NUTRITIONAL STATUS OF SOILS AND THE INCIDENCE OF BUNCHY TOP DISEASE OF BANANAS (*Musa species*) Part V

EFFECT OF COMBINED APPLICATION OF CALCIUM AND MAGNESIUM TO SOIL ON THE RATIO OF CALCIUM OXIDE / MAGNESIUM OXIDE IN THE PLANT AND ITS RELATION TO BUNCHY TOP INFECTION

BY

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THESIS

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CERTIFICATE

This is to certify that the thesis herewith submitted contains the results of bona fide research work carried out by Sri. R. Vikraman Nair under my supervision. No part of the work embodied in this thesis has been submitted earlier for the award of any degree.

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INTRODUCTION

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The attempt to study the nutritional status of soil and the plant as predisposing factors to infection of "Bunchy Top" disease of banana has been initiated as part of the continuous research programme of the Principal and Additional Director of Agriculture (Research), at the Agricultural College and Research Institute, Vellayani, since 1962. The survey conducted during the first year of investigation showed that soils of disease-free areas had lower content of major nutrients, nitrogen, phosphorus and potassium and higher content of secondary elements, calcium and magnesium. Leaf samples of healthy and diseased banana plants also followed the same pattern as that of soils in their content of nutrients. The experiment conducted during the same year based on the survey showed that a combination of calcium and magnesium in the nutrient medium could bring about a significant delay in the appearance of disease symptoms.

Sand culture experiments conducted during 1964-'65 with different forms and levels of calcium and magnesium showed that appropriate combination of elements in the nutrient medium arrested the incidence of the disease for a significant period. Treatments supplying calcium oxide and magnesium oxide at 0.6 per cent and 0.1 per cent, respectively, on the basis of the weight of sand arrested the incidence of the disease till the emergence of the bunch. The plants which resisted infection showed a calcium oxide/magnesium oxide ratio of 3.5 to 4 and a calcium oxide plus magnesium oxide/

potassium oxide ratio of 1 or near about 1. The corresponding values in the plants which contracted the disease were lower.

Experiments during the next year to confirm the results of sand culture experiments under semi-field conditions showed that variations in the ratio of calcium oxide/magnesium oxide in the plant did not follow any fixed pattern. All the plants of the experiment contracted the disease even though a calcium oxide/magnesium oxide ratio of upto 3.71 in the leaf could be observed. However, calcium oxide plus magnesium oxide/potassium oxide ratio of 1 could not be attained in any case. It was concluded that resistance to Bunchy Top infection could have been actually related to the ratio of calcium oxide plus magnesium oxide/potassium oxide ratio and not merely to the ratio of calcium oxide/magnesium oxide. The unpredictable nature of absorption of nutrients from soil in contrast to that in sand medium, the influence of several uncertain factors due to addition of large amounts of organic matter and the high concentration of the insect inoculum were considered the reasons for the variation in results.

Further investigation under low organic matter conditions and using lower concentration of insect inoculum were necessitated to confirm the results of the previous workers. Hence, the study under semi-field conditions was continued. Two ratios of calcium oxide and magnesium oxide, 3:1 and 6:1 were tried each at two levels of magnesium, 0.05 per cent and 0.10 per cent.

REVIEW OF LITERATURE

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A detailed account of the history and distribution of the Bunchy Top disease of banana has been given by Nambiar and Nair (1965).

Mehta, Joshi, Rao, and Ranjhan conducted a detailed survey of the incidence and intensity of the disease in Kerala in 1960. Based on this survey, they reported in 1964 that in the central parts of the State, where the disease had initially appeared, the incidence and intensity were much lower than in the past. The high incidence areas were located in recently invaded northern parts of the State.

Effect of plant nutrients on virus infection.

Different plant nutrients exert differing roles in the resistance of plants to infection by virus. This has been reviewed with special reference to Bunchy Top infection by previous workers (Nambiar and Nair 1965; Nair and Pillai 1966; Nair and George, 1966) However, information which has not been touched up on by them is summarised in the following pages.

(i) Nitrogen.

(a) Effect on symptom expression:

Spencer (1937) reported that, in tobacco plants supplied with either a deficiency or excess of nitrogen, mosaic symptoms appeared earlier than in those receiving a medium amount of the nutrient. Felton (1948) working on Irish potato found that leaf roll symptoms appeared at lower nitrogen levels and lower temperatures than at high nitrogen levels and high temperatures. Arenz (1949) experimenting on potatoes observed that a deficiency of nitrogen caused earlier appearance of leaf roll. Wünscher (1952) reported that increasing amounts of nitrogen increased the susceptibility of potatoes to virus infection through aphids. According to Diercks (1953), potato plants in the low-nitrogen group reacted negatively to infection by X-virus. He recommended moderate supplies of nitrogen as a method of control. Bawden (1955) cited the work of Broadbent and Heathcote who found that the incidence of cauliflower mosaic virus increased with more nitrogen. De Robertis (1959) demonstrated that nitrogen applications reduced symptoms of wheat streak mosaic virus but led to the appearance of tulip breaking virus symptoms in Rembrandt tulips. Contradictory to the observations of Arenz (1949) and De Robertis (1959), Weathers (1960) found that the development of exocortis symptoms in Eureka lemon (*Poncirus trifoliata*) was correlated with increased nitrogen application. At very low levels no symptoms were noticed. Similar results have been recorded by Kender and Smith (1964) in virus-infected strawberry. Broadbent and Weathers (1964) failed to get any effect from urea and monoammonium phosphate sprays on tomatoes infected with tobacco mosaic virus. Carpenter (1964) and Weathers (1964) found that nitrogen nutrition of the host had no effect on the transmission of bean yellow mosaic virus. Prusa *et al.* (1965) observed that difference in nitrogen contents of the plants showed no significant relationship to the incidence of hop curl disease.

(b) Effect on virus concentration, multiplication, activity and movement:

Spencer (1939) found that virus concentration of expressed sap of diseased, mosaic infected tobacco plants supplied with nitrogen was over 80 times that from nitrogen deficient plants. Virus activity of expressed sap was directly correlated with the amount of nitrogen supplied to plants. In 1941 he attributed the reason for increased virus activity to an increase in the rate of virus multiplication in the high nitrogen plants. The increased virus activity had reduced the biological activity of the plant by 40 per cent. Kendrick et al. (1951) observed that virus concentration was reduced to a minimum by low nitrogen application in tomatoes infected with tobacco mosaic virus. However, Best and Gallus (1953) reported that, at nitrogen levels which limited growth, the amount of infective virus per plant was greater in tobacco plants infected with tobacco mosaic virus than those receiving adequate nitrogen. According to them, reduced nitrogen supply affected the production of virus rather than plant proteins. Mierzke (1953) had observed that excess of nitrogen in the soil had accelerated the movement of X-virus in potato plant. Pound and Weathers (1953) found in Connecticut Havana No.38 tobacco that virus activity of expressed sap was directly correlated with plant growth. Papasolomontos and Wilkinson (1959) found that raising nitrogen levels from subnormal to above normal resulted in increased virus concentration in the case of tomato plants infected with tobacco mosaic virus. Sastri and Vasudeva (1962) indicated that sunnhemp mosaic virus concentration was directly correlated with growth of sunnhemp plants in respect of nitrogen. They showed in 1963 that movement of sunnhemp mosaic virus started earlier in plants receiving optimum levels of nitrogen and much later in those receiving excess or deficient levels. According to Sadasivan (1963) nitrogen levels that increased plant growth also increased virus concentration and vice versa. Nitrogen ions had a profound influence on virus multiplication. Singh and Bhargava (1966) found that virus concentration coincided with growth even at concentrations which caused stunting in watermelons infected with watermelon mosaic virus.

(c) Effect on nitrogen content:

Commoner et al (1953) compared the nitrogen contents of tobacco leaf discs at various intervals after inoculation with tobacco mosaic virus and observed a net increase in protein content as a concomitant of virus synthesis. Best and Gallus (1953) reported that the concentration of protein nitrogen was higher in leaves of infected plants throughout the growing period. Borges and Beato (1953) showed that both total and soluble nitrogen in diseased *Brassica chinensis* had increased. Orlob and Arny (1961) concluded from their work on barley yellow dwarf virus that virus infection affected the nitrogen metabolism by reducing the total nitrogen in the leaves and increasing it in the roots. Enkarous et al (1964) obtained increased protein and peptide nitrogen in tobacco plants inoculated mechanically with tobacco mosaic virus. Narayana Swamy and Ramakrishnan (1966) working on Pigeon peas infected with sterility mosaic disease found a decrease in chloroplastic protein and an increase in cytoplasmic protein in the diseased leaves. A decrease in C:N ratio was observed due to virus infection, and this reduction was attributed to the reduction in carbohydrate content and increase in nitrogen content of diseased leaves. Nambiar and Nair (1965) and Nair and Pillai (1966) also noted significant differences in nitrogen contents of banana leaves due to the incidence of Bunchy Top disease.

(ii) Phosphorus

(a) Effect on symptom expression:

Spencer (1957) found that in tobacco, symptoms of systemic infection of mosaic virus developed earlier in plants that received no phosphorus than those with excess phosphorus. Bode (1949) comparing the effects of nitrogen, phosphorus and potassium found that infection of potatoes by leaf roll was least in KP plots. Aranz (1949) had concluded that deficiency of nitrogen caused an earlier appearance of leaf roll on potatoes than did lack of potassium and phosphorus. Kendrick et al (1951) observed a reduction in weight of tomatoes infected with tobacco mosaic virus. The reduction was accentuated with high phosphorus treatments. Wünscher (1952) found decreased susceptibility of potatoes to virus infection through aphids by decreased phosphorus application. Schlegel *et al* (1953) found that radioactive phosphorus (P^{32}) in young mosaic infected tobacco leaves inhibited virus formation and symptom expression. Carpenter (1964) concluded that transmission of bean yellow mosaic virus by aphids was unaffected by phosphorus nutrition of the host. Welton (1964) observed that the susceptibility of Lincoln peas to inoculation with bean yellow mosaic virus by *Myzus persicae* was unaffected by addition of phosphorus.

(b) Effect on virus concentration, multiplication, activity and movement:

Pound and Weathers (1953) reported that in *Nicotiana glutinosa* and *N. multivalvis* affected by turnip virus I, virus activity corresponded closely to the amount of phosphorus supplied to hosts. Papasolomontos and Wilkinson (1959) found that the virus concentration assayed on *N. glutinosa* increased as the phosphorus level was raised from subnormal to above normal. Sastry and Vasudeva (1962) had observed that concentration of the sunnhemp mosaic virus progressively increased with increase in phosphorus supply, even though growth was retarded at higher levels of phosphorus. They reported in 1963 that movement of sunnhemp mosaic virus started earlier in plants receiving excess phosphorus. According to Sadasivan (1963) increased phosphorus supply had increased virus activity of expressed sap, but levels causing stunting also increased virus multiplication. Singh and Bhargava (1966) observed that in the case of watermelon, concentration of mosaic virus continued to increase at phosphorus levels higher than the optimum for growth.

(c) Effect on phosphorus content:

Best and Gallus (1953) observed increased concentrations of protein phosphorus in tobacco leaves infected with mosaic virus. Shaw and Samborski (1956) showed that phosphorus accumulated in the young local lesions of tobacco mosaic virus on Nicotiana. Koslowska (1959) had obtained higher percentage of phosphorus in potato plants infected by virus Y than in healthy controls. He observed in 1964 greater amounts of phosphorus in potato tubers infected by virus X and Y. Prusa et al (1965) found that the phosphorus content in hop plants affected by hop curl disease was higher.

(iii) Potassium:

(a) Effect on symptom expression:

Spencer (1937) working on the role of potassium on symptom expression of mosaic virus of tobacco found that application of excess potassium immediately before inoculation was conducive to the early development of symptoms. Symptom expression was delayed when the interval between fertilizer application and inoculation was higher. He could correlate between the duration of the treatment and incubation period of virus in plants. Bode (1949) observed that infection of potatoes by leaf roll was markedly higher in the plots where potassium was applied. Arenz (1949) found that too much potassium promote symptom expression of potato leaf roll. Kendrick et al (1951) observed a reduction in weight of tomatoes infected with tobacco mosaic virus. This reduction was minimised with high potassium and accentuated with low potassium treatments. Wünscher (1952) reported that increasing amounts of potassium sulphate decreased the susceptibility of potatoes to virus infection through aphids. It was found that the incidence of crown disease and little leaf of oil palm increased when they were supplied only with potassium (Anon. 1958). Welton (1964) observed that susceptibility of Lincoln peas to inoculation with bean yellow mosaic virus by _Myzus persicae_ was unaffected by additions of potassium.

(b) _Effect on virus concentration, activity, multiplication and movement:_

Pound and Weathers (1953) found that variations in the potassium supply did not noticeably affect virus activity of turnip virus I on _Nicotiana glutinosa_ and _N. multivalvis_. Papasolomontos and Wilkinson (1959) experimenting on tomatoes infected with tobacco mosaic virus reported that when potassium levels were raised from sub-normal to above-normal, there was no significant effect on virus concentration in the excised tomato roots. Sastry and Vasudeva (1962) found that though increasing levels of potassium showed slight increase in growth, there was no marked effect on virus concentration. They indicated in 1963, that movement of sunnhemp mosaic virus started earlier in plants receiving deficient potassium levels.

(c) _Effect on potassium content:_

Kozlowska (1959) got higher percentage of potassium in potato plants infected with potato virus Y than in healthy controls. He observed in 1964 higher amounts of potassium in potato tubers

infected with viruses X and Y than in the healthy plants.
Prusa *et al* (1965) showed that in diseased plants, the content of potassium was regularly higher than in healthy ones.

(iv) Calcium:

According to Sadasivan (1963), calcium deficiency reduces the number of local lesions by affecting intrinsic cell susceptibility rather than by mechanical resistance to entry of viruses. Welton (1964) found that the susceptibility of Lincoln peas to inoculation with bean yellow mosaic virus by *Myzus persicae* was unaffected by addition of calcium chelates.

Sastry (1965) observed that above an optimum level of calcium, growth of *Crotalaria juncea* was retarded and concentration of sunnhemp mosaic virus reduced.

Shaw and Samborski (1956) showed that calcium accumulated in young local lesions of tobacco mosaic virus on Nocotiana.
Prusa *et al* (1965) found that in hop plants infected with hop curl disease, the content of calcium was higher than in healthy ones.

(v) Magnesium:

It was found that incidence of oil palm crown disease and little leaf increased where potassium was applied alone, but this was counterbalanced by the addition of magnesium (Anonymous, 1959).
Welton (1964) reported that susceptibility of Lincoln peas to inoculatio[n] with bean yellow mosaic virus by *Myzus persicae* was unaffected by

addition of magnesium chelate. Prusa et al (1965) showed that infection of hop plants with hop curl disease was noticeably inhibited by spraying or irrigation with salts of magnesium.

Ryjkoff and Smirnova (1948) found that when half leaves of *Nicotiana glutinosa* plants inoculated with tobacco mosaic virus were kept submerged for seven days in a 0.1 per cent solution of magnesium sulphate, multiplication of virus was markedly depressed. Sastry (1965) observed that above a certain optimum magnesium level, growth of *Crotalaria juncea* infected with sunnhemp mosaic virus was was retarded and virus concentration reduced.

Hale et al (1946) showed that magnesium content was consistently higher in beet plants infected with beet yellow virus than the healthy plants and that the difference varied with the degree of infection. Prusa et al (1965) got no significant difference in magnesium contents of healthy and diseased hop plants infected with hop curl disease

(vi) Sulphur:

Arenz (1949) found that regeneration of potatoes infected with potato leaf roll could be effected only by application of nitrogen. This effect was favoured by application of sulphate. According to him, this was due to the higher formation of plant protein.

Ling and Pound (1962) reported that in tobacco plants grown without sulphur or with sub-optimal sulphur, accumulation of tobacco mosaic virus was markedly and consistently less than that in plants receiving optimal sulphur levels. Sastry (1965) noted that growth of <u>Crotalaria juncea</u> and concentration of sunnhemp mosaic virus were reduced at levels of sulphur above the optimum for growth.

Suss (1956) observed that in healthy potato leaves sulphur was uniformly distributed, but in those infected by potato leaf roll virus, it accumulated in the veins though uptake was less than in the healthy. With mosaic virus, it tended to accumulate at the edges of the leaves. In tobacco plants infected by mosaic virus and potato virus X, uptake of the element was also reduced and it accumulated in the veins. Prusa <u>et al</u> (1965) found that hop curl disease of hop plants did not bring about any change in sulphur content in the plants.

(vii) <u>Zinc</u>:

Yarwood (1954) demonstrated that the susceptibility of <u>Phaseolus vulgaris</u> leaves to tobacco mosaic virus was induced by 10 minutes' immersion in 0.001 to 0.003 per cent zinc sulphate. The same treatments decreased the numbers of tobacco mosaic lesions on <u>Nicotiana glutinosa</u> leaves. Rich (1956) got promising results with zinc sulphate which reduced the percentage of diseased plants per plot from 8.6 to 8.0. Prusa (1965) found that hop curl disease of hop plants was noticeably inhibited by spraying or irrigation with salts of zinc.

Garcia (1965) got increased virus concentration and local lesion production in tomato plants infected by tobacco mosaic virus by zinc sprays.

(viii) Boron:

Pruss et al (1965) reported that hop curl disease was noticeably inhibited by spraying or irrigation with salts of boron. According of Milbrath et al (1966), in a disease of sweet berry in which a virus and boron deficiency were involved, trees sprayed with boron produced normal fruits and leaves.

Ford and Bateman (1964) concluded that potato virus X concentration in N.tabacum increased more slowly initially, but later reached higher concentrations in inoculated leaves of boron - deficient plants than in those with sufficient boron. Boron deficiency did not alter virus translocation.

Ford and Bateman (1964) found no significant difference in boron deficiency of Nicotiana tabacum due to potato virus X infection.

(ix) Iron:

Zelenova (1964) reported that insufficient iron and manganese diminished symptoms of infection of cucumber mosaic virus in cucumber (Cucumis sativus)

Nadi and Raychaudhuri (1966) observed in tomato plants that concentration of potato virus X was less at low than at high iron levels. Deficiency of iron appeared to limit virus multiplication.

Pruss et al (1965) found in hop curl disease of hop plants that there was no difference in iron contents before and after the incidence of the disease.

(x) Manganese:

Welkie and Pound (1957) found in tobacco plants infected with tobacco mosaic virus, that symptoms were less marked in manganese deficient plants, than those receiving complete nutrients. Carpenter (1964) showed that transmission of bean yellow mosaic virus by aphids was unaffected by manganese nutrition of host. Zelenova (1964) observed that insufficient manganese in the nutritive medium diminished symptoms of infection with cucumber mosaic virus on cucumber. Prusa (1965) showed that hop curl disease in hop plants was noticeably inhibited by spraying or irrigation with salts of manganese.

Welkie and Pound (1957) got 50 per cent more virus per unit weight of tissue in manganese deficient tobacco plants infected with tobacco mosaic virus than the manganese supplied.

Welkie and Pound (1957) reported that tobacco plants infected with tobacco mosaic virus showed less chlorosis in the case of manganese deficiency than in uninfected plants.

(xi) Molybdenum:

Prusa et al (1965) showed that hop curl disease of hop plants was inhibited by spraying or irrigation with salts of molybdenum.

According to Sastry (1962) virus concentration is positively correlated with plant growth. He found that the maximum concentration of virus was obtained at the level optimum for growth at all stages following inoculation.

(xii) Chlorine:

Diercks (1953) found that excess chloride in the soil amendments strongly accelerated the movement of X virus of the tomato plant.

Effect of nutrients (nitrogen, phosphorus, potassium, calcium and magnesium) on Bunchy Top virus of bananas.

Nambiar and Nair (1965) showed that nitrogen contents of soils taken from infected areas were high in comparison to healthy areas. Comparative leaf analysis indicated that the diseased leaves contained more nitrogen than the healthy. Nair and Pillai (1966) concluded that the uptake of nitrogen was significantly influenced by magnesium and calcium. It was also shown that higher nitrogen contents led to an early incidence of infection. Nair and George (1966) reported that there was an increase in nitrogen content of leaves after the incidence of the disease than before it. Also, the nitrogen content of infected plants remained fairly constant in the control and the plants treated with calcium and magnesium. The amount of nitrogen in the leaves of all the plants under different treatments were found to be higher than that in the leaves of plants which resisted infection in the work of Nair and Pillai (1966).

Nambiar and Nair (1965) found higher content of available phosphoric acid in soils collected from diseased areas. Higher phosphoric acid content was noticed also in the case of diseased leaf samples. Nair and Pillai (1966) concluded that the uptake of phosphorus appeared to have a significant effect in delaying the incidence of the disease. The higher the uptake of phosphorus, the earlier was the infection. Nair and George (1966) observed higher phosphorus content in leaves of infected plants. The increased concentration of phosphorus noticed in the plant leaves after the incidence of the disease was pointed out to be due either to increased absorption of the element or to disturbance in the mechanism of translocation.

Nambiar and Nair (1965) reported that there was a higher concentration of available potash in the soils of healthy areas as compared to the diseased. They also observed higher concentration of potash in the diseased leaf samples as compared to the healthy. Nair and George (1966) found that there was an increase in potassium content of leaves after the incidence of the disease. Also, it was noted that potassium content of the plant tissue in all the treatments was higher than what was reported by Nair and Pillai (1966) for plants which delayed infection by an appreciable period of time.

It was observed by Nambiar and Nair (1965) that soils from sites of healthy plants in both laterite and sandy areas showed a higher content of total and exchangeable calcium. Analysis of healthy and diseased leaves showed significantly higher values in the healthy plants. Nair and Pillai (1966) concluded that the uptake of calcium had a major role in the incidence of the Bunchy Top disease. The plants which had delayed infection had a higher percentage of calcium, than the plants which got disease earlier. Nair and George (1966) observed higher calcium content in leaves before incidence of the disease than after infection. The absorption of calcium by plants under different treatments before infection was not significantly different, indicating that beyond a certain level of calcium, further additions to the nutrient medium would have no effect on tissue composition.

Nambiar and Nair (1965) showed that the soils from the sites of healthy plants were higher in total and exchangeable magnesium compared to diseased areas. Healthy leaf samples were high in the content of magnesium as compared to the diseased. The work of Nair and Pillai (1966) showed that there was a high content of magnesium in the leaves of plants which had delayed infection, compared to those which had earlier infection. Nair and George (1966) reported that increased absorption of magnesium by plants was favoured by lower concentrations of calcium and that all the plants contained appreciably higher quantities of magnesium before the incidence of the disease than after infection by the virus.

Calcium plus magnesium:

Nambiar and Nair (1965) reported that soils collected from disease prevalent areas had lower calcium and magnesium in the case of Bunchy Top disease of banana. Calcium and magnesium levels were lower in the diseased leaves also. It was concluded that magnesium alone or in combination with calcium had a remarkable effect in delaying the appearance of disease symptoms. Studies on

Bunchy Top of banana by Nair and Pillai (1966) revealed that calcium oxide/magnesium oxide ratio had a major role in delaying the disease. A ratio of 3.5 to 4.0 in the plant tissue could resist the incidence of Bunchy Top disease until the emergence of bunch. Nair and George (1966) concluded that resistance to Bunchy Top virus may be correlated to the ratio of calcium oxide plus magnesium oxide/potassium oxide in the leaf and not merely to the ratio of calcium oxide/magnesium oxide.

Calcium plus magnesium/potassium:

Nambiar and Nair (1965) reported that calcium oxide plus magnesium oxide/potassium oxide ratio in the leaves had a bearing on the incidence of Bunchy Top disease of banana. The ratio was lower in diseased leaf samples compared to the healthy. Further experiments by Nair and Pillai (1966) revealed that a calcium oxide plus magnesium oxide/potassium oxide ratio of one or near about one in the plant tissue could successfully resist the incidence of Bunchy Top disease until the emergence of bunch. George and Nair (1966) concluded that the resistance of Bunchy Top virus might be correlated to the ratio of calcium oxide plus magnesium oxide/potassium oxide ratio in the leaf, and not merely to the ratio of calcium oxide/magnesium oxide.

MATERIALS AND METHODS

MATERIALS AND METHODS

The experiment was conducted at the Agricultural College and Research Institute, Vellayani during 1966-'67 to study the relationship between the nutritional status of soil and the incidence of Bunchy Top disease of banana. This is in continuation of the previous work under semi-field conditions.

A. MATERIALS

1. Reinforced cement concrete rings:

Thirty reinforced cement concrete rings used in the previous year were used for planting suckers after filling with one ton soil. The rings were 1.5 metres long with a radius of 50 cm and were implanted 2.5 metres centre to centre either way. Semi-field conditions with restriction in spread of roots laterally was thus obtained. The rings also helped in using a weighed quantity of soil in which to plant the suckers.

2. Soil:

Each pit was filled with one ton soil. Before the pits were filled in, the soil was mixed with NPK fertilizers, lime and magnesium carbonate. The mechanical and chemical composition of the soil are given below.

Mechanical composition of soil

(Expressed as percentage on oven dry basis)

Coarse sand	-	49.28
Fine sand	-	6.35
Silt	-	10.60
Clay	-	28.80

Chemical composition of soil

(Expressed as percentage on oven dry basis)

Nitrogen	-	0.0862
Potash	-	0.1664
Calcium oxide	-	0.0815
Magnesium oxide		0.0625

3. Manures and fertilizers:

No organic manure was used. Nitrogen, phosphorus and potassium were supplied through fertilizers.

(i) Nitrogen: A total quantity of 1350 g ammonium sulphate (20%N) was applied in two doses to supply nitrogen. (900 g first mixed with the soil)

(ii) Phosphoric acid: Super phosphate (16% P_2O_5) was applied at the rate of 1360 g per plant (mixed with the soil).

(iii) Potash: Muriate of potash (60% K_2O) was used at the rate of 1360 g per plant (mixed with the soil).

(iv) Secondary elements: Slaked lime analysing to 59.85 per cent CaO and magnesium carbonate containing 41.002 per cent MgO were used to supply calcium and magnesium respectively as per the various treatments.

4. Calcium carbonate - magnesium carbonate emulsion:

The emulsion was prepared by mixing calcium carbonate and magnesium carbonate with water to give a pasty consistency. The chemicals were used in such a way as to give a CaO:MgO proportion of 3:1. 'Tepol' was used as the spreading agent.

5. Banana suckers:

Suckers of the susceptible 'Nendran' variety were collected from a nearby disease-free plantation. These were dried and kept in shade for a month before planting. The weights of dry suckers ranged from 0.8 kg to 1.75 kg. These were ranked according to weights and allotted to blocks in the order of weights.

6. Vector:

Banana aphids, *Pentalonia nigronervosa* Coq. reared on diseased plants were collected along with plant tissues and released on healthy experimental plants at the rate of 25 aphids per plant.

D. METHODS

1. Lay out:

The experiment was laid out in randomised block design with five treatments and six replications.

2. Treatments:

Two ratios of CaO/MgO in the soil were compared at two levels of magnesium and three levels of calcium. The treatments were as follows:

	Ratio of application	Actual ratio in soil
1. CaO 0.00% and MgO 0.00%	0 (Control)	1.3 : 1
2. CaO 0.15% and MgO 0.05%	3 : 1 ratio	2.1 : 1
3. CaO 0.30% and MgO 0.10%		2.4 : 1
4. CaO 0.30% and MgO 0.05%	6 : 1 ratio	5.4 : 1
5. CaO 0.60% and MgO 0.10%		4.2 : 1

Calcium oxide and magnesium oxide were applied on the basis of the above percentages in one ton soil used in each pit. The emulsion of calcium carbonate and magnesium carbonate was applied on all plants of the sixth replication.

3. Sterilisation of pits:

Sterilisation of concrete cylinders was done by stuffing trash and dry leaves inside, and burning.

4. Application of fertilizers and secondary nutrients:

900 g ammonium sulphate and entire quantities of super phosphate, muriate of potash, lime and magnesium carbonate were applied just before filling the pits. These were mixed thoroughly with the soil. 450 g ammonium sulphate was applied on 1-12-1966, 97 days after planting. This was applied and mixed with the top soil to a depth of 4 inches.

5. Planting:

Planting was done in the centre of the ring on 4-10-1966. Planting was done in such a way that the rhizome was completely below the soil surface. 10 plants, randomly selected were planted in an adjacent plot to check whether the suckers were originally disease-free.

6. Irrigation:

Irrigation was given as and when required.

7. Spraying:

All plants were sprayed with Folidol E 605 (0.02 per cent) at an interval of 10 days from 3-11-1966, to prevent any natural infection through aphids. This was continued till 10 days before inoculation.

8. Application of emulsion:

The emulsion was applied on plants of the sixth replication on 3-2-1967 one day prior to inoculation. Petiole and pseudostem were uniformly pasted with the emulsion. All the leaf axils were covered with the paste.

9. Release of aphids:

A cool and moist atmosphere was provided by forming a pandal over the experimental plants, a day prior to liberation of aphids. To provide congenial conditions, the floor was moistened a day prior to inoculation and this was continued for 5 days. Inoculation was done on 4-2-1967 when the plants were 4 months old. Infective aphids at the rate of 25 per plant were released in the axils of the top-most leaves of all the plants. This portion was covered with banana leaves to provide humid conditions.

Pandal was removed on 9-2-1967, 5 days after inoculation and Folidol E 605 (0.02 per cent) sprayed to destroy the aphids.

10. Recording observations:

(a) Plant growth

The growth characteristics of the plant recorded were the following.

(i) Height of the plant: This was measured from the soil level to the apex of the pseudostem.

(ii) Girth of pseudostem: Measured at the base of pseudostem.

(iii) Number of fully opened leaves.

(iv) Length of lamina.

(v) Width of leaves: The region of maximum width of the leaf was measured.

The observations were recorded regularly at an interval of 7 days.

(b) Disease symptoms

Symptoms noted for the Bunchy Top disease were the following.

(i) Presence of irregular, nodular, dark green streaks seen along the secondary veins of the leaf blade, along leaf stalk and along the lower portion of the mid rib.

(ii) Reduction in size of leaves.

(iii) Harsh and brittle nature of petiole and lamina, corrugated nature of mature leaves, and upward-rolled margins of young leaves.

(iv) Absence of normal elongation of the petiole causing leaves to assume an unusually erect position, thus leading to the 'rosetted' condition.

(c) Chemical analysis

Analysis of samples of soil, leaf and root were done for nitrogen, potassium, calcium and magnesium. The samples were taken from all plants of the sixth replication.

Soil samples were taken on 4-2-1967, prior to inoculation from a region 9 inches to one foot deep. These were analysed for nitrogen, potassium, calcium and magnesium.

Monthly leaf samples were collected from all plants of the sixth replication from 4-1-1967, one month prior to inoculation and continued till 4-5-1967. These were analysed for the same constituents as in the case of soil.

Monthly samples of roots were collected from 4-1-1967 onwards and continued till 4-4-1967. Analysis for the same constituents as in soil and leaf samples were made.

Leaf samples of daughter suckers were collected on 26-6-1967 and analysed for potassium, calcium and magnesium.

Nitrogen was estimated by Kjeldahl method as givenby Piper (1950). Potash was estimated by the method adopted by the A.O.A.C. (1960). Versene method as given by Jackson (1958) was adopted to estimate calcium and magnesium.

RESULTS

R E S U L T S

Growth measurements of all plants were recorded at weekly intervals from one month after planting and were continued till the appearance of disease symptoms. Height of plant, girth of pseudostem, number of fully opened leaves and length and width of leaves were recorded. Inoculation with infective aphids was done on 4-2-1967, four months after planting. The number of days taken for the appearance of disease symptoms, was noted. Samples of soil leaf and root were collected from all the treatments of the sixth replication for chemical analysis.

Growth characteristics:

The average growth measurements for height of plant, girth of pseudostem, number of fully opened leaves and length and width of leaves at weekly intervals are given in Tables I to V. There was increased growth rate for all characters till the appearance of disease symptoms. The plants ceased to increase their height and girth after the occurrence of the disease. The length and width of newly emerged leaves decreased and later the leaves failed to emerge fully.

The growth measurements, two days prior to inoculation and three days before the appearance of first symptom were analysed statistically. There was no significant difference between the treatments, showing thereby that growth rate was uniform for all the treatments. The analysis of variance tables are given in Appendices I to X.

TABLE I

Average growth measurements at weekly intervals - Height of plants in cm.

Date of measurement	Ratio of CaO:MgO				
	0	3:1		6:1	
	Level of MgO in percentage				
	0(T1)	0.05(T2)	0.10(T3)	0.05(T4)	0.10(T5)
17—11—66	50.17	46.00	45.00	53.67	45.67
24—11—66	54.83	51.67	48.50	57.00	49.00
1—12—66	59.83	55.67	52.17	61.67	52.17
8—12—66	65.50	59.17	56.83	66.17	55.83
15—12—66	70.00	64.83	62.00	71.67	60.00
22-12—66	78.50	69.67	69.17	76.50	65.50
29—12—66	83.17	75.33	72.83	80.00	69.17
5—1—67	90.83	80.00	78.50	83.83	72.00
12—1—67	100.83	90.83	86.00	94.67	80.67
19—1—67	108.17	96.50	91.83	101.33	85.50
26—1—67	112.50	103.83	96.67	107.33	91.00
2—2—67	119.67	110.17	101.50	114.00	96.33
9—2—67	124.50	116.17	106.33	119.83	100.67
16—2—67	127.83	120.50	109.83	124.00	104.33
23—2—67	133.83	126.00	116.50	130.17	109.33
2—3—67	142.00	135.50	125.67	139.50	115.17
9—3—67	144.83	138.67	130.83	143.83	119.33

TABLE II

Average growth measurements at weekly intervals-Girth of Pseudostem in cm

Date of measurement	Ratio of CaO:MgO				
	0	3:1		6:1	
	Level of MgO in percentage				
	0(T1)	0.05(T2)	0.10(T3)	0.05(T4)	0.10(T5)
17-11-66	16.50	14.83	15.83	15.17	13.33
24-11-66	17.33	15.67	16.83	16.67	14.50
1--12-66	18.50	16.67	18.17	17.67	15.50
8--12-66	19.50	17.67	18.67	19.50	16.33
15-12-66	21.12	20.00	20.00	20.33	17.50
22-12-66	23.12	21.67	21.33	21.67	18.33
29-12-66	24.33	23.17	23.00	22.37	20.33
5--1-67	26.83	25.83	25.67	25.00	22.67
12-1--67	29.50	28.83	28.17	28.67	25.83
19-1--67	31.83	31.67	30.17	31.17	28.50
26-1--67	34.17	33.83	32.17	33.50	29.50
2--2--67	35.67	34.50	33.83	35.83	31.33
9--2--67	36.33	36.50	34.67	36.33	31.83
16-2--67	36.83	36.67	35.17	36.83	32.33
23-2--67	38.50	39.83	37.00	39.33	34.50
2--3--67	41.00	42.83	40.17	42.33	34.87
9-3-67	42.17	43.67	41.33	43.00	39.33

TABLE III

Average growth measurements at weekly intervals

Number of fully opened leaves

Date of measurement	Ratio of CaO:MgO				
	0	3:1		6:1	
	Level of MgO in percentage				
	0(T1)	0.05(T2)	0.10(T3)	0.05(T4)	0.10(T5)
17-11-66	5.50	4.17	4.67	4.67	4.17
24-11-66	6.67	5.17	6.00	6.00	5.17
1--12-66	8.00	7.00	7.17	7.17	6.67
8--12-66	9.17	8.00	8.17	8.17	7.67
15-12-66	10.67	9.00	9.33	9.17	8.67
22-12-66	11.17	10.00	10.50	10.17	9.67
29-12-66	12.33	11.00	11.50	11.17	10.67
5--1--67	13.50	12.00	12.67	12.33	11.83
12-1--67	15.17	13.33	14.17	14.17	13.33
19-1--67	16.33	14.50	15.17	15.33	14.33
26-1--67	17.33	15.50	16.17	16.33	15.50
2--2--67	18.67	16.67	17.17	17.33	16.50
9--2--67	19.67	17.67	18.17	18.33	17.50
16-2--67	20.50	18.67	19.17	19.33	18.50
23-2--67	21.33	19.67	20.00	20.17	19.33
2--3--67	22.00	20.67	20.83	21.17	20.17
9--3--67	22.50	21.33	21.83	21.50	20.83

TABLE IV

Average Growth Measurements at weekly intervals

Length of leaves in cm.

Date of measurement	Ratio of CaO:MgO				
	0	3:1		6:1	
	Level of Mg_O in percentage				
	0(T1)	0.05(T2)	0.10(T3)	0.05(T4)	0.10(T5)
17—11—66	52.50	49.33	47.83	55.67	48.83
24—11—66	57.50	51.67	48.00	57.17	51.50
1—12—66	59.83	54.83	49.83	59.17	52.83
8—12—66	64.67	56.50	52.17	62.83	54.50
15—12—66	70.17	59.83	57.67	67.83	59.67
22—12—66	75.67	66.50	63.50	70.00	63.17
29—12—66	84.17	75.33	68.33	77.67	70.00
5—1—67	93.33	84.33	79.83	85.67	75.17
12—1—67	104.33	94.33	89.67	93.50	82.67
19—1—67	109.33	100.67	94.67	99.67	87.00
26—1—67	115.17	106.83	99.33	106.00	92.17
2—2—67	119.83	112.50	104.83	110.67	93.33
9—2—67	123.83	115.50	108.50	115.00	100.17
16—2—67	127.83	119.50	112.67	121.67	102.67
23—2—67	133.33	124.33	116.83	127.33	109.67
2—3—67	137.33	131.50	121.33	134.00	114.50
9—3—67	139.33	134.33	125.83	136.00	117.67

TABLE V

Average growth measurements at weekly intervals

Width of leaves in cm.

Date of measurement	Ratio of CaO:MgO				
	0	3:1		6:1	
	Level of MgO in percentage				
	0(T1)	0.05(T2)	0.10(T3)	0.05(T4)	0.10(T5)
17-11-66	28.67	27.33	23.83	28.33	24.83
24-11-66	29.83	27.50	24.67	30.00	25.50
1-12-66	30.33	28.33	25.00	30.67	26.67
8-12-66	32.67	28.83	25.83	32.67	28.83
15-12-66	36.00	31.33	30.17	35.17	29.67
22-12-67	37.33	38.33	32.83	38.17	31.17
29-12-66	40.67	39.33	37.33	39.17	34.17
5-1-67	44.83	44.33	41.17	41.17	39.17
12-1-67	49.33	47.33	45.00	46.00	42.83
19-1-67	50.33	48.00	45.30	46.50	42.83
26-1-67	50.67	48.00	44.67	47.00	41.50
2-2-67	53.33	51.50	47.17	50.67	43.67
9-2-67	54.50	52.67	49.50	51.33	44.83
16-2-67	55.00	53.33	51.17	53.17	46.17
23-2-67	55.00	53.17	51.00	52.50	45.83
2-3-67	53.67	54.17	52.00	55.17	46.17
9-3-67	54.83	55.83	52.50	55.33	47.17

Appearance of disease symptoms:

The number of days taken for the appearance of symptoms in the diseased plants under various treatments are given in Table VI. The number of plants infected in the treatments 1, 2, 3, 4 and 5 were two, one, five, four and five respectively. Treatment 2 appeared the best with only one out of six plants infected, followed by the control with two infected plants. Treatments 3 and 5 had the maximum number of five plants each and treatment 4, four.

The number of days taken for infection varied from 36 to 50, except for treatment 5 in block III which showed symptoms 122 days after inoculation.

Disease symptoms in daughter suckers:

All the suckers of diseased plants showed symptoms of primary infection. Suckers of healthy plants remained healthy. Suckers appeared to emerge earlier and in larger numbers in diseased plants.

Nutrient content of soil:

Samples of original soil were collected before mixing with fertilisers and secondary nutrients. On the date of inoculation, soil samples from all treatments of the sixth replication were collected. Chemical analysis of soil was done for nitrogen, potassium, calcium and magnesium. The data on the nutrient status of soil are given in Tables VII and VIII.

TABLE VI

Number of days taken for the appearance of disease symptoms after the release of aphids

Blocks	Ratio of CaO:MgO				
	0	3:1		6:1	
	Levels of MgO in percentage				
	0(T1)	0.05(T2)	0.10(T3)	0.05(T4)	0.10(T5)
I	H	H	H	38	39
II	H	H	36	37	50
III	H	H	39	H	122
IV	50	39	38	H	37
V	39	H	37	38	36
VI	H	H	37	42	H

H - Healthy plants

TABLE VII

Nutrient content of original soil and the treatments during filling pits

Nutrient	Original soil	Ratio of CaO: MgO				
		0	3:1		6:1	
		Level of MgO in percentage				
		0(T1)	0.05(T2)	0.10(T3)	0.05(T4)	0.10(T5)
N	0.0862	0.1042	0.1042	0.1042	0.1042	0.1042
K_2O	0.1664	0.2480	0.2480	0.2480	0.2480	0.2480
CaO	0.0815	0.0815	0.2315	0.3815	0.3815	0.6815
MgO	0.0623	0.0623	0.1123	0.1623	0.1123	0.1623
CaO/MgO	1.3082	1.3082	2.0614	2.3506	3.5971	4.1990
CaO+MgO/K_2O	0.8642	0.7452	1.3863	2.1928	1.9911	3.4024

TABLE VIII

Nutrient content of soil on the date of inoculation (Expressed as percentage on oven dry basis)

Nutrient	Ratio of CaO:MgO				
	0	3:1		6:1	
	Level of MgO in percentage				
	0(T1)	0.05(T2)	0.10(T3)	0.05(T4)	0.10(T5)
N	0.0810	0.0688	0.0587	0.0681	0.0508
K_2O	0.1397	0.1848	0.2259	0.1561	0.1212
CaO	0.0438	0.0533	0.0933	0.1067	0.1600
MgO	0.0524	0.1024	0.1524	0.0952	0.1476
CaO/MgO	0.8359	0.5205	0.6109	1.1208	1.0840
CaO+MgO/K_2O	0.6886	0.8425	1.0877	1.2934	2.5319

There was a marked decrease in nitrogen content of soil four months after planting. The percentage of nitrogen came down from 0.10 in the beginning to 0.08 in control and to 0.05 in treatment 5. Analysis of soil on the date of inoculation, four months after planting showed a decrease in nitrogen content of soil with increasing amounts of calcium and magnesium application. Nitrogen content was highest in the control and the lowest in treatment 5. The levels of magnesium had influenced the nitrogen status of soil more than that of calcium. Increasing the level of magnesium from 0.05 - 0.10 per cent markedly reduced the nitrogen content from 0.0681 - 0.0587 per cent. The influence of the various levels of calcium was found to be slight. The ratio of CaO/MgO did not seem to have any influence on the nitrogen status of soil.

A reduction in potash content was observed four months after planting. It decreased from 0.25 per cent in the beginning to 0.23 per cent in treatment 3 and to 0.12 per cent in treatment 5. The potash content showed higher values with increasing amounts of calcium and magnesium application upto a level, on the date of inoculation. A narrow CaO/MgO ratio increased the potash status and a wider ratio tended to reduce the same. Treatment 5 which received the higher levels of CaO and MgO in the ratio 6:1 recorded lower status than even the control.

A marked decrease in calcium content was observed in the case of calcium four months after planting. The percentage of calcium oxide came down from 0.08 to 0.04 in the control and from 0.68 to 0.16 in treatment 5. Analysis of soil on the date of inoculation four months after planting showed an increase in calcium content with increasing levels of application. Treatment 5 showed the highest value of 0.16 per cent and the control, the lowest. For the same levels of calcium application, calcium content was found to be higher when the level of magnesium was lower. The ratio of CaO/MgO does not seem to have any effect on the calcium status.

The decrease in content of magnesium four months after planting had not been as marked as that of calcium and potassium. It came down from 0.06 per cent at the time of planting to 0.05 in the control and from 0.16 to 0.15 in treatment 5. As in the case of calcium, the content of magnesium followed the same pattern as that of application on the date of inoculation. Treatment 3 showed the highest amount of 0.15 per cent MgO followed by treatment 5 with 0.148 per cent. The magnesium content in all the other treatments were lower. For the same levels of application, magnesium content was found to be lower with higher levels of calcium application. The ratio of CaO/MgO does not appear to show any effect on the magnesium content.

The ratio of CaO/MgO came down to relatively very low values four months after planting. From 1.31 and 4.19 in treatments, 1 and 5, the ratios decreased to 0.52 and 1.08 respectively. On the date of inoculation, treatment 4 showed the highest CaO/MgO ratio of 1:12. Treatment 5 showed the next lower value followed by treatments 3 and 2. Higher ratios were shown by treatments of ratio 6:1 as compared to those of 3:1 ratio and the control. The data on the CaO/Mgo ratios of the various treatments on the date of planting and on the date of inoculation are given in Tables VII and VIII respectively.

The decrease in the calcium oxide plus magnesium oxide/ potassium oxide ratio on the date of inoculation as compared to that in the beginning, eventhough marked, had not been as much as that of calcium oxide/magnesium oxide ratio. It came down from 0.75 to 0.69 in the control and from 3.40 to 2.54 in treatment 5. The ratios of the various treatments on the date of inoculation ranged from 0.69 in the control to 2.54 in treatment 5. Treatment 4 which received calcium oxide and magnesium oxide in the 6:1 ratio at the lower levels recorded the value 1.29 followed by treatments 3 and 2. Control showed the lowest value. As in the case of calcium oxide/magnesium oxide ratio, the ratio of calcium oxide plus magnesium oxide/potassium oxide also was highest for treatments of calcium oxide and magnesium oxide application in the ratio 6:1, followed by those of 3:1 ratio.

Nutrient content of leaf samples.

Nitrogen:

It was observed that there was a gradual decrease in nitrogen content of leaf samples with time, in all the healthy plants. The same trend was noticed in the infected plants also, till the date of appearance of symptoms. The nitrogen content showed an increase after sympton expression.

On 4-1-1967, one month before inoculation, treatment 2 showed the highest content of nitrogen in leaves followed by the control whereas treatment 4 showed the lowest percentage.

On the date of inoculation, control plants showed the highest value of nitrogen followed by treatment 2. Treatment 5 showed the lowest value of 3.39 per cent.

One month after inoculation, control plants had the highest percentage of nitrogen. Treatment 2 showed the next lower value and treatment 4, the least. During the next month, infected plant of treatment 4 showed the highest value of nitrogen followed by treatment 2 and then by the infected plant of treatment 3.

The data on the nitrogen contents of leaf samples are given in Table IX.

Potassium:

A gradual decrease in potash content was noticed with time in the control plants. It was found that the CaO/MgO ratio influenced the potash content of plants more than infection of virus or the levels of calcium and magnesium application.

TABLE IX

Nitrogen content of leaf samples
(Expressed as percentage on oven dry basis).

Date of sample collection	Healthy plants			Diseased plants	
	Ratio of CaO:MgO			Ratio of CaO:MgO	
	0	3:1	6:1	3:1	6:1
	Level of MgO in percentage			Level of MgO in percentage	
	0(T1)	0.05(T2)	0.10(T5)	0.10(T3)	0.05(T4)
4-1-67	3.6189	4.1003	3.4167	3.5724	3.5917
4-2-67	3.6262	3.5262	3.3995	3.4657	3.4291
4-3-67	3.6485	3.4808	3.3481	3.4701	3.3365
4-4-67	3.4137	3.6386	3.4643	3.4992	3.6502

TABLE X

Potash content of leaf samples
(Expressed as percentage on oven dry basis)

Date of sample collection	Healthy plants			Diseased plants	
	Ratio of CaO:MgO			Ratio of CaO:MgO	
	0	3:1	6:1	3:1	6:1
	Level of MgO in percentage			Level of MgO in percentage	
	0(T1)	0.05(T2)	0.10(T5)	0.10(T3)	0.05(T4)
4-1-67	6.8350	5.5700	6.4000	5.7520	5.5550
4-2-67	6.5065	5.8400	5.6710	5.7345	6.1045
4-3-67	6.9027	7.2400	6.9922	6.7442	7.6950
4-4-67	6.1803	5.6850	5.3026	6.3150	6.9019
4-5-67	6.2028	6.6427	4.5972	7.4448	5.8418

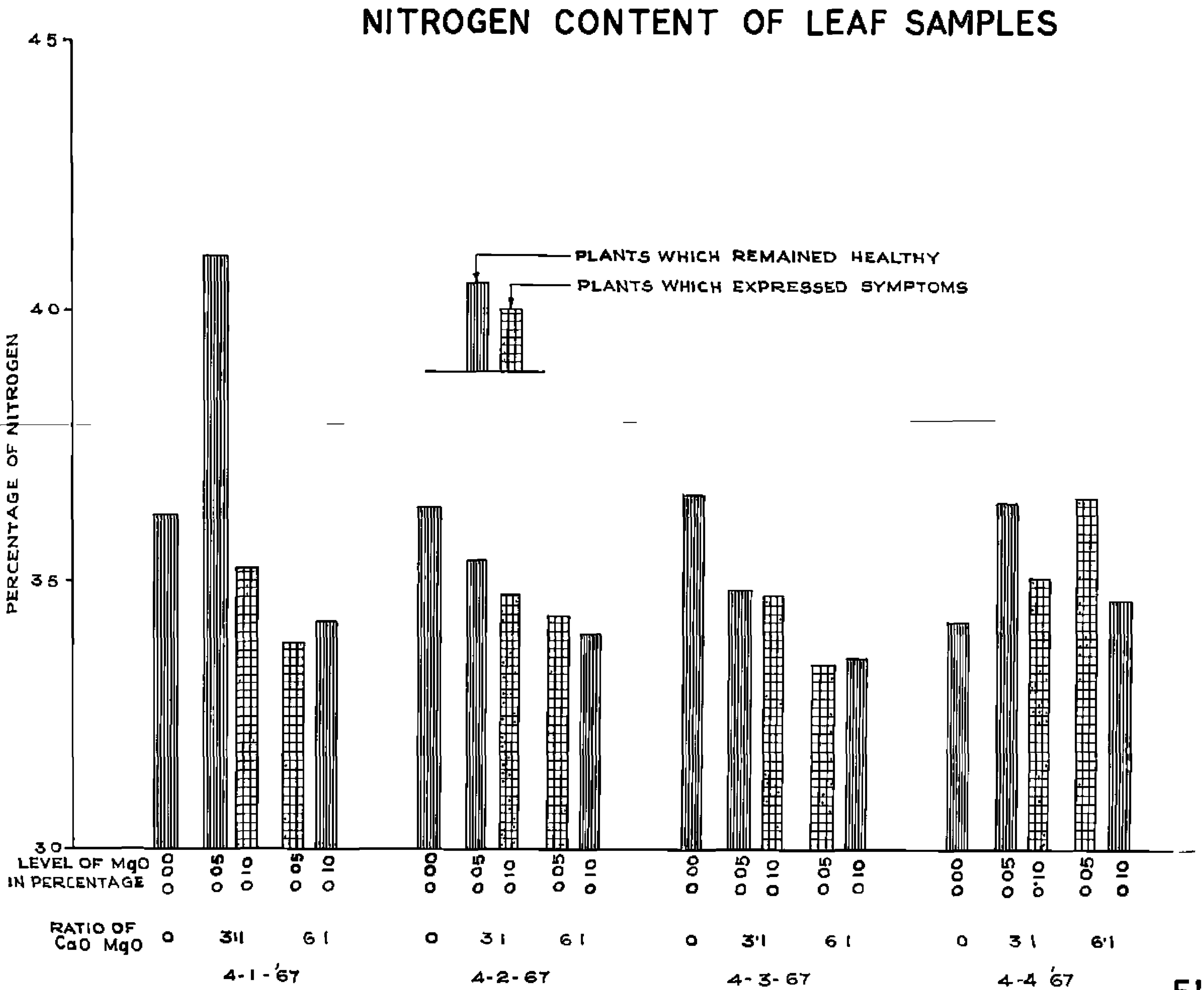
NITROGEN CONTENT OF LEAF SAMPLES
PLANTS WHICH REMAINED HEALTHY
PLANTS WHICH EXPRESSED SYMPTOMS
PERCENTAGE OF NITROGEN
4.5
4.0
3.5
3.0
LEVEL OF MgO IN PERCENTAGE
0.00 0.05 0.10 0.05 0.10
RATIO OF CaO MgO
0 3:1 6:1
4-1-'67
4-2-67
4-3-67
4-4-'67

FIG. I

POTASH CONTENT OF LEAF SAMPLES

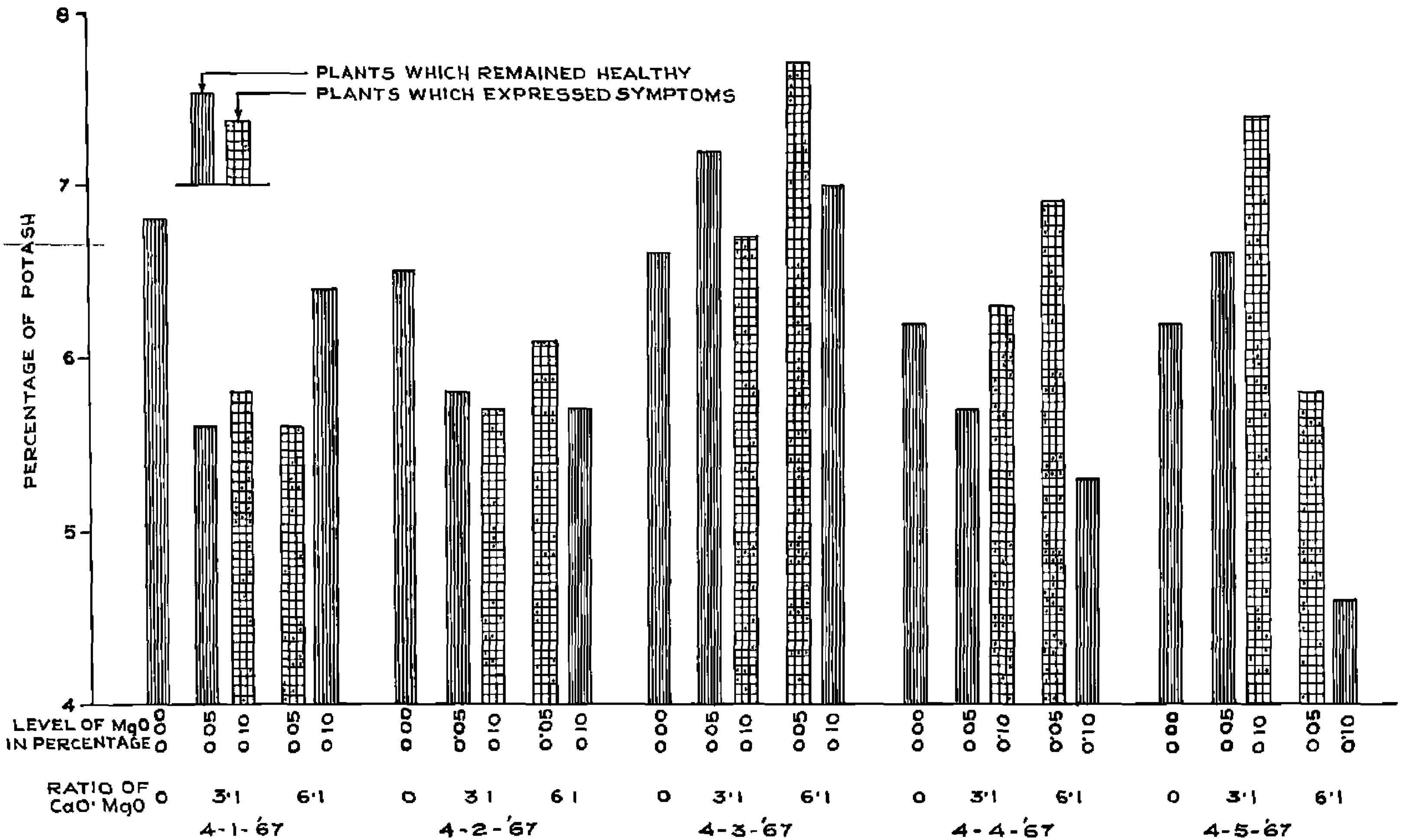

FIG.2.

Treatments 2 and 3, which had received CaO and MgO in the ratio 3:1 showed an increase in potash content in the early and later stages with a decline two months after inoculation. In treatments 4 and 5, of CaO/MgO ratio 6:1, the increase was noticed only in the early stages.

On 4-1-1967, one month before inoculation, control plant showed the highest percentage of potassium in leaves. Treatment 5 showed the next lower value. Treatments 3 and 4 which later took infection had almost similar values lower than the former two.

Analysis on the date of inoculation also showed the highest value of potash for the control followed by treatment 4. Treatment 5 showed the lowest content of potash in leaves, the next higher being that of treatment 3.

One month after inoculation, treatment 4 which expressed symptoms of infection 42 days after inoculation, had the highest content of potash, 7.69 per cent. This was followed by treatments 2, 5 and 3 in the decreasing order. Control plants showed the lowest potash content.

Two months after inoculation, both the infected plants showed the highest potash content. Treatment 4 had the maximum content in leaves followed by treatment 3. Control plant which came next was followed by treatments 2 and 5 in the order.

During the next month, infected plant of treatment 3 had shown the highest potash content of 7.45 per cent. The content in infected plant of treatment 4 dropped to 5.84 per cent which was lower than those of treatment 2 and the control. Treatment 5 showed the lowest value.

Infected plant of treatment 3 which showed symptoms 37 days after inoculation showed an increase in potash content in the beginning. It increased from 5.73 - 6.74 per cent, one month after inoculation. The content of potassium showed a decline two months after, which again increased to 7.44 per cent three months after inoculation. Treatment 4 which expressed symptoms of the disease 42 days after inoculation also had the highest content of potassium one month after inoculation which went on decreasing later.

The data on potash content of leaf sample are given in Table X.

Calcium:

There was a gradual decrease in calcium content of leaves of all the healthy plants except in treatment 5 where there was a drop one month after inoculation. In the case of treatment 3 which expressed symptoms 37 days after inoculation, there was a gradual decrease in calcium content till the date of inoculation. It showed an increase one month after, which later dropped to the lowest value 0.56 per cent during the next month. There was an increase to 1.24 per cent one month later. Almost the same trend was noticed in the case of treatment 4, which showed symptoms 42 days after inoculation. There was a gradual decrease till the date of appearance of symptoms. The lowest value, 0.43 per cent was shown two months after inoculation. There was an increase during the next month to 1.23 per cent CaO.

The calcium content of leaves followed almost the same pattern as that of calcium application. Calcium content was lowest for the control plants at all stages except in the case of infected plants, which showed the lowest values two months after inoculation. Before inoculation and on the date of inoculation, for the same levels of calcium application, percentage of calcium in plants was always higher in treatments of lower magnesium application.

One month prior to inoculation, treatment 5 showed the highest calcium content in leaves followed by treatments 4,2 and 3 in the order. Control plant had the lowest content of calcium.

The same pattern as above continued during the date of inoculation also, being in the decreasing order 5, 4, 2, 3 and control.

On 4-3-1967, one month after inoculation treatment 3 showed the highest content of calcium followed by treatment 5. Treatment 4 and 2 came next, the control plant showing the lowest percentages.

Calcium content was highest for treatment 5 two months after inoculation. This was followed by treatment 2. Control plants showed the next lower value, 0.64 per cent CaO. Leaves of diseased plants showed lower values of calcium, lower than that of control. Treatment 3 analysed to 0.56 per cent CaO and treatment 4, 0.43 per cent.

On 4-5-1967, three months after inoculation, treatment 5 showed the highest calcium content. Infected plants of treatments 3 and 4 come next with 1.24 and 1.23 per cent CaO respectively. These were much higher compared to the calcium content of treatment 2 which had 0.65 per cent CaO. Control plants showed the lowest percentage of 0.53 CaO.

The data on the calcium content of leaves for the different periods are given in Table XI.

Magnesium:

In contrast to calcium, there was a tendency for an increase in magnesium content with time. In the healthy plants, the percentage of MgO, which had been on the increase till the date of inoculation, dropped to very low values two months after inoculation. The highest magnesium content was observed three months after inoculation. The same trend was noticed in the diseased plants also.

TABLE XI

Calcium oxide content of leaf samples
(Expressed as percentage on oven dry basis)

Date of sample collection	Healthy plants			Diseased plants	
	Ratio of CaO:MgO			Ratio of CaO:MgO	
	0	3:1	6:1	3:1	6:1
	Level of MgO in percentage			Level of MgO in percentage	
	0(T1)	0.05(T2)	0.10(T5)	0.10(T3)	0.05(T4)
4-1-67	0.9450	1.6800	1.8200	1.3300	1.7500
4-2-67	0.9600	1.0500	1.1900	0.9800	1.2600
4-3-67	0.8800	0.9067	0.9878	1.2800	0.9067
4-4-67	0.6400	0.8789	1.6534	0.5600	0.4267
4-5-67	0.5333	0.6533	1.5467	1.2400	1.2267

TABLE XII

Magnesium oxide content of leaf samples
(Expressed as percentage on oven dry basis)

Date of sample collection	Healthy plants			Diseased plants	
	Ratio of CaO:MgO			Ratio of CaO:MgO	
	0	3:1	6:1	3:1	6:1
	Level of MgO in percentage			Level of MgO in percentage	
	0(T1)	0.05(T2)	0.10(T5)	0.10(T3)	0.05(T4)
4-1-67	0.5143	0.7999	0.7810	0.9523	0.9040
4-2-67	0.8572	1.3095	1.0239	1.2382	1.0477
4-3-67	0.5619	0.5619	1.1049	0.9905	1.0667
4-4-67	0.3048	0.8476	0.8191	0.5282	0.6000
4-5-67	0.9762	1.0095	1.1809	1.2572	1.1715

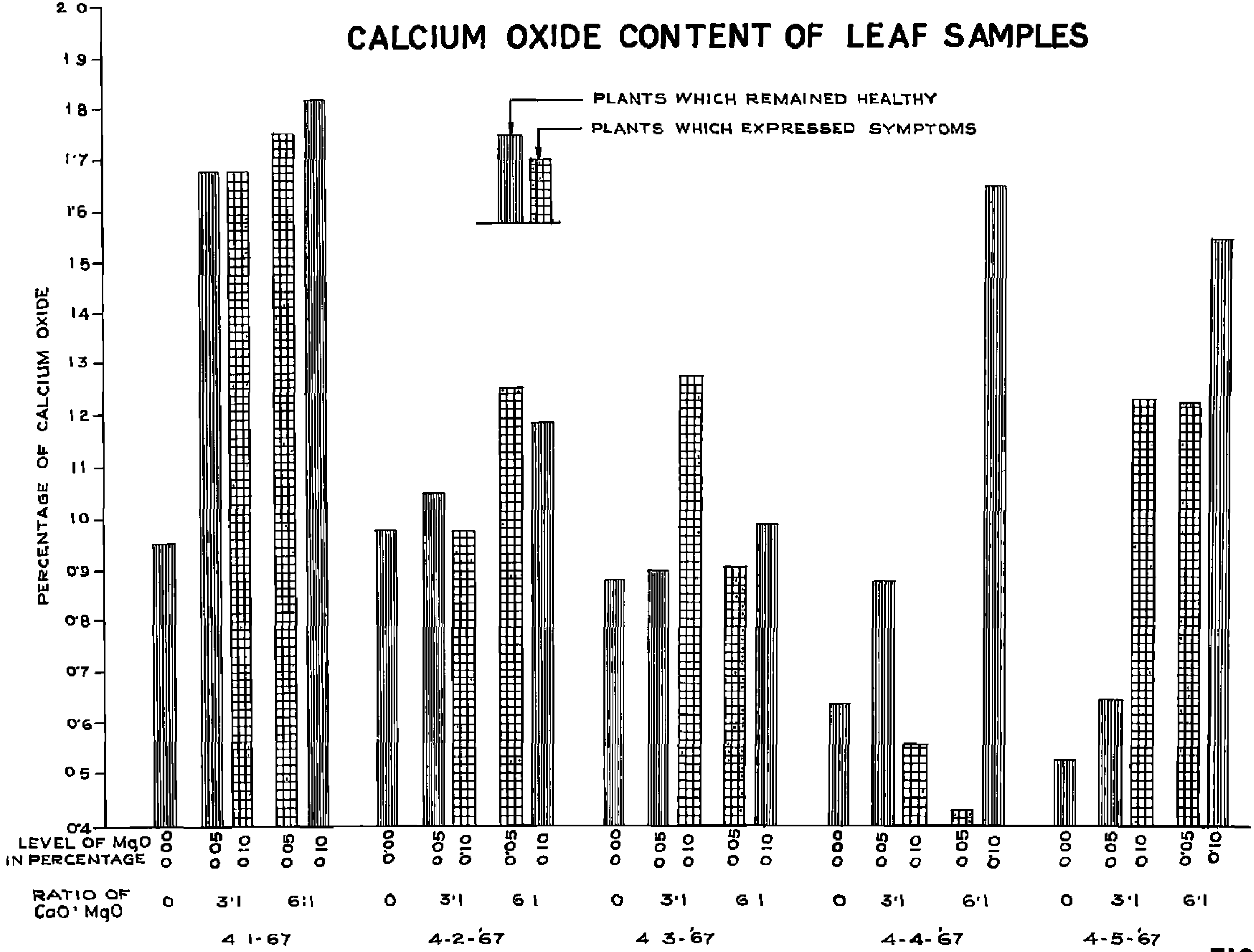
CALCIUM OXIDE CONTENT OF LEAF SAMPLES
PLANTS WHICH REMAINED HEALTHY
PLANTS WHICH EXPRESSED SYMPTOMS
PERCENTAGE OF CALCIUM OXIDE
LEVEL OF MgO IN PERCENTAGE
RATIO OF CaO : MgO
4-1-67
4-2-'67
4-3-'67
4-4-'67
4-5-'67

FIG. 3.

MAGNESIUM OXIDE CONTENT OF LEAF SAMPLES

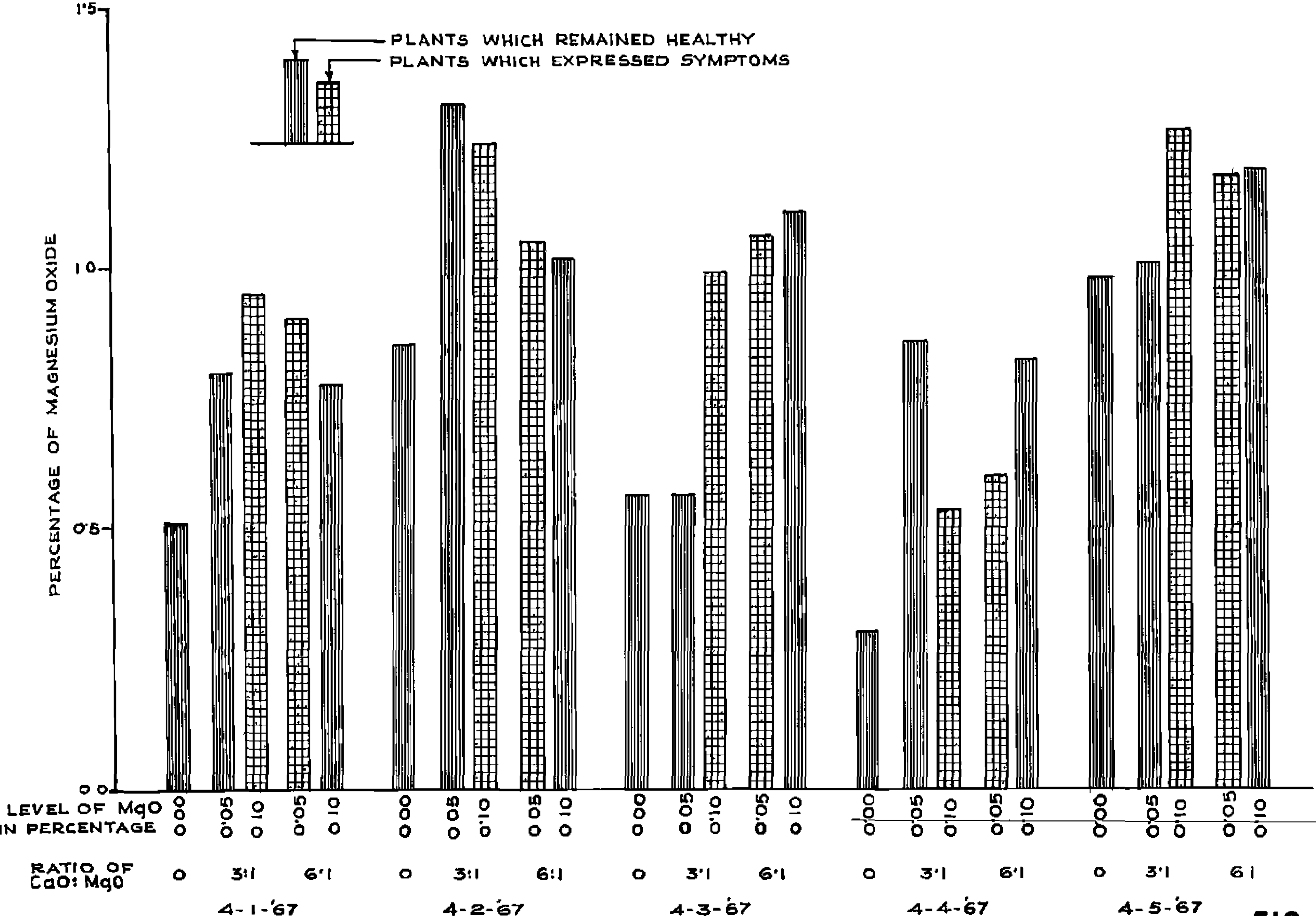

FIG. 4.

In treatment 3 which showed symptoms 37 days after inoculation, the content of magnesium decreased till two months after inoculation after which it increased again. The same trend was noticed in treatment 4 also, which showed symptoms 42 days after inoculation. The lowest content of magnesium in this case was recorded two months after inoculation.

As in the case of calcium, magnesium content also followed the same pattern as that of application. Magnesium content was lowest for the control plants in all cases. Before inoculation and on the date of inoculation, for the same levels of application, magnesium contents of plants were higher in plants that received lower calcium application.

On 4-1-1967, one month before inoculation highest magnesium content was recorded by treatment 3 with 0.95 per cent followed by treatment 4. Treatment 2 and 5 had lower contents in the decreasing order and the control plants had the lowest.

On the date of inoculation treatment 2 showed the highest magnesium content followed by treatments 3, 4, 5 and control in the order.

Treatment 5 showed the highest content of magnesium in leaves one month after inoculation. Treatments 4 and 3 had lower values and treatment 2 and control, the lowest.

On 4-4-1967, two months after inoculation, treatment 2 had the highest magnesium content followed by treatment 5. Infected plants of treatments 4 and 3 showed very low values of magnesium, 0.60 and 0.53 per cent respectively. The content in the control plants were still lower, 0.31 per cent.

During the next month, on 4-5-1967 also, treatment 5 analysed the highest content of magnesium. This was followed by treatments 3, 4, 2 and control in the order.

The data on the magnesium content of leaves are given in Table XII.

Calcium oxide/magnesium oxide ratio:

The ratio varied from 0.55 to 2.33 during the period of observation. The ratio did not appear to follow any defenite pattern with treatments or with time.

On 4-1-1967, one month prior to inoculation all the plants showed ratios more than one. Treatment 5 showed the highest value of 2.33 followed by treatments 2, 4, 1 and 3 in the order. The plants of treatments 3 and 4, which later got infected showed values, 1.39 and 1.93 respectively.

On the date of inoculation also, treatment 5 showed the highest value of 1.16. Treatments 4 and the control had values 1.20 and 1.14 respectively. Ratios of treatments 2 and 3 were much lower, being 0.80 and 0.79 respectively.

One month after inoculation, treatment 2 had the ratio 1.61 followed by control with 1.57. Treatment 3 which showed symptoms of infection 37 days after inoculation showed the value 1.29. Treatment 5 had the value 0.89 and treatment 4, 0.85. This was the lowest.

Control plants showed the highest value two months after inoculation followed by treatment 5 with a ratio of 2.02. The ratios for treatments 2 and 3 were lower than treatment 5, and treatment 4 had the lowest value of 0.71.

On 4-5-1967, three months after inoculation, treatment 5 showed the highest value of calcium oxide/magnesium oxide ratio followed by treatment 4. Control plant showed the lowest value 0.55, those for treatments 2 and 5 being slightly higher.

The data on the calcium oxide/magnesium oxide ratio for the different treatments are given in Table XIII.

Calcium oxide plus magnesium oxide/potassium oxide ratio:

In the healthy control plant, the value of CaO + MgO/ K_2O ratio increased from 0.21 to 0.28 on the date of inoculation. There had been a gradual decrease thereafter and the lowest value 0.15

TABLE XIII

Calcium oxide/magnesium oxide ratio in the leaf

Date of sample collection	Healthy plants			Diseased plants	
	Ratio of CaO:MgO			Ratio of CaO:MgO	
	0	3:1	6:1	3:1	6:1
	Level of MgO in percentage			Level of MgO in percentage	
	0(T1)	0.05(T2)	0.10(T5)	0.10(T3)	0.05(T4)
4-1-67	1.8374	2.1002	2.3303	1.3966	1.9358
4-2-67	1.1432	0.8011	1.0622	0.7913	1.2027
4-3-67	1.5661	1.6136	0.8941	1.2922	0.8500
4-4-67	2.0997	1.0369	2.0185	1.0594	0.7112
4-5-67	0.5463	0.6472	1.3098	0.9864	1.0471

TABLE XIV

Calcium oxide plus magnesium oxide/potassium oxide ratio in the leaf

Date of sample collection	Healthy plants			Diseased plants	
	Ratio of CaO:MgO			Ratio of CaO:MgO	
	0	3:1	6:1	3:1	6:1
	Level of Mgo in percentage			Level of MgO in percentage	
	0(T1)	0.05(T2)	0.10(T5)	0.10(T3)	0.05(T4)
4-1-67	0.2135	0.4313	0.4064	0.3968	0.4777
4-2-67	0.2824	0.4040	0.3904	0.3868	0.3780
4-3-67	0.2190	0.2028	0.2993	0.3367	0.2565
4-4-67	0.1529	0.3037	0.4663	0.1724	0.1488
4-5-67	0.2434	0.2503	0.5502	0.3354	0.4105

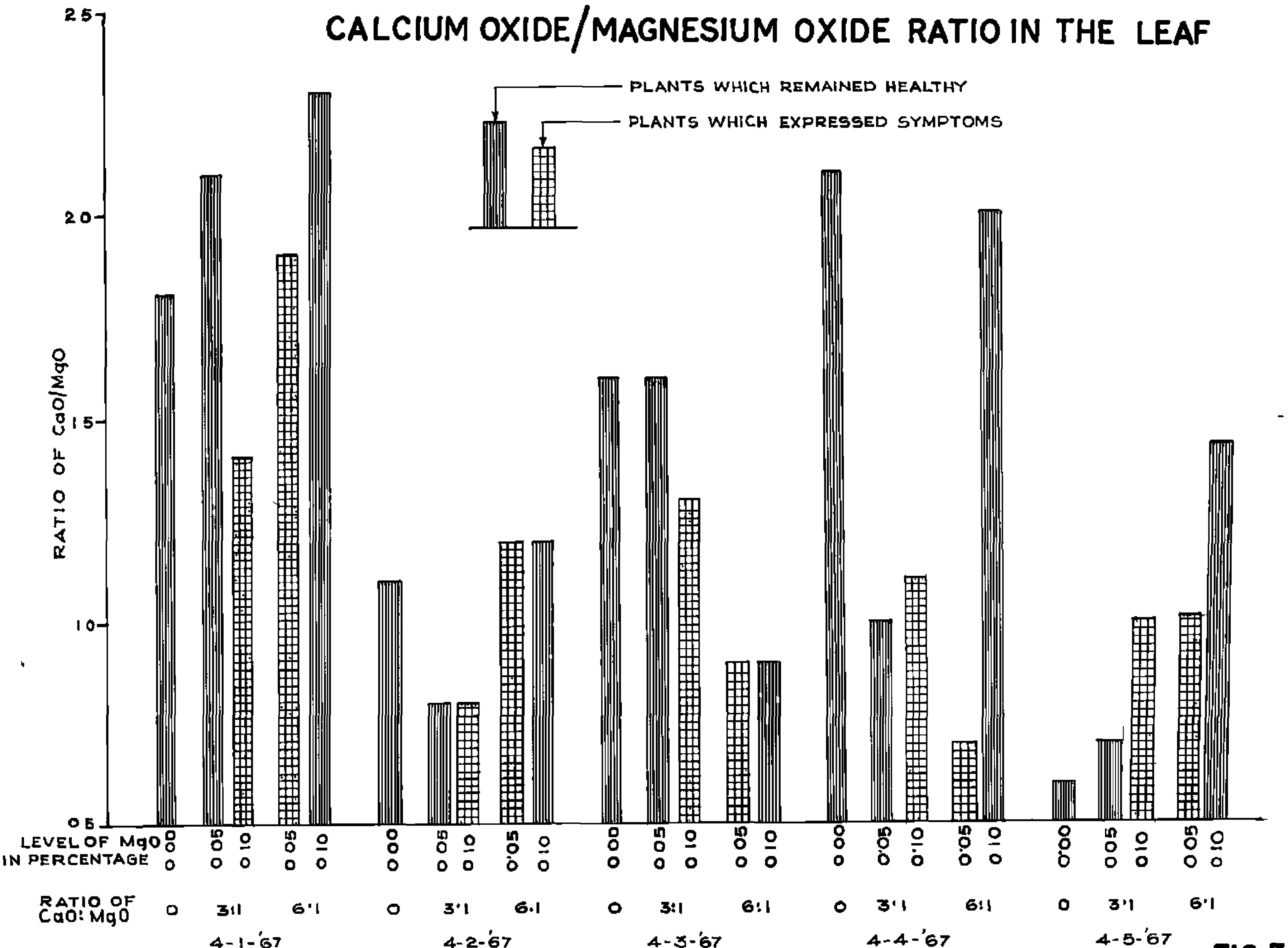
CALCIUM OXIDE/MAGNESIUM OXIDE RATIO IN THE LEAF
PLANTS WHICH REMAINED HEALTHY
PLANTS WHICH EXPRESSED SYMPTOMS
RATIO OF CaO/MgO
2·5
2·0
1·5
1·0
0·5
LEVEL OF MgO IN PERCENTAGE
0·00
0·05
0·10
RATIO OF CaO: MgO
0
3:1
6:1
4-1-'67
4-2-'67
4-3-'67
4-4-'67
4-5-'67

FIG. 5.

CALCIUM OXIDE PLUS MAGNESIUM OXIDE/POTASSIUM OXIDE RATIO IN LEAF

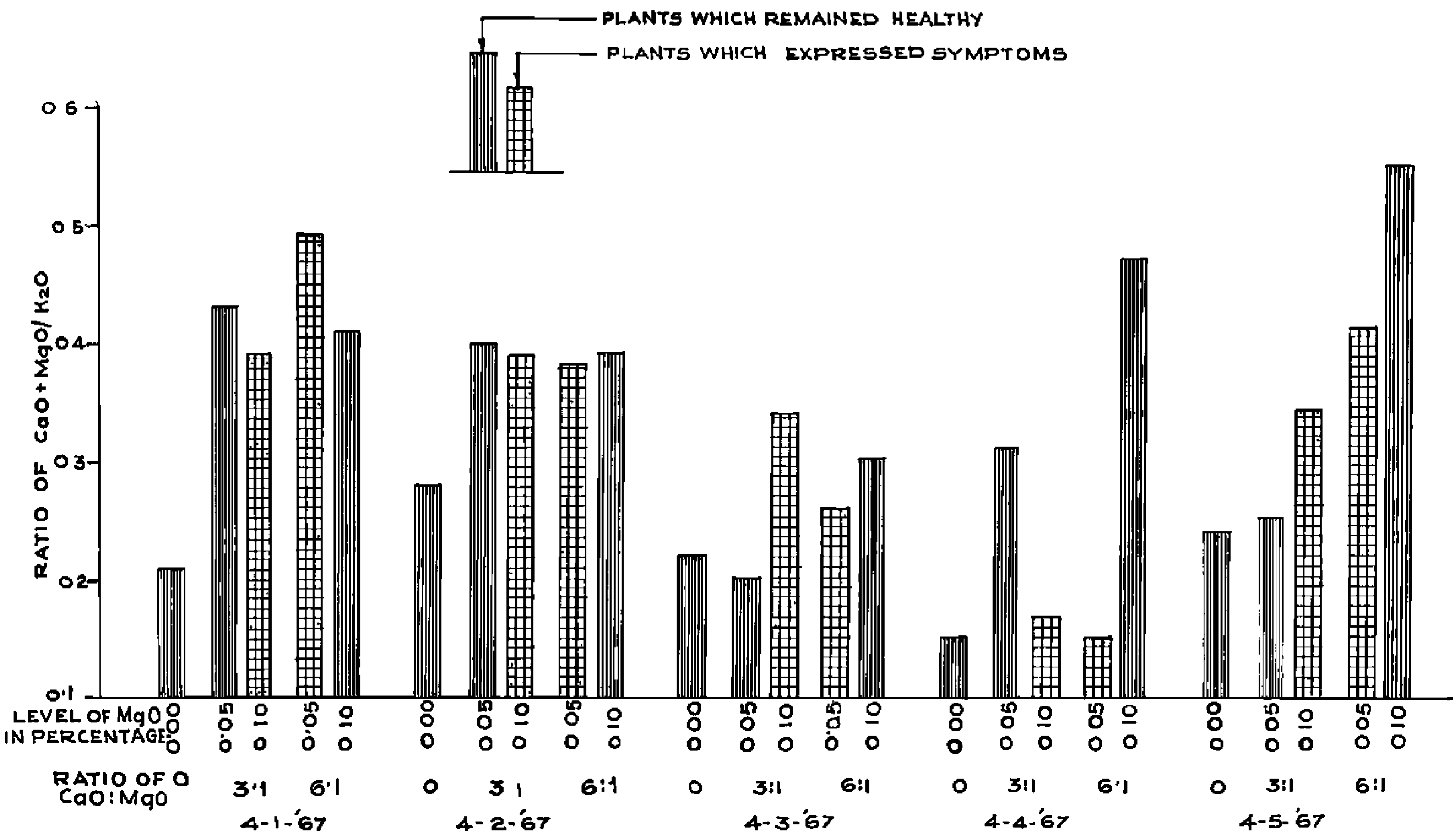

FIG. 6.

was recorded two months after inoculation. It rose to 0.24 during the next month. In treatment 2 which had received the lower level of calcium and magnesium in the ratio 3:1 and which remained healthy, there had been a drop in ratio from 0.40 to 0.20, one month after inoculation. During the next month, the value increased to 0.30. In treatment 3 of CaO and MgO in 3:1 ratio at the higher levels, which showed symptoms 37 days after inoculation, the ratio dropped to 0.17 two months after inoculation from 0.34. It again rose to 0.34, three months after inoculation. In treatment 4, which expressed symptoms 42 days after inoculation there had been a gradual decrease in the ratio from 4-1-1967. One month after inoculation, it dropped to 0.26 from 0.38. A sudden drop to 0.15 was recorded two months after inoculation, which again rose to 0.41, the next month. In treatment 5 which remained healthy, there had been a drop one month after inoculation to 0.30 from 0.39. It rose to 0.47 two months after inoculation and to 0.55 the next month.

The ratio showed an increase with increasing levels of calcium and magnesium application, excepting the plants which took infection. In other cases, the control plants had the lowest value.

One month before inoculation, control plants showed the lowest value. Treatment 4 had the highest value of 0.48 followed by treatments 5, 2 and 3.

On the date of inoculation, treatment 2 had the highest value followed by treatment 5. Treatments 3 and 4 which showed symptoms of infection 37 and 42 days after inoculation had lower values 0.39 and 0.38 respectively. Control plants showed the lowest value of 0.28.

One month after inoculation, treatment 3 showed the highest value of 0.34 followed by treatments 5, 4 and 2. Control plant showed the lowest value of 0.22.

On 4-4-1967, two months after inoculation, treatment 5 had the highest value of 0.47 followed by treatment 2 with 0.30. Treatments 3 and 4 had very low values 0.17 and 0.15 respectively. Control plant showed the value 0.15.

Three months after inoculation, treatment 5 had the highest value 0.55, followed by treatment 4. Treatments 3, 2 and control had lower values.

The data on the calcium oxide plus magnesium oxide/ potassium oxide ratio are given in Table XIV.

Nutrient content of root samples.

Nitrogen:

There had been a decrease in nitrogen content with time in the control and also in treatments that received calcium oxide and magnesium oxide in the ratio 6:1. Those that received the nutrients in the 3:1 ratio showed high percentages of nitrogen on the date of inoculation which decreased gradually later. In the infected plants, there appeared to be a lowering in nitrogen content after appearance of symptoms.

One month prior to inoculation, treatment 5 showed the highest content of nitrogen in roots followed by the control. Treatments 2, 3 and 4 had correspondingly lower values.

On the date of inoculation, treatment 2 had the highest content of nitrogen in roots followed by treatment 3 which later showed symptoms of the disease. Treatments 4 and 5 which had received calcium oxide and magnesium oxide in the ratio 6:1 showed lower percentages.

On 4-3-1967, one month after inoculation, treatment 2 showed the highest value followed by treatments 3, 1, 4 and 5 in the order.

Two months after inoculation, treatments 1 and 3 showed the highest values followed by treatments 2, 4 and 5.

The data on the nitrogen content of root samples are given in Table XV.

Potassium:

As against a lowering in potash content in leaves, the roots showed a tendency towards an accumulation of potassium with time.

TABLE XV

Nitrogen content of root samples

(Expressed as percentage on oven dry basis)

Date of sample collection	Healthy plants			Diseased plants	
	Ratio of CaO:MgO			Ratio of CaO: MgO	
	0	3:1	6:1	3:1	6:1
	Level of MgO in percentage			Level of MgO in percentage	
	0(T1)	0.05(T2)	0.10(T5)	0.10(T3)	0.05(T4)
4-1-67	2.0402	1.8424	2.0542	1.5963	1.4568
4-2-67	1.7828	2.4677	1.7475	2.2914	1.9995
4-3-67	1.5375	2.1666	1.2418	2.1198	1.3412
4-4-67	1.3924	1.1538	1.0454	1.2918	1.0458

TABLE XVI

Potash content of root samples

(Expressed as percentage on oven dry basis)

Date of sample collection	Healthy plants			Diseased plants	
	Ratio of CaO:MgO			Ratio of CaO:MgO	
	0	3:1	6:1	3:1	6:1
	Level of MgO in percentage			Level of MgO in percentage	
	0(T1)	0.05(T2)	0.10(T5)	0.10(T3)	0.05(T4)
4-1-67	5.4332	8.8312	6.7232	7.0225	6.3791
4-2-67	5.1420	6.7223	6.4227	6.7030	6.2872
4-3-67	5.7743	8.8720	7.0221	7.1003	5.2780
4-4-67	6.7666	7.4883	8.0298	10.8265	7.7588

NITROGEN CONTENT OF ROOT SAMPLES

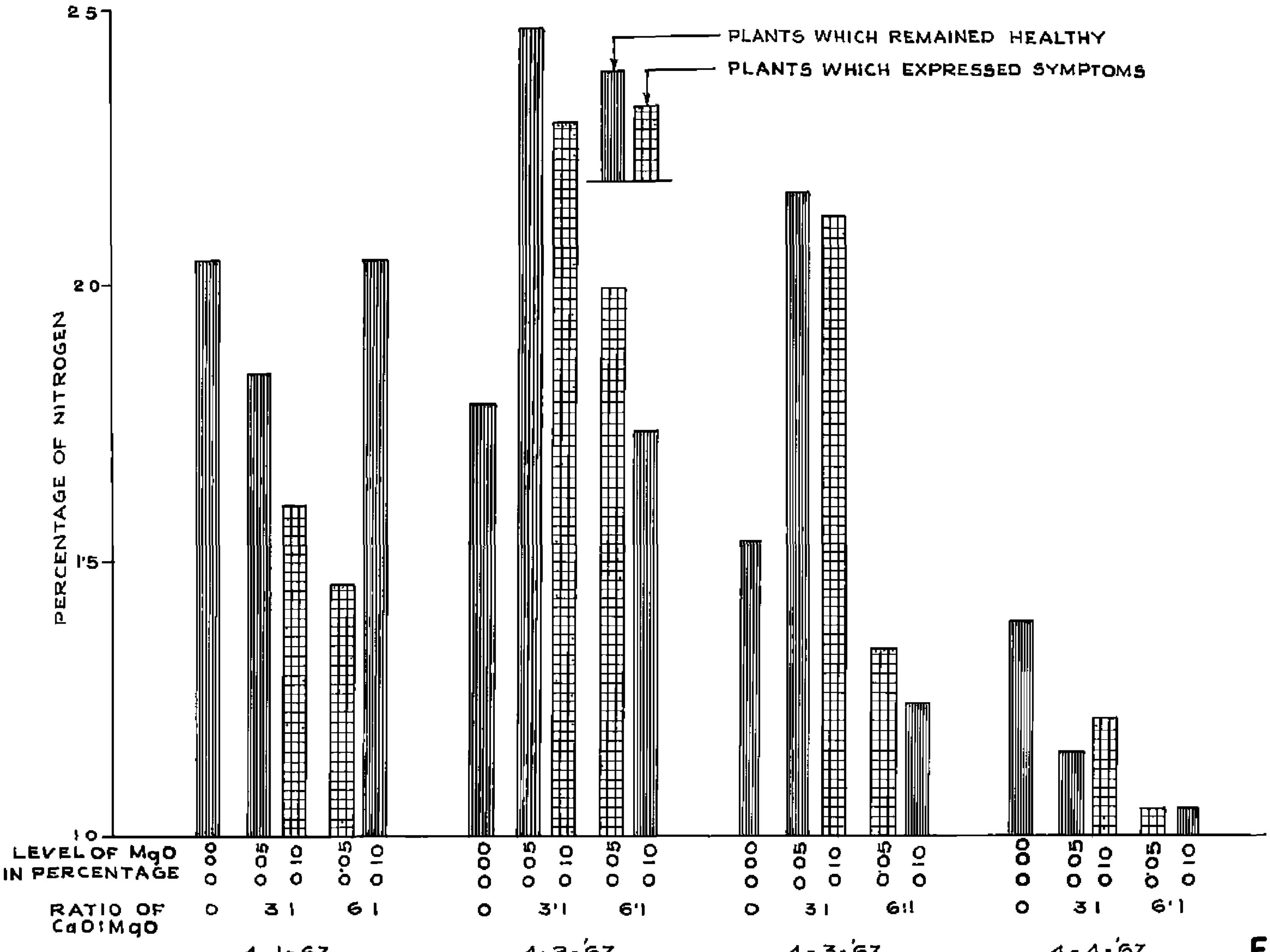

FIG. 7

POTASH CONTENT OF ROOT SAMPLES

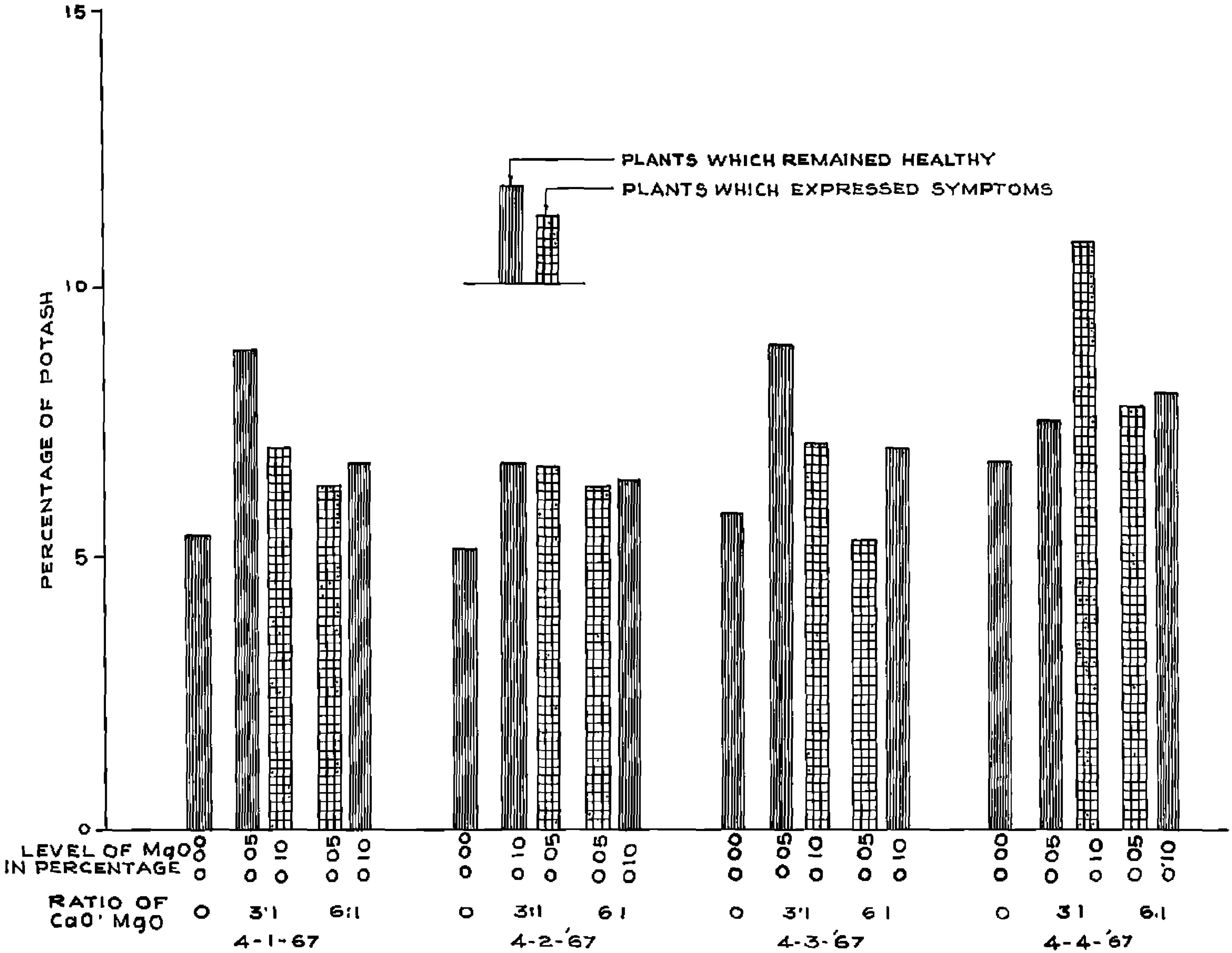

FIG. 8.

A drop in potash content from 6.29 to 5.28 was recorded in treatment 4 which showed symptoms of infection 42 days after inoculation.

In almost all cases, the control plants showed the lowest value of potash in roots which remained more or less steady throughout.

On 4-1-1967, one month before inoculation treatment 2 showed the highest value of 8.83 followed by treatment 3 with 7.02 per cent. Treatments 5 and 4 came next and control plants showed the lowest value of 5.43 per cent.

On the date of inoculation, the same trend as above followed with control plants showing the value 5.14 per cent K_2O in roots.

The same pattern as above followed one month after, with treatment 2 analysing 8.87 per cent potash and treatment 3, 7.10 per cent. The lowest potash content 5.28 per cent was shown by the infected plant of treatment 4.

Two months after inoculation, treatment 3 showed the highest content of potassium in roots with 10.83 per cent potash. This was followed by treatments 5, 4 and 2 in the order. Control plants showed the lowest value of 6.77 per cent.

The results of chemical analysis on potash content of roots are given in Table XVI.

Calcium:

The calcium content of roots tended to increase with increased application. The control plants showed the lowest values in all cases except the diseased plants of treatments 3 and 4. For the plants which received the same level of calcium, the percentage in the roots was higher for the plant, which received the lower level of magnesium. This was altered after the incidence of the disease.

The percentage of calcium in roots remained more or less steady throughout in all the healthy plants excepting treatment 2 which showed a lowering two months after inoculation. In the case of infected plants, the same trend as that in leaves was noticed. There had been a drop to very low values two months after inoculation. In treatment 3 which expressed symptoms 37 days after inoculation, there had been a slight increase in calcium content from 1.40 to 1.53 per cent one month after inoculation. During the next month it dropped to 0.91 per cent. In treatment 4, the highest content of calcium oxide, 2.33 per cent was recorded on the date of inoculation. It dropped to 1.01 per cent one month after inoculation, and to 0.75 per cent during the next month.

One month before inoculation, treatment 4 showed the highest value of calcium, 1.52 per cent followed by treatment 2 with 1.43 per cent. Treatments 3 and 5 showed 1.42 per cent each. Control plant showed the lowest calcium content of 0.98 per cent.

On the date of inoculation also, the same pattern followed with treatment 4 showing the highest value, 2.33 per cent and the control the lowest.

One month after inoculation, treatment 5 analysed the highest percentage of calcium 1.37 per cent, followed by treatments 3 and 2. Treatment 4 which showed symptoms of infection 42 days after inoculation had the lowest value, 1.01 per cent which was lower than the control. Treatment 5 showed the highest percentage of 1.36 CaO two months after inoculation. Infected plants of treatments 3 and 4 showed lower values, lower than the control.

The data on calcium content of roots are given in Table XVII.

Magnesium:

The magnesium content of roots did not appear to follow any defonite pattern though there had been fluctuations with time.

The values varied from 0.36 to 1.43 per cent. The highest magnesium content was recorded by treatment 3 which received CaO and MgO in the ratio 3:1 at the higher level of magnesium. The lowest percentage in almost all cases were recorded by treatment 5 which also received 0.1 per cent magnesium oxide. For the same levels of magnesium, the higher contents in roots were shown by the treatments which received the lower levels of calcium.

TABLE XVII

Calcium oxide content of root samples

(Expressed as percentage on oven dry basis)

Date of sample collection	Healthy plants			Diseased plants	
	Ratio of CaO:MgO			Ratio of CaO:MgO	
	0	3:1	6:1	3:1	6:1
	Level of MgO in percentage			Level of MgO in percentage	
	0(T1)	0.05(T2)	0.10(T5)	0.10(T3)	0.05(T4)
4-1-67	0.9828	1.4327	1.4220	1.4227	1.5224
4-2-67	0.8400	1.6700	1.4000	1.4000	2.3300
4-3-67	1.0567	1.3334	1.3692	1.5263	1.0134
4-4-67	0.9600	0.6933	1.3531	0.9067	0.7467

TABLE XVIII

Magnesium oxide content of root samples

(Expressed as percentage on oven dry basis)

Date of collection	Healthy plants			Diseased plants	
	Ratio of CaO:MgO			Ratio of CaO:MgO	
	0	3:1	6:1	3:1	6:1
	Level of MgO in percentage			Level of MgO in percentage	
	0(T1)	0.05(T2)	0.10(T5)	0.10(T3)	0.05(T4)
4-1-67	1.0029	1.3629	0.7661	1.3612	0.9983
4-2-67	0.5713	0.6349	0.5239	1.3333	0.5175
4-3-67	1.1429	1.2699	0.6627	1.4333	0.9905
4-4-67	0.3619	0.7429	0.5524	1.0667	0.8000

CALCIUM OXIDE CONTENT OF ROOT SAMPLES

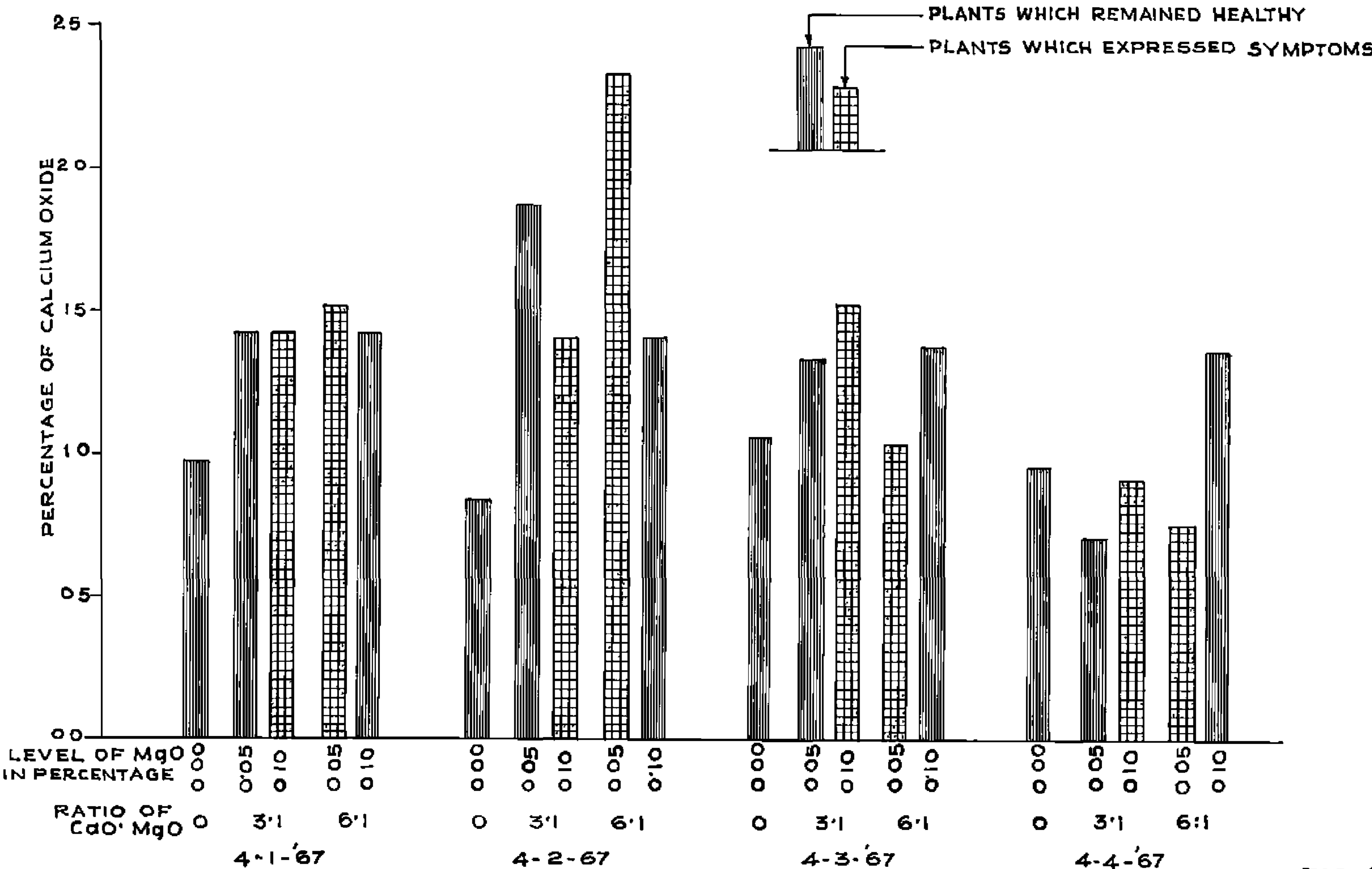

FIG. 9.

MAGNESIUM OXIDE CONTENT OF ROOT SAMPLES

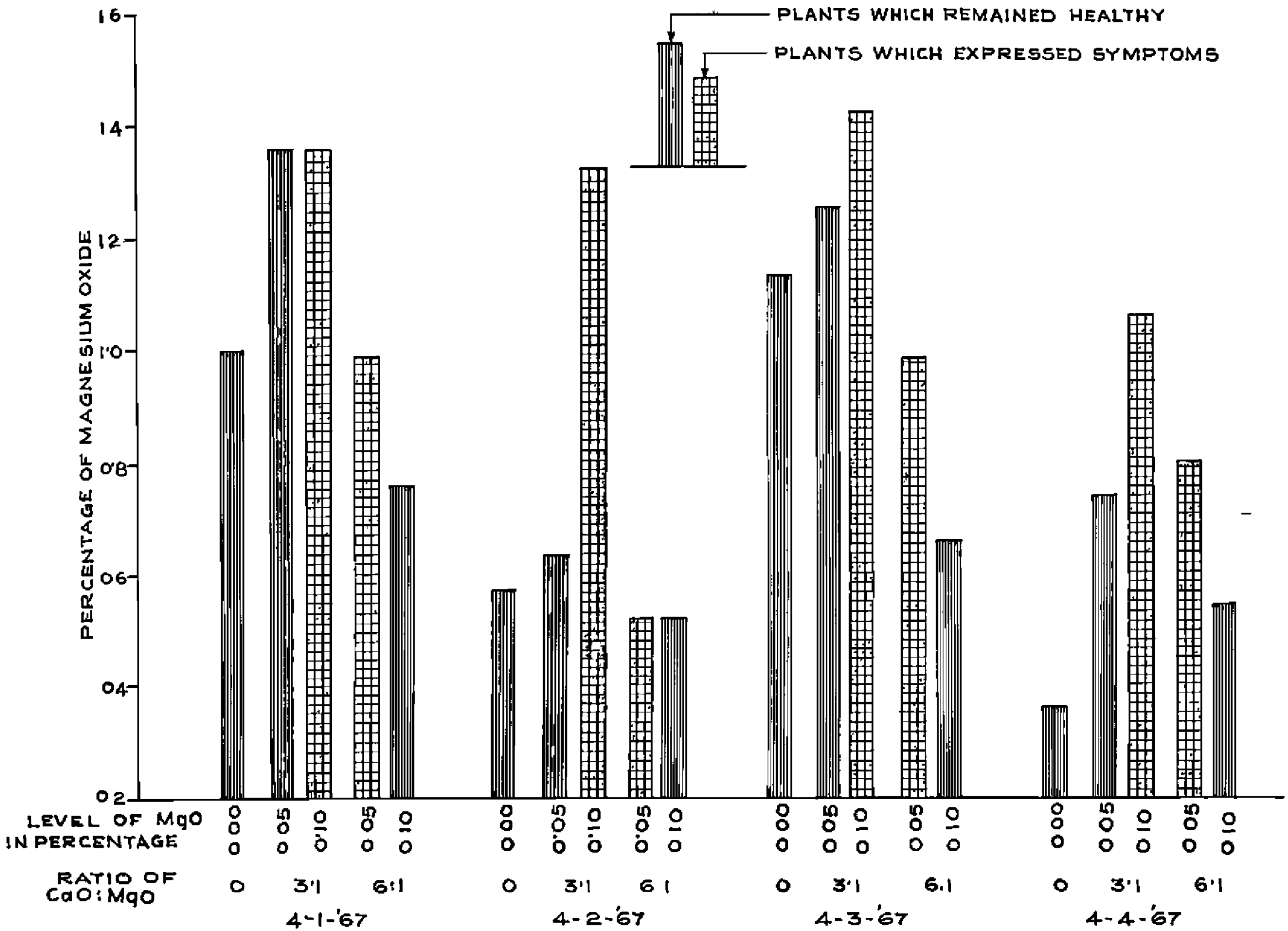

FIG. 10

On 4-1-1967, one month before inoculation, the highest magnesium content was recorded by treatment 2 followed by treatment 3. The control plant came next with 1.00 per cent magnesium oxide. Treatments 4 and 5 had lower values of 0.99 and 0.76 per cent respectively.

On the date of inoculation, treatment 3 which showed symptoms of infection later, had the highest content of magnesium in roots followed by treatment 2. Control plant analysed 0.57 per cent and treatment 5, 0.52 per cent. Treatment 4 which also contracted the disease recorded the lowest value 0.52 per cent.

One month after inoculation, treatment 3 had the highest percentage of magnesium, 1.43. Treatments 3, 1 and 4 had lower values. Treatment 5 had the lowest value of 0.66 per cent.

Two months after inoculation, infected plant of treatment 3 showed the highest value of 1.07 per cent followed by treatments 4, 2 and 5 in the order. The lowest value 0.36 per cent was shown by the control.

The data on the magnesium content of root samples are given in Table XVIII.

Calcium oxide/magnesium oxide ratio:

In all the healthy plants, there had been a tendency towards an increase in value of CaO/MgO ratio with time. In the control, it increased from 0.98 one month before inoculation to

2.65 two months after it. In treatment 5, the value rose to 2.67 from 1.86 on the date of inoculation. It dropped to 2.07 one month after inoculation. There was a rise to 2.45 during the next month. Treatment 2 showed an increase from 1.05 to 2.95 on the date of inoculation. The values dropped to 1.05 and 0.93 during the next two months. Treatment 3 which showed symptoms 37 days after inoculation recorded increased values till symptom appearence. The highest value, 1.06 was recorded one month after inoculation. There was a drop to 0.85 during the next month. Infected plant of treatment 4 showed the highest value, 4.50 on the date of inoculation. There had been a drop to lower values during the next two months.

The values of CaO/MgO ratio varied, in general from 0.93 to 4.50. The highest value in almost all cases have been recorded by treatment 5.

One month before inoculation, treatment 5 had the highest value of 1.86 per cent followed by treatments 4, 3, 2 and control in the order.

On the date of inoculation, treatment 4 which showed symptoms 42 days after inoculation recorded the value 4.50 followed by treatments 2 and 5 with 2.95 and 2.67 respectively. Control had 1.47 and treatment 3, 1.05.

One month after inoculation, treatment 5 had the highest ratio of 2.07 followed by treatment 3 with 1.06. Treatments 2 and 4 had values 1.05 and 1.02 respectively. Control plant showed the lowest value of 0.93.

Control plant showed the highest value two months after inoculation, with 2.65. Treatment 5 showed 2.45 and treatments 2 and 4, 0.93 each. Treatment 3 had the lowest value 0.85.

The data on the calcium oxide/magnesium oxide ratios of root samples are given in Table XIX.

Calcium oxide plus magnesium oxide/potassium oxide ratio:

There appeared to be a lowering in the ratio with time in all the treatments. Treatments 3 and 4 which showed symptoms later, had the highest values on the date of inoculation which came down later to very low values. In treatment 5 of CaO and MgO in the 6:1 ratio, the values were fairly high though there had been a gradual lowering.

The ratios were highest for treatments 3 and 4 till the date of appearance of symptoms which dropped to the lowest values two months after inoculation.

One month before inoculation, treatments 3 and 4 showed the highest values of 0.39 each. Treatments 1,5 and 2 had lower values of 0.37, 0.33 and 0.32 respectively.

TABLE XIX

Calcium oxide/magnesium oxide ratio in the root

Date of sample collection	Healthy plants			Diseased plants	
	Ratio of CaO:MgO			Ratio of CaO:MgO	
	0	3:1	6:1	3:1	6:1
	Level of MgO in percentage			Level of MgO in percentage	
	0(T1)	0.05(T2)	0.10(T5)	0.10(T3)	0.05(T4)
4-1-67	0.9799	1.0512	1.8562	1.0452	1.5249
4-2-67	1.4703	2.9450	2.6722	1.0500	4.5024
4-3-67	0.9333	1.0500	2.0661	1.0648	1.0231
4-4-67	2.6527	0.9352	2.4500	0.8500	0.9334

TABLE XX

Calcium oxide plus magnesium oxide/potassium oxide ratio in the root

Date of sample collection	Healthy plants			Diseased plants	
	Ratio of CaO:MgO			Ratio of CaO:MgO	
	0	3:1	6:1	3:1	6:1
	Level of MgO in percentage			Level of MgO in percentage	
	0(T1)	0.05(T2)	0.10(T5)	0.10(T3)	0.05(T4)
4-1-67	0.3655	0.3166	0.3255	0.3964	0.3951
4-2-67	0.2745	0.3577	0.2995	0.4075	0.4211
4-3-67	0.3827	0.2934	0.2894	0.4168	0.3797
4-4-67	0.1954	0.1918	0.2374	0.1823	0.1993

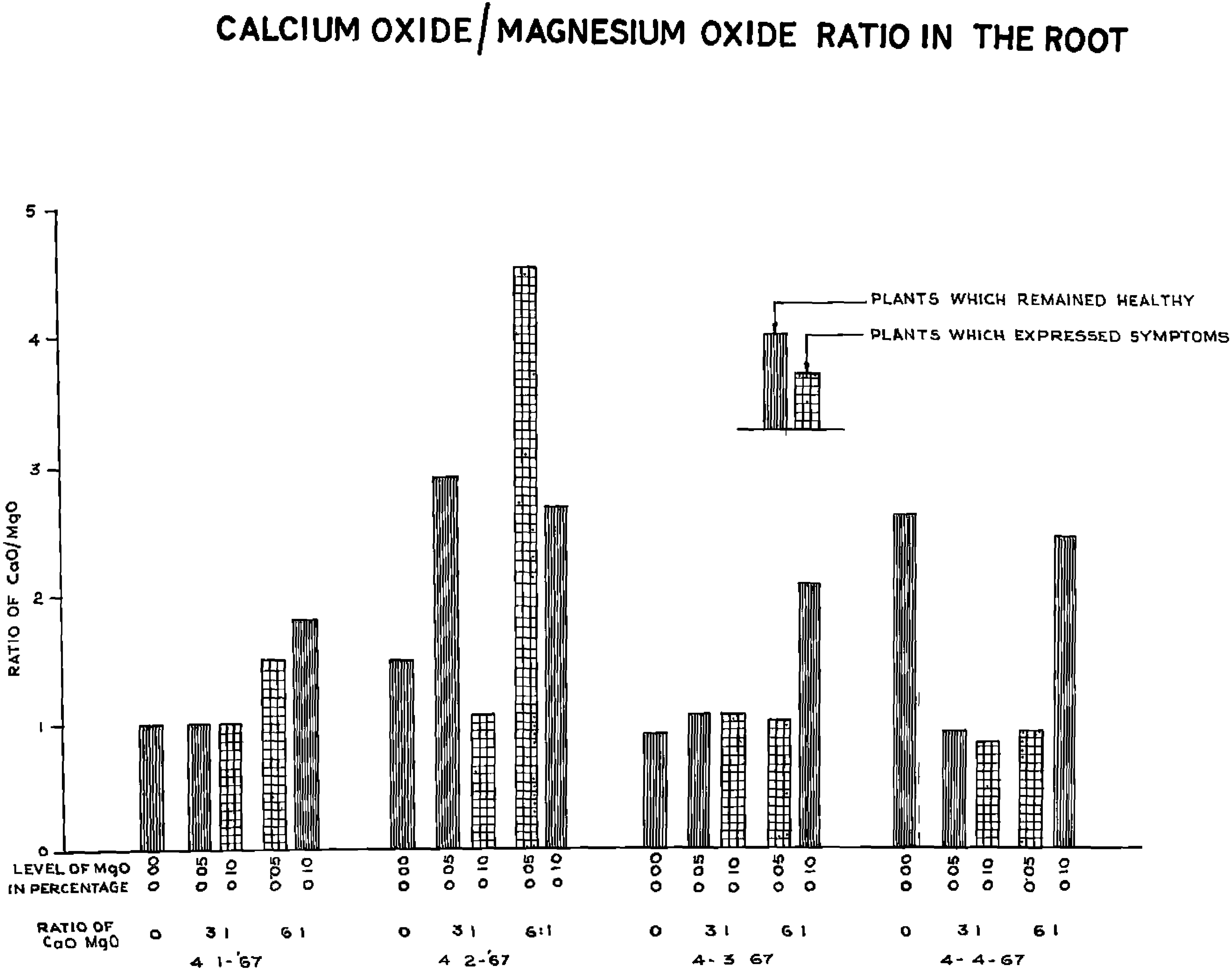
CALCIUM OXIDE/MAGNESIUM OXIDE RATIO IN THE ROOT
PLANTS WHICH REMAINED HEALTHY
PLANTS WHICH EXPRESSED SYMPTOMS
RATIO OF CaO/MgO
0
1
2
3
4
5
LEVEL OF MgO IN PERCENTAGE
0·00
0·05
0·10
RATIO OF CaO MgO
0
3 1
6 1
4 1-'67
4 2-'67
4-3 67
4-4-67

FIG. 11.

CALCIUM OXIDE PLUS MAGNESIUM OXIDE/POTASSIUM OXIDE RATIO IN ROOT

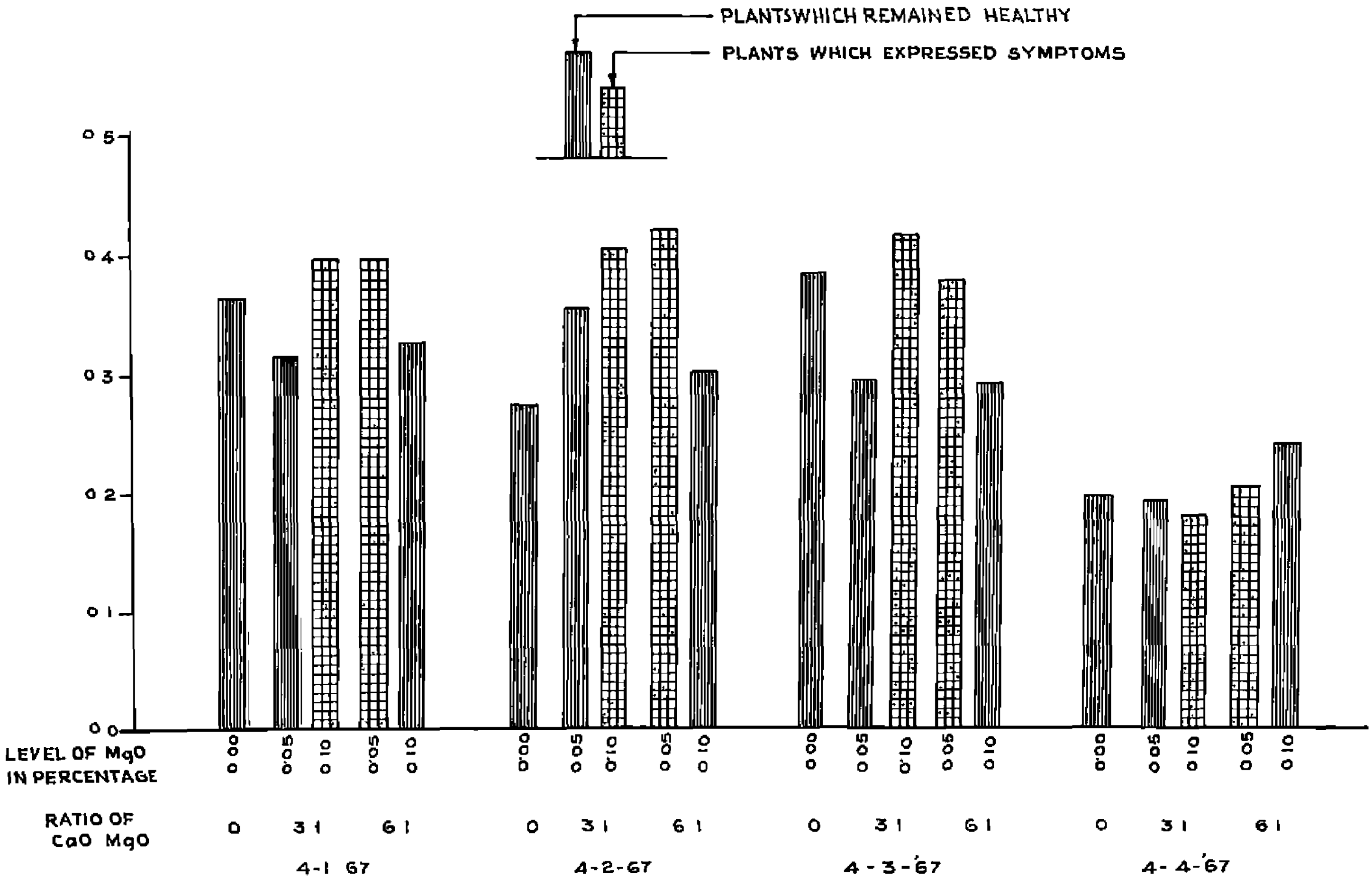

FIG. 12.

On the date of inoculation, treatments 4 and 3 had shown the highest values of 0.42 and 0.41 respectively. Treatment 2 had the value 0.36 and treatment 5, 0.29. Control plants showed the lowest value of 0.27.

One month after inoculation and before the appearance of disease symptoms, treatments 3 and 4 had values of 0.42 and 0.38 respectively. The ratios for treatments 2 and 5 were still lower.

Two months after inoculation when the disease symptoms had already appeared, treatments 4 and 3 showed the lowest ratios of 0.19 and 0.18 respectively. Treatment 5 had the highest value 0.24 followed by treatments 2 and control which had ratios 0.19 each.

The data on the calcium oxide plus magnesium oxide/potassium oxide ratio of root samples are given in Table XX.

<u>Nutrient content of leaves of suckers:</u>

Samples were collected from the suckers of all treatments on 26-6-1967 and analysed for potassium, calcium and magnesium. All the samples were taken from infected plants of various blocks.

Treatment 3 of the fifth replication which showed symptoms 37 days after inoculation recorded the highest content of 7.5 per cent potash in leaves. This was followed by the control plant which showed symptoms 50 days after inoculation. The potash content was

TABLE XXI

Nutrient content of leaves of diseased suckers
(Expressed as percentage on oven dry basis)

Nutrient	Ratio of CaO:MgO				
	0	3:1		6:1	
	Level of MgO in percentage				
	0(T1)	0.05(T2)	0.10(T3)	0.05(T4)	0.10(T5)
K_2O	6.2754	4.0887	7.5042	5.5608	5.7446
CaO	0.4002	0.8004	0.4000	0.2000	0.5334
MgO	1.1072	1.2321	0.8572	0.9524	0.9524
CaO/MgO	0.3615	0.6496	0.4666	0.2099	0.5601
$CaO+MgO/K_2O$	0.2402	0.4157	0.1675	0.2072	0.2586

6.28 per cent. Treatment 5 of fifth replication analysed to 5.75 per cent and treatment 4 of the sixth replication 5.56 per cent. Treatment 2 of fourth replication which showed symptoms 39 days after inoculation analysed to 4.89 per cent potash. This was the lowest.

Treatment 2 which showed symptoms of disease 39 days after inoculation recorded the highest content of 0.80 per cent calcium oxide followed by treatment 5, control and treatment 3 which had 0.53, 0.40 and 0.40 per cent calcium oxide respectively. Treatment 4 recorded the lowest content of calcium oxide, 0.20 per cent, symptoms in which appeared 42 days after inoculation.

Magnesium content of suckers did not vary to any great extent between treatments. Treatment 2 showed the highest percentage of 1.23 followed by the control. The magnesium content in all other treatments were lower.

Calcium oxide/magnesium oxide ratio was highest for treatment 2 followed by the control which had 1.23 and 1.11 respectively. Treatment 4 had the lowest value of 0.21.

Calcium oxide plus magnesium oxide/potassium oxide ratios of treatments varied from 0.17 in treatment 3 and 0.21 in treatment 4 to 0.42 in treatment 2. Control plants showed the value 0.24 and treatment 5, 0.26.

The data on the nutrient content of leaves of suckers are given inTable XXI.

Emulsion of calcium carbonate and magnesium carbonate:

The emulsion pasted on the plants of all the treatments of the sixth replication did not bring out any effect on infection of virus. Treatments 3 and 4 showed symptoms 37 and 42 days after inoculation while the other three plants remained healthy.

DISCUSSION

DISCUSSION

Possibility of building up resistance to Bunchy Top disease of banana plants by manipulation of the nutritional status of soil has been started as a continuous programme of research of the Principal and Additional Director of Agriculture (Research) since 1962. Nambiar and Nair (1965) found that the ratio of calcium and magnesium in the nutrient medium significantly influenced the incidence of the Bunchy Top disease of banana and that an appropriate combination of the two elements could delay the incidence of the disease by several days over control. Sand culture experiments by Nair and Pillai (1966) indicated that by regulating the calcium to magnesium ratio in the nutrient medium and plant tissue, the incidence of Bunchy Top disease could be successfully delayed until the emergence of bunch. It was found that a calcium oxide/magnesium oxide ratio of 6:1 in the nutrient medium and 3.5 to 4 in the leaf or a calcium oxide plus magnesium oxide/potassium oxide ratio of 1 or near about 1 in the leaf could arrest the incidence of the disease till the emergence of bunch. Further work by Nair and George (1966) under semi-field conditions indicated that the resistance to Bunchy Top virus noted by Nair and Pillai (1966) might be actually due to the ratio of calcium oxide plus magnesium oxide/potassium oxide ratio and not merely to the ratio of calcium oxide/magnesium oxide.

The present studies were undertaken as a continuation of the work of Nair and George (1966) under semi-field conditions. Calcium oxide and magnesium oxide were applied in the ratios 3:1 and 6:1 at the two levels of magnesium to study their effects on the incidence of the disease. The treatment supplying calcium oxide and magnesium oxide in the ratio of 3:1 at the lower level of magnesium appeared the best with only one out of the six plants infected, followed by the control with two infected plants. In treatments of 3:1 and 6:1 ratios at the higher levels of magnesium, maximum number of diseased plants, five each was noted. Four diseased plants were observed in the treatment of calcium oxide and magnesium oxide application in the ratio 6:1 at the lower level of magnesium. There had also been not much variation in the number of days taken for infection. The variation in results in the present studies as compared to treatments under controlled sand culture experiments may indicate the influence of various uncertain factors affecting the calcium to magnesium ratio in the nutrient medium and within the plant tissue. Another uncertain factor is the variation in the concentration of the insect inoculum. The number of aphids in the study was 25 as compared to 20 and 100 in the works of Nair and Pillai (1966) and Nair and George (1966), respectively. The absorption of the nutrients did not follow any defenite pattern in contrast to the work of Nair and Pillai (1966). This may point to the unpredictable nature of absorption of nutrients under semi-field conditions as observed by Nair and George (1966).

Nitrogen content of soil and absorption by plants:

A marked decrease in nitrogen content of soil was observed on the date of inoculation four months after planting. Analysis of soil on the date of inoculation showed a decrease in nitrogen content of soil with increasing levels of calcium and magnesium application. Level of magnesium appeared to influence the nitrogen content more than that of calcium.

The same trend as in soil nitrogen was observed in the nitrogen content of leaves also, the lowest percentage of nitrogen being observed at the highest levels of calcium and magnesium application. A gradual decrease in nitrogen content of leaves was observed with time in all the healthy plants. The same trend was observed in the plants which showed symptoms of infection till the date of appearance of symptoms. The nitrogen content was lowest for the healthy plant which received the secondary nutrients at the highest levels. Plants which contracted the disease had higher content of nitrogen before inoculation. Healthy plants of control and that which received calcium oxide and magnesium oxide in the 3:1 ratio recorded higher levels.

In diseased plants, a marked increase in nitrogen content was observed after symptom appearance. Higher content of nitrogen in virus-infected leaves have been recorded by Commoner et al (1953);

Best and Gallus (1953); Borges and Bento (1953); Eskarous et al (1964); and Narayana Swamy and Ramakrishnan (1966). Works of Nambiar and Nair (1965); Nair and Pillai (1966) and Nair and George (1966) also indicated an increase in nitrogen content of leaves due to incidence of Bunchy Top disease.

Gradual decrease in nitrogen content of roots also was observed with time. The gradual depletion of the nutrient in the rooting medium might have had its influence in lowering the nitrogen content in plants. This may also be due to disturbance in the mechanism of translocation. Of the treatments, the highest nitrogen content was recorded one month before inoculation in the treatment which received calcium oxide and magnesium oxide at the 6:1 ratio at the higher level of magnesium. It came down to the lowest value two months after inoculation. The higher levels of secondary nutrients might have contributed to the release of nitrogen inthe beginning and to the depletion, later. In treatments of calcium oxide and magnesium oxide in the ratio of 3:1 and that at 6:1 ratio at the lower levels, the release of nitrogen might have been more gradual, the stage of depletion starting only two months after inoculation. There had also been a gradual lowering in nitrogen content of roots in the healthy control also.

In treatments of calcium and magnesium oxides in the 3:1 ratio at the higher level, and at 6:1 ratio at the lower level, the content of nitrogen which had been on the increase showed a decline after symptom appearance. This is in contrast to the observation on the nitrogon content in leaves.

Potassium content of soil and absorption by plants:

Potassium content of soil showed a marked decline with time, though not as much as in calcium. Calcium oxide and magnesium oxide application in the ratio 3:1 tended to increase the potash status of soil as compared to the control on the date of inoculation four months after planting, whereas application in the 6:1 ratio was conducive to a lowering in potash content. The treatment receiving the secondary nutrients in the 6:1 ratio at the highest levels recorded the lowest percentage of potash in soil. The high rates of application of calcium and magnesium might have caused a heavier loss of potassium through leaching or through increased absorption.

As in the case with soil, a gradual decrease in potash content of leaves also was observed in the control plants. Marked fluctuations in potash content of leaves have been observed in the calcium and magnesium treated plants. In the healthy plant which received calcium oxide and magnesium oxide in the 3:1 ratio, a gradual increase in the content of potassium was observed. From 5.8 per cent potash one month before inoculation, it rose to 6.6 per cent three months after inoculatio the comparable percentages in the control being 6.8 and 6.2 respectively. In the healthy plants of treatment 5 which received calcium oxide and magnesium oxide in the 6:1 ratio, the potash content of leaves showed a steady decline with time. The percentage in all caseswas lower than those of plants receiving the secondary nutrients at the 0 level and those at the 3:1 ratio. This is in conformity with the results of Nair and George (1966), who noted the maximum potash content in the leaves of banana plants which received calcium oxide and magnesium oxide in the 3:1 ratio and the lowest in those receiving in the ratio 9:1. In the leaves of plants which contracted the disease, a gradual increase in potash content was noticeable till the time of inoculation. A marked increase was observed after appearance of symptoms in the plants which contracted the disease. The higher potassium content in the leaves of diseased plants may either be due to increased absorption or disturbed translocation from the leaf. Nambiar and Nair (1965); and Nair and George (1966) also observed higher contents of potassium in leaves of infected plants as compared to the healthy. Similar results of increased potash content in virus infected hop plants have been reported by Prusa et al (1965).

The absorption of potassium by roots followed a pattern different from that of leaves. There was increased accumulation of potassium in roots with time in all the treatments. The rate of increase had been more or less steady in all the healthy plants. In the infected plant of treatment which received calcium oxide and magnesium oxide in the 3:1 ratio and which showed symptoms 37 days after inoculation, the highest values of potash percentage 10.83 was recorded two months after inoculation. In treatment 4 of calcium oxide and magnesium oxide application in the 6:1 ratio in which symptoms appeared 42 days after inoculation, the percentage of potash dropped from 6.29 to 5.29, one month after inoculation. The highest value of 7.76 per cent potash was recorded two months after inoculation, and after appearance of symptoms. Higher percentage of potassium in potato tubers infected with potato viruses X and Y have been reported by Kozlowska (1964).

Calcium content of soil and absorption by plants:

A marked lowering in calcium content of soil has been observed four months after planting. This points to the heavy loss of calcium by leaching from the surface layers of soil when applied in large quantities. On the date of inoculation, four months after planting, the same trend as that of application was observed. For the same levels of calcium application, calcium content was higher for the treatment receiving the lower level of magnesium. The relatively rapid loss of calcium from soil in presence of magnesium is thus brought out.

A gradual decrease in calcium content of leaves of all the healthy plants have been observed with time. The same was the case with infected plants till the date of inoculation. In treatment 3 of calcium oxide and magnesium oxide application in the 3:1 ratio, which showed symptoms of infection 37 days after inoculation, the content of calcium showed an increase one month after inoculation and just before appearance of symptoms. The lowest calcium content was observed during the next month, after the appearance of symptoms. A marked lowering in calcium content of diseased banana leaves have been reported by Nambiar and Nair (1965) and Nair and George (1966). The percentage of calcium increased again during the next month, three months after inoculation. The same trend was noticed in the case of infected plant of treatment 4 also, which had received calcium oxide and magnesium oxide in the 6:1 ratio at the lower level of magnesium. Shaw and Samborski (1956) and Prusa et al (1965) also observed accumulation of calcium in virus-infected leaves of plants. As in the case with calcium content of soil on the date of inoculation, the percentage of calcium in the leaves followed the same pattern as that of calcium application. Before inoculation and on the date of inoculation, for the same levels of calcium application, percentage of calcium in plants was always higher in treatments of lower magnesium application. Control plants showed the lowest percentage of calcium in all cases.

The increased rates of application of calcium showed the same trend in the uptake of calcium by roots, also. The control plants showed the lowest values in all cases except in diseased plants after symptom appearance. As in the case with soil and leaves, for the same levels of application, calcium content of roots was higher when the amount of magnesium applied was low. This relation was upset after the incidence of the disease. The variation in calcium contents of roots in infected plants followed the same trend as that in leaves. There was an increase in percentage of calcium one month after inoculation and just before appearance of symptoms in treatment 3, which showed symptoms of the disease 37 days after inoculation. In treatment 4 which expressed symptoms 42 days after inoculation, a lowering in percentage of calcium was observed one month after inoculation, the lowest value being recorded during the next month.

Magnesium content of soil and absorption by plants:

The decrease in content of magnesium four months after planting had not been as marked as that of calcium and potassium. Magnesium when combined with large quantities of calcium is more stable against leaching and removal to the lower layers. As in the case with calcium, the content of magnesium in soil followed the same pattern as that of application four months after planting. The control showed the lowest percentage of magnesium. For the same levels of application, magnesium content of the soil at the root zone was lower with higher levels of calcium application.

In contrast to calcium, there was a tendency towards an increase in magnesium content with time in the leaves for a certain period and then a decline. In diseased plants, a marked lowering in magnesium content was observed two months after inoculation. Similar results of lowered magnesium contents in virus infected banana leaves have been observed by Nambiar and Nair (1965); and Nair and George (1966). A marked accumulation of magnesium in leaves was observed one month later in diseased plants. Hale et al (1946) and Prusa et al (1965) also had observed higher magnesium contents in leaves of virus infected plants. As in the case of calcium, magnesium content also followed the same pattern as that of application. Magnesium content was lowest for control plants in all cases. Before inoculation and on the date of inoculation, for the same levels of application, magnesium content of plants were higher in plants that received lower calcium application.

The magnesium content of roots remained more or less steady throughout except in the roots of diseased plants. In infected plants, a marked lowering in percentage of magnesium oxide was noticed after symptom appearance. In treatment 3 of application of calcium oxide and magnesium oxide in the 3:1 ratio at the higher level of magnesium, an accumulation of magnesium in roots one month after inoculation and just before symptom appearance was noticed. The lowest values were recorded two months after inoculation and after symptom appearance.

In infected plant of treatment 4, the lowering in magnesium content had been gradual to the lowest values two months after inoculation. The behaviour of magnesium in roots followed the same pattern as that of root calcium also. As in the case with leaf calcium and leaf magnesium, the magnesium content of roots for the same levels of application was lower in treatments of lower calcium application.

Calcium and magnesium thus present an entirely different picture from nitrogen and potash in the plants. While the concentration of calcium and magnesium in the healthy plants in much higher than in the infected plants, the situation is reversed in the case of nitrogen and potash. The same results were recorded by Nambiar and Nair (1965); Nair and Pillai (1966); and Nair and George (1966). It can be concluded from those results that unlike the other major nutrient elements, the absorption of calcium and magnesium by leaf and root is slowed down after infection. Calcium and magnesium thus play a unique role in Bunchy Top infection and resistance of plants to attack by the virus.

<u>Calcium oxide/magnesium oxide ratio in soil and plant:</u>

There had been a marked lowering in the ratio with time. The relatively high rate of removal of calcium and the marked stability of the smaller amounts of magnesium had been responsible for bringing down the ratio. The ratio had been the highest for the treatment receiving the highest levels of calcium oxide and magnesium oxide in the 6:1 ratio, on the date of inoculation.

The ratio in the leaf varied widely with treatments and with time. The plants which withstood infection appeared to show slightly higher ratios before and after inoculation date. In infected plants, a marked lowering after appearance of symptoms have been noted.

The ratio for roots also showed a marked decline after appearance of symptoms in the infected plants.

Calcium oxide plus magnesium oxide/potassium oxide ratio of soil and plants

The ratio in the soil showed a decrease on the date of inoculation four months after planting as compared to that in the beginning though not as much as in the calcium oxide/magnesium oxide ratio. The control plant showed the lowest value.

The ratios in the leaves had been the lowest for the control plants in all cases except in infected plants after symptom appearance.

In roots, the highest values have been recorded by the plants which got infected on the date of inoculation. The values came down to the lowest after infection.

SUMMARY AND CONCLUSIONS

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The experiment to study the effect of combination of calcium and magnesium application to soil on the calcium oxide/magnesium oxide ratio in the plant and on the Bunchy Top disease of banana, was laid out under semi-field conditions. Calcium oxide and magnesium oxide were applied in the ratios 3:1 and 6:1, at two levels of magnesium, 0.05 and 0.10 per cent by weight of soil. Uniform levels of nitrogen, phosphorus and potassium in all treatments were given by application of equal quantities of fertilisers. No organic manure was added, to avoid too many uncertain factors which might have influenced the behaviour of calcium and magnesium in the soil and absorption by the plants. The concentration of the insect inoculum was maintained at a uniform level, by releasing infective aphids at the rate of 25 each. Inoculation was done four months after planting. To avoid natural infection before inoculation, periodical sprays of parathion 0.01 per cent had been given as a regular practice. The results of the experiment are summarised below.

1. The treatment supplying calcium oxide and magnesium oxide in the 3:1 ratio at the lower level of magnesium appeared the best with only one out of six plants infected, followed by the control with two infected plants. In treatments of 3:1 and 6:1 ratios at the higher levels of magnesium, maximum number of diseased plants, five each, was noted. Four diseased plants were observed in the treatment of calcium oxide and magnesium oxide application in the 6:1 ratio at the lower level of magnesium.

2. There was a marked decrease in the nitrogen content of soil with time. On the date of inoculation, four months after planting, treatments receiving the higher levels of calcium and magnesium showed correspondingly lower percentages of nitrogen in soil.

3. The nitrogen content of leaves and roots followed the same trend as that of soil nitrogen. There had been a gradual decline in percentage of nitrogen with time and with increasing amounts of the secondary nutrients.

4. An increase in the nitrogen content of leaves was observed after appearance of symptoms.

5. In contrast to nitrogen content of leaves, the percentage of nitrogen in roots showed a decline after symptom appearance.

6. Calcium oxide and magnesium oxide application in the 3:1 ratio tended to retain soil potassium while supply of nutrients in the 6:1 ratio was conducive to a greater potash loss from soil.

7. A decline on content of potash in leaves and an accumulation in roots was observed with time.

8. Marked accumulation of potash in leaves and roots was observed after appearance of symptoms.

9. The loss of calcium from soil had been marked and relatively more rapid.

10. For the same levels of calcium application, the calcium content in soil four months after planting, in leaves and roots had been higher when the level of magnesium was lower.

11. Calcium content of leaves and roots of infected plants showed an increase just before appearance of symptoms one month after inoculation. The value went down considerably during the next month after symptom appearance. An accumulation was again noticed one month later.

12. The decrease in content of magnesium in soil had not been as marked as that of calcium and potassium.

13. For the same levels of application of magnesium, the magnesium content of soil four months after planting and of leaves and roots of healthy plants were always higher when the level of calcium application was lower.

14. As in the case of calcium, the percentage of magnesium in leaves and roots of infected plants came down after appearance of symptoms.

15. The ratio of calcium oxide/magnesium oxide in leaf and root were slightly higher in the plants which withstood infection than those which showed symptoms. A marked lowering in the ratio was observed in the infected plants after symptom appearance.

16. The lowering in the calcium oxide plus magnesium oxide/potassium oxide ratio of soil had not been as marked as that of the calcium oxide/magnesium oxide ratio. A marked lowering in the ratio in leaves and roots to the lowest values was observed after appearance of symptoms.

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APPENDICES

APPENDIX I

Analysis of variance

Height of plants before inoculation

Source	S.S.	Df.	Variance	F	Inference
Total	15722.67	29			
Treatment	2127.67	4	531.92	$F_{4,20}$=0.9983	Not significant
Block	2938.67	5	587.33	$F_{5,20}$=1.1023	Not significant
Error	10656.33	20	532.82		

APPENDIX II

Analysis of variance

Height of plants before symptom appearance

Source	S.S.	Df.	Varience	F	Inference
Total	23053.50	29			
Treatment	2698.30	4	674.58	$F_{4,20}$=0.9465	Not significant
Block	6101.00	5	1220.20	$F_{5,20}$=1.1023	Not significant
Error	14254.20	20	712.71		

APPENDIX III

Analysis of variance

Girth of Pseudostem before inoculation

Source	S.S.	Df.	Variance	F	Inference
Total	1927.47	29			
Treatment	98.80	4	24.70	$F_{4,20}=0.3251$	Not significant
Block	309.07	5	61.81	$F_{5,20}=0.8135$	Not significant
Error	1519.60	20	75.98		

APPENDIX IV

Analysis of variance

Girth of Pseudostem before symptom appearance

Source	S.S.	Df.	Variance	F	Inference
Total	2163.47	29			
Treatment	73.13	4	18.28	$F_{4,20}=0.2112$	Not significant
Block	359.47	5	71.89	$F_{5,20}=0.8307$	Not significant
Error	1730.87	20	86.54		

APPENDIX V

Analysis of variance

Number of fully opened leaves before inoculation

Source	S.S.	Df.	Variance	F	Inference
Total	85.70	29			
Treatment	19.20	4	4.80	$F_{4,20}$=1.9835	Not significant
Block	18.17	5	3.63	$F_{5,20}$=1.5000	Not significant
Error	48.33	20	2.42		

APPENDIX VI

Analysis of variance

Number of fully opened leaves before symptom appearance

Source	S.S.	Df	Variance	F	Inference
Total	93.37	29			
Treatment	8.87	4	2.22	$F_{4,20}$=0.7500	Not significant
Block	25.37	5	5.07	$F_{5,20}$=1.7128	Not significant
Error	59.13	20	2.96		

APPENDIX VII

Analysis of variance

Length of leaves before inoculation

Source	S.S.	df.	Variance	F	Inference
Total	13835.37	29			
Treatment	2069.87	4	517.22	$F_{4,20}$=1.1831	Not significant
Block	3022.57	5	604.51	$F_{5,20}$=1.3827	Not significant
Error	8742.93	20	437.19		

APPENDIX VIII

Analysis of variance

Length of leaves before symptom appearance

Source	S.S.	df.	Variance	F	Inference
Total	15465.37	29			
Treatment	1887.87	4	471.97	$F_{4,20}$=0.9223	Not significant
Block	3342.57	5	668.51	$F_{5,20}$=1.3063	Not significant
Error	10234.93	20	511.75		

APPENDIX IX

Analysis of varience

Width of leaves before inoculation

Source	S.S.	df.	Variance	F	Inference
Total	2309.20	29			
Treatment	246.20	4	61.55	$F_{4,20}$=0.9859	Not significant
Block	814.40	5	162.88	$F_{5,20}$=2.6090	Not significant
Error	1248.60	20	62.43		

APPENDIX X

Analysis of varience

Width of leaves before symptom appearance

Source	S.S.	df	Variance	F	Inference
Total	1719.47	29			
Treatment	306.14	4	76.54	$F_{4,20}$=1.2653	Not significant
Block	203.47	5	40.69	$F_{5,20}$=0.6727	Not significant
Error	1209.86	20	60.49		

PLATES

PLATE. I. General view of the healthy banana plants before inoculation.

PLATE. II. General view of the banana plants after appearance of symptoms.

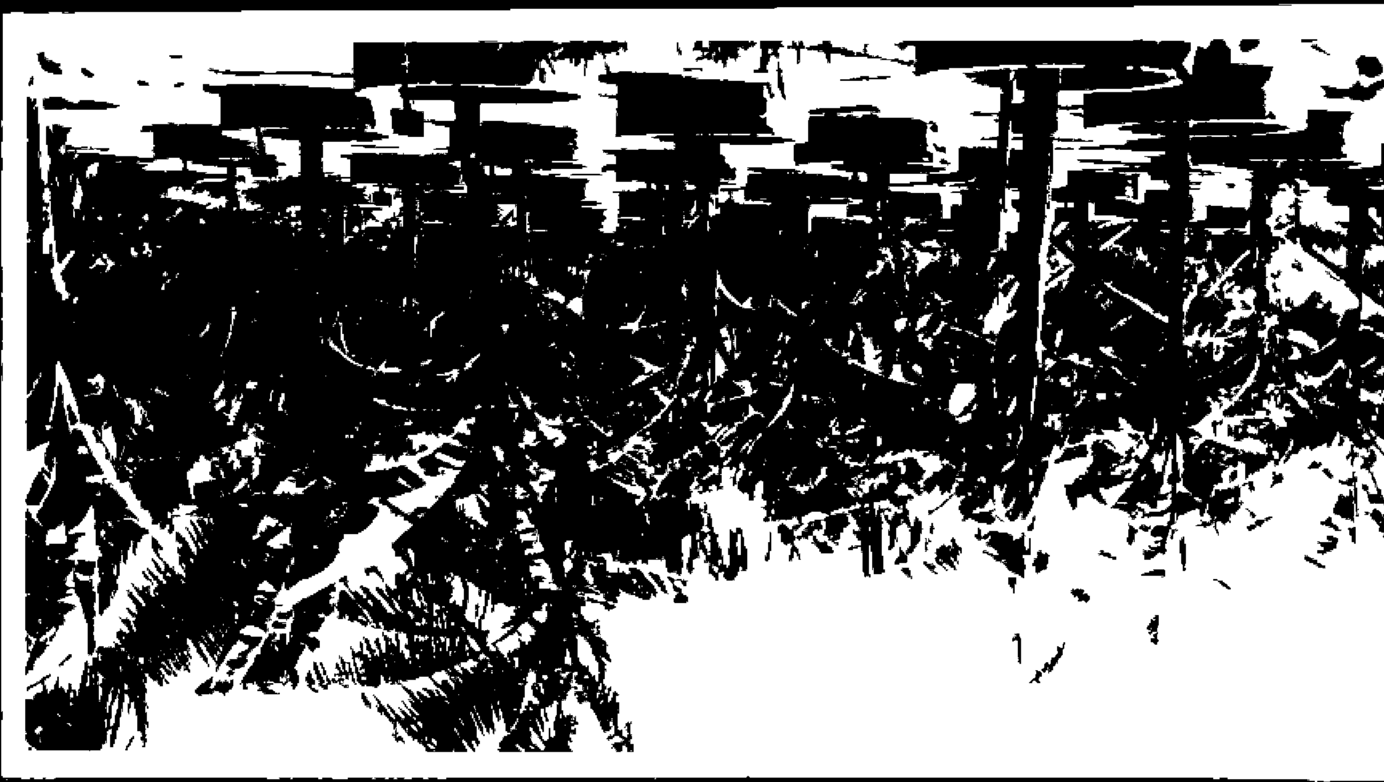

PLATE. III. Healthy Banana plant of treatment 1 before inoculation.

PLATE. IV. Diseased banana plant of treatment 1 after inoculation.


BV

PLATE. V. Healthy banana plant of treatment 2 before inoculation.

PLATE. VI. Healthy banana plant of treatment 2 after inoculation.

PLATE. VII. Healthy banana plant of treatment 3 before inoculation.

PLATE. VIII. Diseased banana plant of treatment 3 after inoculation.

PLATE. IX. Healthy banana plant of treatment 4 before inoculation.

PLATE. X. Diseased banana plant of treatment 4 after inoculation.

PLATE. XI. Healthy banana plant of treatment 5 before inoculation.

PLATE. XII. Diseased banana plant of treatment 5 after inoculation.


BV
T-5

PLATE. XIII. Healthy banana plant of treatment 1 (emulsion-treated) before inoculation.

PLATE. XIV. Healthy banana plant of treatment 1 (emulsion-treated) after inoculation.

PLATE. XV. Healthy banana plant of treatment 2 (emulsion-treated) before inoculation.

PLATE. XVI. Healthy banana plant of treatment 2 (emulsion-treated) after inoculation.

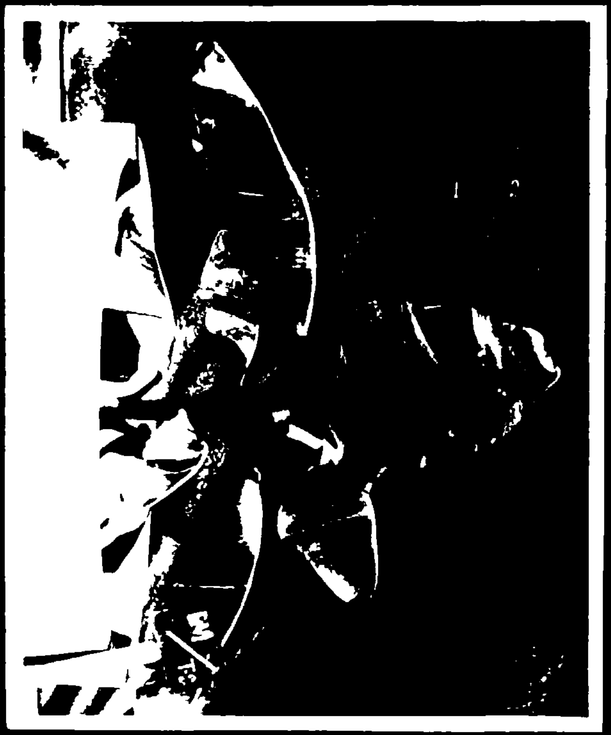

PLATE. XVII. Healthy banana plant of treatment 3 (emulsion-treated) before inoculation.

PLATE. XVIII. Diseased banana plant of treatment 3 (emulsion-treated) after inoculation.


BV/T3

PLATE. XIX. Healthy banana plant of treatment 4 (emulsion-treated) before inoculation.

PLATE. XX. Diseased banana plant of treatment 4 (emulsion-treated) after inoculation.

PLATE. XXI. Healthy banana plant of treatment 5 (emulsion-treated) before inoculation.

PLATE. XXII. Healthy banana plant of treatment 5 (emulsion-treated) after inoculation.