
	ce	410	80	0	490
	a	20	140	0	160
	abcef	10	10	0	20
	e	170	210	0	380
	ac	10	30	0	40
7	abde	70	140	10	220
	bcd	280	340	10	630
	bf	100	370	0	470
	cdef	310	160	0	470
	adf	30	20	0	50
	ad	10	160	0	170
	bcdf	660	300	0	960
	abdef	20	10	30	60
8	b	300	330	0	630
	acf	50	20	10	80
	abce	0	0	20	20
	ef	730	330	0	1060
	cde	330	50	0	380

TABLE 78 CONTINUED.

Replication II ABF CDF ADE BCE ABCD BDEF ACEF confounded.

		Helicotylenchus	Meloidgyne	Trichodorus	Totals
	af	0	150	0	150
	bef	200	110	0	310
	abde	0	30	0	30
1	abc	0	80	0	80
	acdef	10	0	0	10
	bcdf	220	170	0	390
	d	320	180	0	500
	ce	270	140	0	410
	bcd	470	150	0	620
	abcf	50	0	0	50
	be	770	340	0	1110
	acde	0	0	0	0
2	cef	370	60	0	430
	df	430	480	0	910
	a	0	80	10	90
	abdef	0	40	0	40
	e	220	50	0	270
	ab	0	0	0	0
	acf	0	0	0	0
	cd	580	340	0	920
3	abcde	0	0	0	0
	bcef	130	40	0	170
	adef	0	50	0	50
	bdf	590	30	10	630
	abe	0	190	10	200
	abcd	40	70	0	110
	bdef	350	580	0	930
	bcf	130	220	0	350
4	acef	0	0	0	0
	(1)	110	120	0	230
	cde	220	240	0	460
	adf	0	0	0	0

TABLE 78 CONTINUED.

Replication II continued.

		Helicotylenchus	Meloidgyne	Trichodorus	Totals
	abdf	0	70	0	70
	def	590	140	0	730
	b	340	160	0	500
5	cf	170	150	0	320
	acd	0	60	0	60
	ae	0	120	0	120
	abcef	0	80	0	80
	bcde	300	10	0	310
	bc	50	30	0	80
	abcdf	0	10	0	10
	abef	40	50	0	90
	bde	490	250	0	740
6	cdef	370	150	10	530
	ace	0	40	0	40
	f	100	130	0	230
	ad	20	40	30	90
	ade	0	180	0	180
	ac	0	60	0	60
	abcdef	0	0	0	0
	bce	540	360	0	900
7	ef	90	40	0	130
	cdf	210	30	0	240
	abf	30	80	0	110
	bd	20	30	0	50
	de	150	60	0	210
	c	90	0	0	90
	bf	140	80	0	220
	abce	20	100	0	120
8	abd	60	80	0	140
	bcdef	90	40	0	130
	aef	10	0	0	10
	acdf	0	0	0	0

TABLE 79.

FERTILIZER/FUMIGATION TRIAL.

NEMATODE COUNTS 19/3/66 : COMPOSITE SAMPLES FROM FOUR TREATED AND FOUR UNTREATED PLOTS FROM EACH BLOCK OF EIGHT : PLANT PARASITIC NEMATODES PER 100 ml SAMPLE OF SOIL.

2^6 FACTORIAL — REPLICATION I.

		Helicotylenchus	Meloidgyne	Trichodorus	Total
BLOCK 1	Treated	0	0	0	0
	Untreated	240	0	20	260
BLOCK 2	Treated	0	0	0	0
	Untreated	340	0	20	360
BLOCK 3	Treated	0	0	0	0
	Untreated	380	0	0	380
BLOCK 4	Treated	0	0	0	0
	Untreated	360	0	0	360
BLOCK 5	Treated	0	0	0	0
	Untreated	220	0	0	220
BLOCK 6	Treated	0	0	0	0
	Untreated	180	0	0	180
BLOCK 7	Treated	0	0	0	0
	Untreated	320	0	0	320
BLOCK 8	Treated	0	0	0	0
	Untreated	280	0	0	280
		REPLICATION 2.			
BLOCK 1	Treated	0	0	0	0
	Untreated	140	0	0	140
BLOCK 2	Treated	0	0	0	0
	Untreated	280	0	0	280
BLOCK 3	Treated	0	0	0	0
	Untreated	740	0	0	740
BLOCK 4	Treated	0	0	0	0
	Untreated	100	0	0	100
BLOCK 5	Treated	0	0	0	0
	Untreated	0	0	0	0
BLOCK 6	Treated	20	0	20	40
	Untreated	360	0	0	360
BLOCK 7	Treated	20	0	0	20
	Untreated	120	40	0	160
BLOCK 8	Treated	0	0	0	0
	Untreated	80	0	0	80

TABLE 80.

FERTILIZER/FUMIGATION TRIAL.

NEMATODE COUNTS 18/9/70 : COMPOSITE SAMPLES FROM FOUR TREATED AND FOUR UNTREATED PLOTS FROM EACH BLOCK OF EIGHT : PLANT PARASITIC NEMATODES PER 100 ml SAMPLE OF SOIL.

2^6 FACTORIAL REPLICATION I.

		Helicotylenchus	Meloidgyne	Trichodorus	Total
BLOCK 1	Treated	300	420	20	740
	Untreated	240	220	0	460
BLOCK 2	Treated	520	30	0	550
	Untreated	240	460	10	710
BLOCK 3	Treated	340	190	20	550
	Untreated	280	240	10	530
BLOCK 4	Treated	420	170	0	590
	Untreated	580	300	0	880
BLOCK 5	Treated	150	270	0	420
	Untreated	190	500	0	690
BLOCK 6	Treated	490	290	0	780
	Untreated	220	360	20	600
BLOCK 7	Treated	110	90	10	210
	Untreated	190	280	10	480
BLOCK 8	Treated	250	60	20	330
	Untreated	190	140	0	330
		REPLICATION 2.			
BLOCK 1	Treated	140	120	0	260
	Untreated	360	140	0	500
BLOCK 2	Treated	350	360	10	720
	Untreated	210	120	0	330
BLOCK 3	Treated	70	130	0	200
	Untreated	580	270	0	850
BLOCK 4	Treated	530	260	0	790
	Untreated	100	110	0	210
BLOCK 5	Treated	300	320	10	630
	Untreated	350	320	0	670
BLOCK 6	Treated	80	200	0	280
	Untreated	230	270	20	520
BLOCK 7	Treated	420	210	0	630
	Untreated	110	60	10	180
BLOCK 8	Treated	70	190	0	260
	Untreated	80	170	0	250