NUTRITIONAL STUDIES IN THE MANGO (MANGIFERA INDICA, LINN) AND MOSAMBI (CITRUS SINENSIS, OSBECK).

by

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CHAPTER I

INTRODUCTION

The mango is considered the national fruit of India and is rightly styled as the king of fruits. It's unique taste, flavour and lusciousness has helped to make the fruit popular with all sections of the society in the country.

India accounts for about 80 per cent of the world acreage under the crop, with 70 per cent of world's production. The country, therefore, holds an important position in mango production and it has almost a virtual monopoly in mango trade of the universe.

The choice varieties of mango like, Alphanso, Langra, Dashehari etc. are being exported every year to foreign markets, though to a limited extent. Not only there is an increasing demand for fresh fruit, but processed produce such as canned slices, nector, pickles and chutneys are finding favour in the importing countries. There appears to be a great scope for stepping up the export of Indian mangoes to European and other western markets. The report of the delegation to West European countries sent by the Government of India in the year 1966 brought out the fact that there is a great scope for the export of fresh mangoes to West Germany, France and England. The mango can, therefore, claim a rightful place in earning increased valuable foreign exchange for the country.

In spite of the unique position which the commodity holds, it appears paradoxical that no much attention is being devoted for its improvement. The mango is still being grown in a semi-wild state and most growers approach their trees only once a year at the time of picking the fruit. There is no wonder, therefore, that proper cultural and manurial practises are rarely adopted by the growers.

In order to place the mango industry on sound base, it is necessary to standardise the cultivation and manuring practices with a view to obtain satisfactory production with regular cropping.

Amongst the well known factors responsible for a good harvest, manuring and tree nutrition are basically important. Very little attention is bestowed on this aspect so far with the result that the nutritional aspect of the mango has been little understood.

The growers seldom apply manures and fertilisers. The average grower in Ratnagiri district, where mango is grown on a commercial scale in an area of 4,486 hectares (1966-67), the usual practise is to apply the dried leaves and sweepings from the groves once in two to four years. Besides, the soil condition being highly acidic, the dangers of leaching of nutrients also exist. The soils are porous and generally poor in nutritional status.

Manurial trials and study of nutrient uptake, therefore, is the vital need of the industry. A comprehensive manurial trial has been laid out at the Regional Fruit Research Station, Vengurla, District Ratnagiri, with various combinations of N, P, K, F.Y.M. and liming.

It was decided to undertake the leaf analysis for determining the important major and minor elements under each treatment in an effort to understand the nutritional status as conditioned by the fertilisation practices.

Citrus is another important fruit crop of India and plays an important role as a cash crop. The area has increased from a meagre 25,000 acres in 1937 to 2,23,357 acres in 1955.

In general, the three citrus species, *viz*. Mandarin orange (*C. reticulata*, Blanco.), sweet orange (*C. Sinensis*, osbeck.) and lime (*Citrus aurentifolia*, Swingle) are commercially important. In Nagpur region of Maharashtra alone, the Mandarin orange is cultivated to the extent of about 42,000 acres and a sound trade has developed in the commodity as reported by Phadnis (1963).

The sweet orange and the acid lime are both important mainly in Western Maharashtra. The lime industry is flourishing on account of the demand for juice and peel oil.

In spite of this commercial importance, the citrus growers do not pay adequate attention to manuring and nutrition. According to Rangarao (1960), 68 per cent of the citrus orchards receive only F.Y.M. of which more than two-third orchards receive less than 20 cart-loads per acre.

Though 2 lbs. of nitrogen per tree has been recommended as an adequate dose (P and K not being found necessary to apply under the prevailing conditions) based on experimental work and in alkaline soils where citrus is generally grown usually micro-nutrient deficiency symptoms are generally observed, bringing the decline condition. The nutritional problem has, therefore, to be viewed not only in relation to manuring, but also in relation to soil type and availability of nutrients on such soils.

Nutritional imbalance is one of the important causes of dieback.

Dieback symptoms were observed in the Mosambi in a private garden in Poona which exhibited malnutrition symptoms in spite of reasonably good care. Nutritional studies with respect of macro and micro elements in these plants were, therefore, undertaken along with apparently healthy ones to determine whether the dieback was induced due to malnutrition and if so, whether the tree condition could be improved by judicious fertilization.

CHAPTER II

REVIEW OF LITERATURE

Workers all over the world have devoted considerable attention to mineral nutrition of fruit trees. Many investigators have used foliar analysis as a tool to detect tree response in nutrient uptake as conditioned by the application of manures and fertilizers.

Soil test alone has not been helpful since they have many limitations like complication of chemical reaction, moisture, variety, rootstock, biological conditions and related matters. Taking these factors into consideration, greater reliance can be placed on plant analysis report for predicting response to added nutrients.

Probably Saussure (1804) reported the earliest work on plant analysis. He was the first worker to show that the ash content varied with the plant, age and the soil on which it grew.

Liebig (1850) indicated that for maintaining fertility the quantities of nutrients removed from the soil in the crop should be reported in the form of fertilizer application.

Hannon (1904) considered that in general ash analysis would show elements that are in inadequate supply in poorly cropping plantation. Leaf analysis was considered most reliable as an index of mineral deficiencies.

Reuther and Smith (1952) pointed out that leaf is the focal point of many plant functions and so is a more sensitive indicator for mineral elements. Besides, leaf is the most convenient plant part for sampling.

Hance (1937) argued that in the life of growing cane crop from earlier stages to maturity the major chemical activities take place within the leaf tissue.

Lundegardh (1951) who was the father of leaf analysis gave the concept of triple analysis, based on the results of this extensive work on oat. After Lundegardh, many research workers have devoted the technique of foliar - analysis in different fruit crops so as to make corrective fertiliser recommendation.

Chapman (1941) worked with rubber tree and suggested that the per cent content of potassium, phosphoric acid and nitrogen can be taken as a measure of fertiliser requirement of tree.

Drosdoff (1944) determined N, P, K, Ca, Mg and iron with the help of leaf analysis in tung tree.

Jones *et.al.* (1955) discussed at full length, that the leaf analysis conserve as a guide for fertiliser needs of orange, lemons and avocado.

Shaulis (1960), working on grape, showed the association between symptoms of K deficiency, plant analysis and yield of concord grapes.

Ferwerda (1961) used foliar analysis as a tool for the diagnosis of nutritional deficiencies in the oil palm and described effect of nutritional deficiencies on growth production and composition of leaf.

Plant part to sample

In mango and citrus, whole leaf with petiole is used to represent the samples and is the best indicator and is being used for analysis by many workers. Embleton and Jones (1961) reported that significant differences were found in leaf nutrient contents in samples of 60 leaves per tree.

Size of sample

Joshi, A.T. (1966) has reported that in case of mango to study the nutrient status, about 20 to 22 mature leaves, collected all over the tree are quite sufficient.

Hass (1945), while studying the chemical composition of leaves in citrus as a result of rootstock influences used mature leaves.

Chapman et.al.(1944) have recommended that 30 to 50 leaves picked in a circle from waist to shoulder, height around a tree are sufficient to give a representative sample.

Optimum value concept

Currently, two schools of thought are known to prevail amongst the workers on mineral nutrition of plants. The optimum value concept mentions that optimum growth and yield are reflected by specific concentration of each essential element. Further, wide variation in soil and climate little affect this values though they may vary between species and among varieties within species. In the 'critical value' concept, attempt is made to fix limits for each essential plant element, below which visual 'deficiency' symptoms are likely to occur for the element in short supply. According to Beattie (1953) both these concepts are equally important for basing fertiliser recommendations using foliar analysis.

Work done in deciduous fruits

Woodbridge (1940) has stated that boron deficient leaves of apples contained boron below 10 ppm., while healthy ones had more than 14 ppm. He further observed (1951) 24 to 268 ppm Mn in healthy apple trees, while deficient ones contained less than 16 ppm.

Batjer (1956), while working on application of tissue analysis technique to nutritional problems in apple, observed that the growth increased linear with increase in leaf nitrogen until the latter reached 2.2 per cent. If the leaf N increased above this amount, there was no increase in growth. When the N content exceeded 2.40 per cent, the fruit usually lacked colour and its storage life was adversely affected. When it fell below 1.65 per cent, very little growth took place and the foliage was pale green.

Woodbridge (1955) has reported that the leaf blotch symptoms in apples were due to magnesium deficiency. Contents below 0.18 per cent Mg, symptoms were observed, while above 0.26 per cent Mg, no symptoms were observed.

Demetrides et.al. (1963) have observed that leaves from an apparently normal medlar tree contained 22 ppm of Mn compared with 9 ppm for a Mn deficient tree in the same locality.

Pfaff (1963) has stated that early application of N promoted leaf and shoot growth immediately and increased yields in the subsequent year. The amount of June drop was reduced by N application at the end of May. Trees deficient in Mg or P tended to crop regularly or biennially but both P and Mg deficiencies were quickly corrected or reduced by supplying the necessary nutrients. There was a close - correction between leaf analysis data and the nutrient - status of the trees. The influences of variety and climate on the apple fruit quality were greater than that of N nutrition.

Fucik (1964) has shown in his nutrient solution - experiment of Ca and Mn with apple seedlings that the lower roots contained higher concentration of Mn than the upper roots under similar treatments. High Mn level increased root Mn but raising the Ca level considerably reduced the root Mn content and reduced the root Ca content slightly. Calcium not only reduced Mn absorption but also caused its retention in the roots and to a lesser extent in other - tissues. All tissues showed some Mn-Ca interaction, this being most noticeable in the lower roots, the reduced growth of the trees in the high Mn plus low Ca treatment indicated a Mn and used physiological disturbance, although no toxicity symptoms were produced. The soil experiment showed that applications of Calcium hydroxide at rates equivalent to 4 tons of calcium carbonates per acre reduced Mn availability to depths of only 4" to 6".

Woodbridge _et.al._ (1961) observed that limiting concentrations of potassium varied with changes in the sodium concentration and limiting concentrations of iron was - increased if the manganese concentration was increased.

Trzcinski _et.al._ (1963) have observed that small amount of nitrogen was as effective as moderate amount provided that other elements were applied at similar rates but higher amount was not effective without high levels of the other elements. High K associated with low N proved very injurious to young apple tree. Imbalance of N, P and K was much more in the pot experiments than in the orchards. The K requirement depended largely on the type of soil. Yields were not significantly reduced by reducing Mg and Ca applications.

Pear

Sato *et.al.*(1961) stated that maximum growth increases were obtained with application of N. The optimum leaf contents of N, P and K were 2.4, 0.12 and 0.8 per cent, respectively. Application of N delayed fruit colouring and P applications increased the acid sugar ratio.

Kumashiro (1965) has observed that with increased application of N, leaf content of N and Mg increased, and K decreased with increase application of P. Leaf contents of P and Mg increased. With increased application of K, the leaf K increased and the leaf content of N, Ca and Mg decreased.

Mohamed Baker (1956) has observed that high soil pH reduced the availability of iron and accordingly the uptake and absorption of iron by the plants was greatly affected. This reduced rate of uptake and absorption resulted in a slow rate of entry of iron in the developing leaves, which favoured inactivation and accumulation of iron in the leaves.

Grapes

Shaulis and others (1957) have given the nutrient composition of concord grape, petiole with deficiency symptoms. Using data taken from field trials in New York State from 1944-53, the authors discussed the relation of petiole composition in the concord grape vine to vine growth, yield and deficiency symptoms. From N, K and Mg data are presented the critical levels of concentration in the petioles. No deficiency symptoms were noticeable at even the low levels of P and Ca reported in these trials.

Hiroyasu (1962), while working on seasonal changes in the inorganic nutrients of grapes, stated that the highest inorganic nutrient content was found in the leaves and - inorganic nutrients were highest in young shoots. Total amount of each element in the whole vine reached a peak when the berries matured at the end of September. The highest rate of absorption of N, P and Mg occurred from May to July. Ca and K were absorbed gradually from May to September.

Kolesnik (1965) states that the application of B at 2 kg per hectare on loamy deep, humus enriched. Chernozem soils which had received N, P and K at 60 to 120 kg per hectare increased the leaf chlorophyll content of the vine variety Aligole, markedly reduced flower and fruit drop increased Catalose peroxidase, polyphenoloxidase activities and raised yields by 40 per cent in the year of application and 33 per cent in the following year.

Sarosi (1965) has observed that in lime induced - chlorosis in grape, the chlorotic leaves were much poorer in Mn and in most cases actually richer in Fe than normal leaves. There was little or no difference in B. The application of a mixture of iron sulphate and manganese sulphate practically eliminated chloresis within two months. Spraying three times with a mixture of $MnSo_4$ and Fe EDTA, completely cured the chloresis but $MnSo_4$ and $ZnSo_4$ had no effect.

Abdulla and Sefic (1965) reported that petiole N was increased by increasing soil application of N and was well within the range for adequate grape production at all levels. Petiole P was not influenced by the levels of P_2O_5 applied. Petiole K was increased by increasing the level of K_2O in the soil. Ca concentration in the petioles were reduced in one year by increasing the K_2O level. Petiole K decreased during the growing season, while Mg and Ca increased. Increasing P_2O_5 and K_2O levels reduced the total acidity of pressed juice in 1960. The pH of the juice was influenced by increasing the level of K_2O fertiliser.

Divate (1967) working on nutrient status of grapes found that increase in nitrogen status was accompanied by a more or less reduced phosphorous status indicating that nitrogen may be antigonistic to phosphorous. It was also noted that in the majority of vine yards where potassium status was of a higher order, nitrogen status was comparatively lower and vice-versa. The antigonistic behaviour of potassium with calcium and magnesium was observed. The gardens where potassium concentration of petiole was more, calcium and magnesium concentration was low. Similarly, where calcium and magnesium content was high, the potassium content was low, showing the depressing effect of one on the other.

Gartel (1965) has observed that the secondary Fe - deficiency produced by an Fe blockage in the tissues was recognised by a large rise in P/Fe ratio and excess of K. Viral chlorosis also caused a high P/Fe ratio but no excess of K. A low K/Mg ratio usually below 1.0 characterized K deficiency whereas this ratio rose above 1.5 in Mg deficiency. Acid injury, induced by very acid soils, produced a very high K/Mg ratio over 20. Very high Mn content and slight rise in the Al content. Both B deficiency and B toxicity showed in the B content of the leaves and Zn deficiency due to excess of phosphatic manures could not be diagnosied with certainty.

Work done in evergreen fruit crops Avocado

Cameron *et.al.*(1937) have noticed in Avocado that when trees were supplied with 10 lbs of nitrogen, in the form of ammonium sulphate and calcium nitrate, the leaf N on dry weight was slightly above or below 2 per cent and there was no difference to control. They also noticed that the blossoming was accompanied by reduction in nitrogen content of the adjacent leaves and there appears to be a direct correlation between the bloom and reduction in the N content of the leaves.

Childer (1954) has stated that the use of phosphorous, in addition to nitrogen in the fertiliser to Avocado, has resulted in an increase in the absorption of this element not only in the leaves but also in the skin, pulp and seed of the fruit.

Embleton _et.al._(1958), while working with Fuerte Avocado, have reported that N applications increased leaf N and P and reduced the percentages of Ca and Mg and the dry weight was also reduced. Phosphate applications increased P, Ca, Mg and Cl contents and reduced K contents. Potash increased K and reduced Ca and dry weight per leaf. Magnesium was only slightly reduced. Applications of steer manure increased leaf contents of nitrogen, phosphorous, potassium and Cl. Contents of magnesium, calcium and chlorine increased but phosphorous decreased with leaf age.

The same workers in another publication (1962) stated that the rootstock race and variety also significantly affect the N, P, K, Ca and Mg contents of the scion leaves. Further more, the percentages of N, K, Ca and Mg in Hass and Fuerte leaves from trees on seedling rootstocks s were more variable than those in the leaves from these trees propagated on their own roots by cuttings.

Cacao

Lockard R.G and Asomaning (1964) have conducted two experiments on Cacao (Theobroma Cacao, L.). The first experiment was concerned with variations in the levels of N, P, K, Ca, Mg and S and the second dealing with Fe, Cu, Zn, B, Mn and Mo. The deficiency symptoms obtained are reported. The effects of all treatments on the dry weight of leaves, stems and shoots were presented. The effects on micro nutrient treatments on the levels of N, P, K, Ca and Mg in the leaves of eight months old plants and the effects of micro nutrient treatments on the levels of N, P, K, Ca, Mg, Fe, Mn, Cu, B, Zn, Mo, Na and Al in the leaves of 11 months old plant were presented.

In the same year, they have reported in the experiment with Cacao seedlings supplied with various levels of N and Ca that the dry weight increased at eight months with increasing N levels and it was highest at 100 ppm Ca level. Raising leaf the N concentration increased leaf N and Na decreased leaf K and Mo. Leaf Mn and B were highest at the lowest N concentrations. Raising the Ca concentration, increased leaf Ca, Zn and Mo and reduced leaf N and Na, leaf Mn fell only at the highest Ca level.

Cunningham (1964) has reported that Cacao showing symptoms of Fe and Zn deficiency and containing little Mn yielded less than half as much as symptomless tree. Chlorotic trees contained more Fe than healthy leaves. Zn deficiency was noticed at 15 ppm Zn in leaves. A wide range of Mn concentrations was tolerated without showing either deficiency or toxicity symptoms. Soil pH above 7.6 was the main cause of decreased availability of soil Fe, Zn and Mn. Reducing soil pH corrected Zn deficiency and increased Mn concentration in the presence of much organic matter but only foliar spraying with Fe corrected iron chlorosis.

Lockard and Asomaning (1965) have reported that in Cacao, all plants receiving nitrate N developed severe leaf edge scorch, except those deficient in P. The deficiency symptoms of K, Ca and Mg in plants receiving nitrate N were accompanied by leaf edge scorch whereas plant receiving urea and N showed deficiency symptoms only.

Coconut

Fremond and Villemain (1964) have reported that on coastal sandy soils, there was a marked and highly economic response to potassium chloride applied annually at 0.5 to 1.5 kg. per coconut plant. Ammonium sulphate increased foliar N but decreased the copra content of the nuts.

Chikoo

Getmare (1960), while studying seasonal variation in th nutrient content of chikoo leaves, observed that the nitrogen was stored in the leaves in summer in higher amounts, later utilized in the production of new growth and fruits in the monsoon season. The storage of nitrogen was also found in monsoon, whereas it is depleted in winter months. He has further observed that relationship between nitrogen and phosphorous holds good in all the seasons. The higher nitrogen accompanied with lower phosphoric acid relationship was favourable for better yield. Regarding potash, he has stated that in chikoo tree, fruit formation mainly occurs in the later season and it can be stated that potassium was utilized in the formation of fruits.

Narke (1969) has observed in chikoo that high nitrogen and low phosphorous coupled with optimum potassium was responsible for healthy development of trees whereas the high phosphorous and low potassium contents in the trees seem to have brought declining condition of trees. The average nitrogen content was slightly higher in the healthy trees as compared to the declining ones. However, the nitrogen content of leaves in general appeared to be adequate in both the types of trees.

Work done in the Mango (Mangifera indica, Lin.)

Smith and Scudder (1947) with sand culture in mango grafts of Haden and Zilla varieties have observed that the nitrogen deficiency showed severe retardation of growth and presence of yellow undersized leaves. The leaves contained on an average of 0.67 per cent N as against 1.54 per cent N in trees receiving the complete solution. However, the phosphoreus, potash and calcium contents were higher in nitrogen deficient leaves than in most of the other treatments. Trees in the P deficient cultures showed stunted growth and premature drop of leaves. Leaves contained 0.05 per cent P which was a little lower than in the leaves from any of the other treatments but N content was normal and about the same. Potash, calcium and magnesium contents were found as in leaves from trees receiving complete solution. Potash deficient leaves contained - 0.25 per cent potash in comparison with that of the control tree of almost 1 per cent.

Kuehle (1952) believed that there was evidence that manganese and magnesium are important to young mango trees on some soil types. Young mango trees planted on the sand as well as on the limestone soils of Florida are given nutritional spray containing 5 lbs of zinc sulphate, 5 lbs of magnesium sulphate, 5 lbs. of lime and a fungicidal - strength of some form of copper per 100 gallons of water at least twice each year for the first couple of years and then once a year thereafter. This seems to supply the minor element nutritional need in the light of what is known present day.

Mallie and DE (1952) reported that bearing in the mango is possible when the mature terminal buds do not all flower in one season and when some remain dormant and flower in the next cultural practices to induce this are desirable. To study the effect of fertilisers N, P and K tests on the variety Langra were began at the Fruit Research Station, Sabur in 1940. The finding confirmed those nitrogen control the uptake of other elements and determines growth effect being greatest in combination with phosphorous and potassium. P and K singly or in combination have little effects. The proportion of nitrogen, phosphorous and potassium required by an adult mango annually are 1.1 : 0.27 : 1.0. The amountof nitrogen being 1.67 lbs., flowering and fruiting were in direct proportion to growth. Some pilot experiments were also carried out to determine the best organic and inorganic manures and the best time for their application from these it was concluded that the annual dose should be divided into two, one containing ammonium sulphate and half the K being applied in June and the other consisting of F.Y.M., phosphorous and the rest of the potassium in October. In 'ON' year, the ammonium sulphate dose should be doubled to force July-August shoots which mature and flower during succeeding 'OFF' year.

Openheimer and Gazit (1963) reported that trees deficient in zinc were found to have very small deformed leaves with rossette formation near the top of the flush. Growth may be retarded before clear symptoms develop and a leaf Zn content below 20 ppm may indicate slight deficiency. Correction was achieved by spraying with 1 per cent $ZnSO_4$ or 0.2 per cent of ZnO. Soil applications, dusting the tree and the application of pellets into holes bored in the trunk were not effective.

Smith and Scudder (1951) studied the mineral deficiency symptoms in mango. They have selected two trees each of Haden and Zill variety of mango which was grown for three years in sand culture with solutions form which 11 essential mineral elements were systematically omitted in an attempts to define as many leaf deficiency symptoms as possible. Deficiency symptoms in leaves were found for six elements as follows :

N - Small leaves and generally yellowish; P - leaf tip necrosis, premature abscission and stem dieback, K - irregularly distributed yellow spot and necrotic areas along the margin of small thin attenuated leaves which are very persistent. Mg - A green wedge pattern formed by the lateral intention of a browned chlorosis along the leaf margin. Zn - Yellowish green chlorosis over the small veinal net work. Sulphur - Lateral necrotic spots in a very deep green leaf and premature defoliation. No specific symptoms were found when Ca, Cu, B, Mn and iron were omitted but omission of the first three resulted in considerable growth reduction. Trees fed only with calcium nitrate showed deficiency leaf pattern as for P, Mg and K in succession trees that were supplied with all of the nitrogen as ammonia showed a marginal scorch of growing leaves and died within few months.

The same authors further working in sand culture, found that in plants receiving no magnesium, a leaf pattern in which the leaves had a distinctive yellowish brown chloresis was noticeable. There was a green wedge down the central part of the leaf on severely affected leaves the chlorosis extended to the midrib and little or no green colour remained, both margins dried more or less regularly surprisingly few leaves developed the symptoms probably because of the premature - defoliation induced by Mg shortage. The analysis of the leaves from the magnesium deficient trees showed normal nitrogen, phosphorous and calcium deficient trees showed normal nitrogen P and Ca. Very little Mg (0.09 per cent) was found in the leaves.

On the same sand culture experiments described above, the same workers had two sets of trees one of which was fed calcium nitrate only and another a complete nutrient in which all of the nitrogen was in the form of ammonia. Trees receiving the calcium nitrate showed the first typical phosphorous deficiency symptoms at the same time as the trees given the minus phosphate treatment and later showed definite magnesium and potassium deficiency pattern. This would indicate the necessity for a complete type of feeding the tree receiving ammonium nitrogen with a complete nutrient solution developed a reddish brown scorch of the entire margin of the leaves became sickly in appearance and all died within a year. The mango trees apparently were unable to use only ammonium as a source of nitrogen in their metabolic processes. The same difficulty with ammonium feeding was observed by the another set of young mango trees receiving a generous mulch of tobacco stems. Warm moist weather caused a fast break down of the tobacco stems, containing about 5 per cent of ammonical nitrogen and on ten acre block not a single tree escaped the leaf scorch.

Although the investigators could find no response to copper, boron, Zn and Fe, when they were omitted from the culture solution, Ruehle (1952) stated recognised copper deficiency symptoms on young mango trees that had been fertilized with N, P, K fertilizers. The symptoms of this trouble were similar in many respects to the copper deficiency symptoms of citrus. They showed a pattern of rapid growth with over sized leaves and often flattened branches, gum exudation from the bark to twigs and branches and dieback of branches. These symptoms failed to appear in new growth following the application of nutritional sprays containing considerable copper.

Young, Koo and Miner (1961), in a two-year study with

Kent mango, reported a correlation coefficient between calcium in the leaves and soft nose of 0.534 for the first year and 0.617 for the second year. They indicated that if Ca is kept at 2.5 per cent or slightly higher, soft nose would drop to very low level regardless of the N level. Calcium can be maintained either by applying lime stone or gypsum. In the same study, they reported a significant relationship between leaf N and yield the relations being linear. The maximum production occurs at about 1.35 per cent N in the leaves. During the first year, no N value were above 1.35 per cent. If further work confirms the curvilinearity and production, it would indicate that the mango is similar to the avocado. Leaf analysis could serve as a guide to N fertilisation of the mango. The 1.35 per cent N for maximum production is somewhat lower than the comparable point for the avocado and additional work is needed to more firmly fix the N level for mango production. Since the mango can become over vegetative like the avocado, it is not surprising to find a curvilinear relation between production and N level, the observed behaviour of other evergreen tropical trees such as the Litchi, fit this same pattern and this might well be the general pattern for all such trees.

Singh (1961) states that the symptoms of nutrient deficiency in mango are less well known. They have generally not been observed in the field and even under pot culture, their expression is very slow. Out of the 11 elements studied, Smith and Scudder (1951) could produce symptoms of deficiency only of N, P, K, Mg, S and Mn. On the other hand, Sen *et.al* (1947) produced starvation signs of N, P and K only on the Langra variety.

Zn and Mg are probably the only elements which were observed to be deficient under field conditions.

idan, Z.I. and Mobeimoso, E. (1969) have reported the effect of season on the chemical composition of mango leaves. The percentage of dry matter in the leaves of Pairi and Alphonso increased with leaf age except during the summer and spring month cycles and was about 25 per cent more in the blades than in the petioles. The N content as a whole generally increased to reach a peak during the winter months in the blade and decreased in the spring flush. - Noticeable decrease also occurred at other times of the year especially during the summer flush. The N content of the petiole showed an opposite trend from that in the blades until winter and then become similar. The P content of the blades as a whole decreased during the summer, increased in winter and decreased again in the spring. Per cent K decreased early in the season rose to a maximum in winter and fell again in the spring.

Sen *et.al.* as quoted by Childer (1 ted in sand culture experiments with Langra mango growing in pot for six years, subjected to three levels of N, P and K. The results indicated that the supply of nitrogen controlled the uptake of other elements and determined the growth. There was an optimum level of N above which the plant developed potash but no phosphorous deficiency symptoms. The balance between K and N appeared to be of major importance. Extreme 'K' deficiency caused dieback which proved fatal to the plants.

Smith and Scudder as quoted by the same author Childer with sand culture started in the fall of 1947 and continued about three years, had partial success in distinguishing specific leaf deficiency symptoms of various essential elements. They used grafted trees of Hadan and Zills varieties supplying a complete solution, except for omitting various single element in each. The N deficiency shows severe retardation of growth in presence of yellow undersized leaves. The leaves contained on an average 0.67 per cent N as against 1.54 per cent in trees receiving the complete solution. However, the phosphorous, potash and calcium contents were higher in nitrogen deficient leaves than in most of the other treatments.

Trees in the phosphorous deficient cultures (Smith and Scudder, 1947) showed a stunted growth during the first year. During the second year, the older leaves began to drop prematurely after partically dying back from the tip. This condition became worse with time and only the younger leaves at the tip of the branches remained during the third year. Wood of the main trunk and branches was thin and somewhat willowy and occasionally branches died back. The purplish pigment did not develop on the under side of the leaves on the varieties tested, whereas this response was noted on the Langra in India (Sen <u>et.al.</u> 1947). Analysis of the leaves showed 0.050 percent phosphorous which was a little lower than in leaves from any of the other treatments, but the nitrogen content was normal and about the same - potash, calcium and magnesium contents were found as in leaves from trees receiving complete solution.

Leaves on trees in the cultures from which potassium was withheld were the largest and most vigorous (Smith and Scudder, 1951) of the experiment for the first two years. The plants showed a remarkable tendency to carry the old leaves. Later small yellow spots started to develop on the oldest leaves. The leaves were smaller than usual, thin and tapered out to a fine point. Necrotic areas developed along the margins of leaves and enlarged with time. Leaves from the potash deficient trees contained a normal amount of nitrogen, phosphorous, calcuim and magnesium as compared with the control trees, but had 0.25 per cent potash in comparison with that of control trees of almost 1 per cent.

Young and Miner (1960) reported that increasing the amount of N by 9 to 10 fold resulted in approximately a three fold increase in yield. The addition of P, K and Mg had no effect on yields. Leaves sampled from the last mature flush, evenly distributed between fruiting and non-fruiting shoots, at the time of fruit harvest contained 1.45 per cent N where N was applied and 0.90 per cent N for the check trees. Unfortunately, soft-nose was greatly increased by the N fertilisation. Soft-nose as described by Young (1957) is a break down of the flesh on the ventral side and toward the apex in mango fruits, while still on the tree and appears to be a physiological disorder.

Young and Miner (1961) in their further work substantiate the effect of N on both yield and soft-nose but soft-nose was greatly decreased by increasing the supply of Ca to the trees. In comparing locations they found that the incidence of soft-nose on acid, sandy soil increased from about 7 per cent on control trees (low N) to around 78 per cent on high N trees. With similar treatments on calcareous rock soil, incidence of soft-nose was around 5 per cent at both rates of N. The Ca content of leaves from trees on the rock soil was 2 to 3 times that of those from the sandy soil.

Garg (1960) reported that the mango trees may be given a copious dressing of Farm Yard Manure after harvest in the 'OFF' year with good cultivation and N, P application in the following January. After harvesting in 'ON' year no manure should be given and no winter irrigation. A full N, P, K mixture should be applied about a month before a first flush is expected.

Tripathi and Sharma (1963) stated that leaves of Dashehari mango were sprayed on both sides with 2.5 per cent urea with and without spreaders. Glycerin in all concentrations slightly depressed the urea absorption in both young and old leaves. Triton B-1956 and Tenso, both at 0.1 per cent, depressed urea absorption in very young pink leaves, but at 0.01 and 0.02 per cent concentrations they enhanced absorption in older dark green leaves. More urea was absorbed at pH 2.6 than at pH 4.25 and 7.6 at which levels, results were variable.

Roy and others (1956) stated that mango produces three main vegetative flushes during the year - in February-March; June-July and October. The earliest shoots generally produce flower during the next bloom, the late flush usually do not get sufficient time to mature and hence do not bear. Previous pot culture experiment revealed that N influences the intake of P and K and determines growth. There is an optimum effect of N after which K deficiency symptoms are developed. The P requirement of mango is much lower than that of K. The plant, however, can recover from the adverse effect of low K and P if they are replenished.

Nitrogen in the form of ammonium sulphate is most -

effective in increasing flowering and the best time for its application is in the month of June. Nitrogen in the form of F.Y.M. applied in October is also beneficial but as it is slow acting, its effect is manifested later than that obtained by ammonium sulphate. Intake of K is most vigorous in presence of N and so it is applied along with N. P is advantageously used by the plants if a slow acting manure, i.e. Bonemeal is given along with F.Y.M. during October. It is recommended to divide the annual doses of N, P and K manure into two parts - one containing ammonium sulphate and half K - Manure for June application and the other consisting of farm yard manure and phosphate along with the remaining half of K for October. In the 'ON' years, the dose of ammonium sulphate should be doubled to force July-August, vegetative shoots which mature and produce flower during the succeeding 'OFF' years. This extra dose should be applied a fortnight after the June application immediately after the harvest.

Citrus

Emmert (1954) studied the effect of time of sampling and leaf composition on both soluble and total N, P, K, Ca and Mg concentrations. He found significant differences in respect of major leaf nutrient elements.

Heymann and Herschberg (1955) studied leaf composition in relation to N and P requirement of citrus trees in Israel.

The N and P nutrients of citrus trees in Israel was studied by means of leaf analysis. The effect of factors other than nutrient supply which causes change in leaf composition are discussed. The N and P contents of lemon and grape fruit leaves were lower than those of orange.

Praloran and Minot (1957) determined the mineral nutrition of orange tree by foliar analysis. Studies over a period of two years laid to the following conclusions :

(1) Leaf content of N was directly related to the amount of nitrogenous fertiliser applied. This was only the case with P at certain seasons and applications of K were not reflected in leaf composition.

(2) Leaf content of N, P and K increased greatly during the flowering period.

(3) Time of application of fertiliser appears to be less important than the maintenance of a constant satisfactory level of nutrient in the soil.

(4) Yield can vary greatly from year to year without causing much change in the nutrient status of the trees. And there is no direct relationship between yield and leaf level of N, P and K.

Sato and Ishihara (1957) undertook studies on leaf analysis of Mg, Mn and Zn deficient citrus trees. Leaf samples from 384 citrus groves in which Mg, Mn or Zn were deficient were analysed for N, P, K, Ca, Mg, Zn and Mn. The survey suggests that critical levels are 0.20 to 0.25 per cent for Mg and 20 to 30 ppm for both Mn and Zinc. In Mg deficient trees, the Mg content of old leaves was much lower than that of the current year's leaves. In Mg deficient leaves, there were positive correlations between Mg and N, Mg and P and to a smaller extent, between Mg and K, whereas in healthy leaves the correlation between the Mg and N and Mg and K were negative.

Heymann and Herschberg (1959) studied the micro-nutrient deficiences in citrus in Israel. Deficiencies of Zn, Mg, Mn, Fe and Boron and excess of boron have been diagnosed in Israeli groves by external symptoms and by leaf analysis. Groves planted on light and calcareous soils are most commonly affected especially where the trees have received excessive irrigation. Zn and Mg deficiences are the most prevalent troubles and need corrective measures. Mn and B deficiences, on the other hand, are not at present considered serious enough to warrent corrective measures. Zinc deficiency can be cured by treatment in spring or early summer with a neutralised zinc-sulphate-spray (2 per cent $ZnSo_4$, 1 per cent lime and spreader) or a zinc oxide dust, both combined if necessary, with sulphur treatments used against rust mites. In Mg deficient groves, good results have been obtained with 4 per cent $MgSo_4$ sprays applied alone or in combination with Fe, Zn, Cu and Mn compounds. A dust mixture of 80 per cent

$MgSO_4$ and 20 per cent talcum has also shown promise. Lime induced chlorosis associated with Fe deficiency can generally be overcome by reducing irrigation.

Labanauskas, et.al.(1960) studied the seasonal changes in concentration of micro-nutrients in leaves of Washington Navel Orange, reported that concentrations of Zn and Cu in the leaves tended to decrease, and those of Mn, B and Fe tended to increase, with the age of the leaf throughout the season until mid winter, and then, before and during the initiation of new bloom and growth flush, they levelled off with relatively small decreases and increases, respectively. B concentration remained constant during the winter months. Zn, Cu, Mn and B concentrations decreased slightly during bloom and the initiation of the new flush at the end of the growing season. The fe concentration increased with the age of the leaf throughout the growing season, with no apparent indication of outward movement of Fe at any time during the season. Linear trends downward for Zn and Cu, and upward for Mn, B and Fe concentrations were highly significant throughout the growing season.

Sato et.al. (1960) have stated the effect of fruiting on N, P and K content of different parts, particularly the leaves of young Satsuma Orange trees were studied in pot - culture experiments using soil and sand culture, the former with and without added K. In case case, the half the trees were prevented from fruiting by removing the flower buds. The addition of K to infertile soils reduced new vegetative growth and number of fruits produced and increased the fruit K content. It decreased foliar K slightly at first but very markedly later, particularly where K was not added. The total K uptake by vegetative parts was 40 to 56 per cent lower in fruiting than in non-fruiting trees, N uptake was 30 to 39 per cent lower and P uptake 35.8 to 42.6 per cent lower. For whole trees, including fruit, the differences were smaller, that in N uptake being very slight.

Labanauskas et.al.(1960) reported that monthly sampling showed in general as leaves become older, concentrations of Mn, B and Fe increased, while those of Zn and Cu decreased. Concentrations of Zn, Cu, Mn, and Boron in the old leaves decreased during the initiation of the new bloom and growth flush in the spring. By contrast Fe increased in concentrations in the same leaves during this period indicating that there was no appreciable redistribution of Fe to the new growth.

Pennisi and Scuderi (1961) carried out the investigations on the mineral composition of sicilian citrus leaves. Analysis of 4 to 8 months old leaves of several orange - varieties and lemon variety in productive orchards in the provinces of Syracuse showed that, in general, N and Ca contents were within the optimum limits, P and K were too high and Mg was low, soil and leaf analysis figures are given in four month old Mandarin leaves, the N, P, K, Ca and Mg contents were 2.45, 0.53, 3.67, 3.47 and 0.10 per cent of dry matter, respectively, and the corresponding figures in seven month old leaves were 2.88, 0.71, 2.82, 3.40 and 0.27 per cent.

Chapman (1961) has reported the different levels of leaf nutrient contents at which plants showed the deficiencies and normal growth. Magnesium below 0.5 per cent was reported deficient. Calcium 2 to 5 per cent was normal, while when more than 7.0 per cent, it might indicate the potassium or magnesium deficiency.

Phosphorous 0.07 to 0.1 per cent deficient, while 0.12 to 0.15 per cent was normal. Excess phosphorous in the soil adversely affected copper, Zn and boron availability. Potassium below 0.3 per cent deficient, while 0.4 to 1.5 per cent was good. High K level might induce Mg, Zn and Mn deficiencies.

Sinha and Randhawa (1961) stated that N, P and K contents were at a maximum in young twigs and decreased with increasing age of twigs. A marked reduction in N content corresponding to the autumn flush was also observed. A definite increase in N content occurred in early spring. The C/N ratio was low in young leaves just before initiation of the spring flush and bloom. The C/N ratio was highest in October flush followed by the July flush and at a minimum in the March flush in the case of Hamlin and in the May flush in Valancia late. Total ash and Ca contents showed an increasing trend with increasing age of the leaf though with some decrease during November. Decreases in K in November and in P during the winter months were pronounced. Marked variations in the composition of twigs of different growth flushes were observed. P and K were highest in autumn flush and Ca was highest in March flush, the summer flush had intermediate concentrations of these elements. High N, accompanied by moderate quantities of P, K, Ca and Carbohydrates was favourable for flowering and fruit set in sweet orange.

Samoladas (1965) stated that when Mn, Zn, B, Mo, Cu, alone and all mixed together were applied annually in a 1 per cent Bordeaux mixture spray to 11 year old Unshin mandarin trees for three years, Zinc stimulated photosynthetic activity, increased yields and controlled irregular bearing. Mn stimulated metabolic activity and growth increased yield but did not affect the bearing habit of the trees. B and Mo had an unfavourable effect on metabolism, growth and fruiting and no effect on variation in the responses to the treatment were apparently due to differences in the availability of the nutrient in the soil.

Ishihara et.al. (1965) studied the K nutrition of -

Satsuma orange and the interrelation between N and K on the growth, leaf analysis, tree analysis and fruit quality They have selected two year old Satsuma orange trees in pots which were fertilised with different combinations of N and K using three levels of nitrogen and four levels of K. N applications improved growth a whereas K applications had no significant effects on top growth, but supressed root growth. Nitrogen fertilisation tended to raise leaf N - content and lower leaf P, K and B contents whereas K fertilisation increased the leaf K and decreased the leaf Ca and Mg content. With an increase in N fertilisation, the fruit rind became thicker. Increased K applications resulted in better fruit colour, large fruit and greater yield but was also associated with thicker rind, lower total sugars and higher citric acid content. Heavy applications of K, - especially when the rate of N applied was low, caused poor fruit colour, smaller fruit and low yield.

DeMello and others (1967) studied the K/Mg ratio in young orange plants. Three months old plant were grown in nutrient solutions with factorial combinations of Mg at 0, 48 and 146 ppm and K at 0,234 and 704 ppm. Foliar analysis showed that at the lower K level, the K uptake was increased by the lower rate of Mg and reduced by high Mg. At high K level, the reverse effect was recorded. At the lower Mg level, the lower rate of K increased and high K reduced Mg uptake.

At the high Mg level, the Mg uptake was inversely related to the K level. Absorption of Ca was reduced with each rise in K level, but Mg only interferred with Ca uptake at high K level.

Kanwar and Dhingra (1963) stated that foliar spray of 0.6 per cent zinc sulphate reduced chlorosis, raised the Zn content of the leaves, but lowered N, P and K contents. Sprays of certain other micro-nutrients also raised the leaf Zn level.

Labanauskas, Jones and Embleton (1960) mentioned the influence of soil application of N, P and K on the micro-nutrient concentration in Washington Naval orange leaves. The concentration of Zn, Cu, Mn, B and Fe in Washington Naval orange leaves as affected by soil applications of urea, urea phosphate, urea potash and no fertiliser treatments for 19 consecutive years were studied in long term orchard experiment. Urea alone increased yield and growth of the trees over the check treatment appreciably, but the addition of phosphate or potash fertiliser was not effective in further increasing yield and growth. Soil pH was not affected significantly by soil application of urea alone, urea phosphate and urea potash as compared to the pH of the soil from the check treatment Plot. 3·3 lbs per tree per year of actual N from urea applied, usually for 19 consecutive years, significantly increased Mn and Fe concentrations in the leaves, whereas Zn, Cu and B were a unaffected as compared to levels found in the leaves of unfertilised trees. Application of 1 lb of P_2O_5 in addition to 3 lbs of N to the trees significantly reduced the Zn and Cu concentrations in the leaves, whereas Mn, B and Fe were unaffected as compared to level found in the leaves of untreated trees. The addition of 1 lb of K_2O from potassium sulphate to 3 lbs of N did not affect significantly the concentrations of Zn, Cu, Mn and B in the leaves as compared to levels found in the levels of N treated leaves.

Heymann and Herschberg (1956) reported that increasing application of quick acting N and P fertilisers were reflected in increasing leaf N and P but did not affect yields or external quality of fruit. In many groves, high yields of good quality fruit were produced with moderate N and infrequent P applications. Although for many years no K deficiency was evident. A single K application tended to increase leaf K. In orchards yielding small fruits, the ratio of Ca plus Mg/K tended to be relatively high. In all groves, leaf Ca was within the optimum range and was not significantly increased by high soil Ca contents. The leaves in the best groves contained 0.200 per cent ± 0.02 per cent Mg compared with 0.178 per cent in groves on calcarious soils and 0.166 per cent in groves producing coarse fruit. External Mg deficiency symptoms were associated with less than 0.17 per cent leaf Mg and even more consistently with ratio below 3.0 per cent of Mg X 100/Ca + K + Mg. The leaves of grape fruit trees differed from those of Shamouti orange trees by containing lower N, P and K and larger Ca and Mg concentrations.

Alim Alis and Musahb (1955) reported that foliar sprays of Zn, Mn, Copper and Cobalt were applied three times in a year to pineapple orange tree on rough lemon which were growing in a sandy loam soil of pH 8.4. Tree vigour was not affected, fruit set was increased by February sprays. June drop was decreased by 4.5 per cent by Zn and Mn and was increased by Cu, Fe and Co. Yield did not show any significant difference in the year following application, but the crop in the next responded sine giving significantly higher yield. Fruit quality was proved by all sprays except Cu. Sprays of Zn and Fe resulted in improved colour and in higher density and non-reducing sugar in the juice.

Smith (1956) studied the relation of boron level to the production of fruit quality of grape fruit and oranges. Various borax levels have been applied to orange and grape fruit since 1951. The treatments have not had any favourable effects on growth or yield but have induced biennual bearing in certain years. In grape fruit, the higher B concentrations increased leaf size and affected K, Ca and Mg concentrations. Similar changes were not apparent in orange leaves. High boron application was associated with reduced Mn content in both orange and grape fruit leaves. Juice content, citric acid and vitamin C were consistently lowered by high boron except in Temple orange which showed no citric acid loss.

Beeftink et.al.(1962) has observed that in heavy moist deep soil citrus trees showed a positive effect to N application. Nitrogen manuring increased the leaf contents of N, Mg and Ca and reduced phosphoreus and potassium content. In second trial with trees growing in a sandy clay layer above a limiting factor, the response to nitrogen fertilisation was not significant or was negative. In both cases, the P and K fertilisation had shown no responses on fruit production.

Bingham (1963) reported the relationship of phosphorous to micro-nutrients in Beans, Tomatoes and in Sour orange seedlings. These plants were grown under controlled sand culture conditions. He has not observed the P induced Zn or Cu - deficiencies in any of the plants. In citrus increasing P reduced the leaf content of B, Cu, Mn and Mo and increased that of Zn. In tomato, it reduced the leaf content of Fe, Mn and Mo and in beans, it increased leaf Mn. In all cases, higher the substrate P level, greater was the Mn content of the roots.

Spencer (1966) reported that application of Cu and P each at four levels were made to pot grown mandarin seedlings growing in sand. High P levels (250 and 750 ppm) reduced the uptake of Cu and Fe. Excessive amounts of Cu (100 to 250 ppm) markedly reduced the uptake of P decreased yields and the top root ratio and resulted in stunted growth. The Fe content of leaves and roots were also diminished.

Reuther and Smith (1950) mentioned that the data of the soil analysis shows that most mature Florida citrus groves have accumulated relatively high concentration of total Cu, Mn and P in the top soil. In general, groves affected with iron chlorosis have higher level of these elements in the soil and a lower level of total Fe than healthy groves. Pot studies indicate that foliage chlorosis and abnormal root development of citrus seedlings can be induced by adding Cu to grove soil, particularly when the soil is acidic and that the Cu levels required to produce the responses within the range found in most affected groves. Cu was found to be many times more potent in producing iron chlorosis of the foliage and toxic effects in the leaves of these elements in the top soil of mature grove on the average lower than the level of Cu. The evidence available suggests that the major factors affecting the incidence of Fe chlorosis groves in excessive accumulation of Cu in the soil. The effects of this is intensified by low pH.

Embleton, T.W. and Jones, W.W. (1965) reported that potassium deficiency symptoms found in the leaves and fruit of Lisbon lemon tree on Cleoptra mandarin rootstock and old

Eureka lemon tree on sweet orange rootstock are described. Visible symptoms were particularly eliminated in the former in about one year by three sprays of KnO_3 at 30 lbs per 100 gallons and considerably reduced in the latter within 2½ years by broadcasting at 20 lbs per tree in two successive years.

Yada and Okamoto (1966) stated that optimum soil pH for growth was 6.23 to 7.25 in the case of NH_4-N + KCl nutrition and 6.23 to 7.18 in the case of NH_4-N + K_2SO_4. However, when NO_3-N was applied, growth was much the same in most of the plots except that of strongly acid soils (nearly pH 4). Regardless of the pH, P_2O_5 and K_2O in the tree increased with its growth. However, MgO was observed more abundantly in NO_3-N plots than in NH_4-N plots. With lowered soil pH, the total content of CaO decreased whereas that of Mn increased evidently independent of growth. The absorption of N and P_2O_5 in NH_4-N plots was promoted more by K_2SO_4 than by KCl.

Sakamota and Okuchi (1967) studied the effect of physical and chemical properties of soil on the growth of Satsuma orange trees and on differences in the constituent of inorganic macro element in Satsuma orange leaves growing on six different soils.

The leaf contents varied widely as follows :

N - 2.77 - 3.49 per cent, P - 0.131 - 0.203 per cent, K - 1.13 to 1.99 per cent, Ca - 1.57 to 3.78 per cent and

Mg 0.254 to 0.513 per cent. Trees on sandy soils shared low N and high K and P, leaf contents. Leaf K was low in trees on soil rich in exchangeable Mg and low in exchangeable Ca and Mg supported trees showing high leaf K contents. Significant negative correlations were found between N and Mg, K and Ca and K and Mg contents and positive correlations between P and K. There was also a tendency towards negative correlation between N and P, P and Mg and Ca and Mg. High leaf Ca, Mg and P were respectively associated with high Ca, Mg and P in the soil, the opposite was true for K.

CHAPTER III

MATERIALS AND METHODS

The mineral nutrition study was undertaken on ten year old Alphanso mango trees in the manurial experiment at the Regional Fruit Research Station, Vengurla, District Ratnagiri.

Prior to planting, the land was fallow which was used as a pasture and no manuring and fertilisation was practised.

The mango orchard was planted in the year 1960 by the use of inarched grafts spaced at 10.5 M x 10.5 m.

Mango stones for raising stock plants were collected from Peshava variety at the Ganeshkhind Fruit Experiment Station, Poona. In all, 400 seedlings were raised in August, 1958. The work of grafting was done in August, 1959 and the grafts were prepared by inarching the branches of selected tree No. 10 in Plot No. 6 at the Ganeshkhind Fruit Experiment Station, Poona. These grafts were used as experimental material, while for guard rows, grafts were obtained locally.

Vengurla lies along the coast at 8 meters above M.S.L. with a mean annual rainfall of 2,776 m.m. distributed mainly during June to September. The climate is comparatively humid and equable with temperatures ranging from 16° C. to 37° C. (60° to 100° F.).

The soils are lateritic and porous. The depth of the soil ranges from 150 to 180 cms. underlaid with laterite rock. Topography consists of gentle slope. The soils are highly acidic with a range of pH of 3.7 to 4.9.

Details of the Experiment and Experimental Design (Fig. 1).

The experiment was laid out in split plot confounded design with $3^2 \times 2^2$ main treatment combinations and two sub-plot combinations having in all 72 treatments. Only one - replication was provided.

Net plot size : 21 M. x 21 M.
Gross plot size : 31.5 M x 31.5 M.

A common guard line between two net plots is provided. Each treatment consists of four experimental trees.

Treatments

Fertiliser			Quantity in kg./tree
Phosphorous	P_0	...	0.0
	P_1	...	0.68
	P_2	...	1.36
Potash	K_0	...	0.0
	K_1	...	0.45
	K_2	...	0.90

PLAN OF LAYOUT OF MANGO MANURIAL EXPERIMENT.

SUB BLOCK I

$P_2K_2N_2F_1L_0$	$P_2K_2N_2F_1L_0$	$P_1K_0N_2F_0L_1$	$P_1K_0N_2F_0L_0$
$P_1K_0N_1F_1L_1$	$P_1K_0N_1F_1L_0$	$P_2K_2N_1F_1L_1$	$P_2K_2N_1F_1L_0$
$P_0K_1N_2F_0L_0$	$P_0K_1N_2F_0L_1$	$P_0K_1N_1F_1L_1$	$P_0K_1N_1F_1L_0$

SUB BLOCK II

$P_2K_2N_2F_1L_1$	$P_2K_2N_2F_1L_0$	$P_1K_0N_1F_0L_1$	$P_1K_0N_1F_0L_0$
$P_0K_1N_1F_0L_0$	$P_0K_1N_1F_0L_1$	$P_1K_0N_2F_1L_1$	$P_1K_0N_2F_1L_0$
$P_0K_1N_2F_1L_1$	$P_0K_1N_2F_1L_0$	$P_2K_2N_1F_0L_0$	$P_2K_2N_1F_0L_1$

SUB BLOCK III

$P_2K_1N_1F_0L_1$	$P_2K_1N_1F_0L_0$	$P_1K_2N_1F_0L_1$	$P_1K_2N_1F_0L_0$
$P_0K_0N_1F_0L_0$	$P_0K_0N_1F_0L_1$	$P_1K_2N_2F_1L_0$	$P_1K_2N_2F_1L_1$
$P_2K_1N_2F_1L_0$	$P_2K_1N_2F_1L_1$	$P_0K_0N_2F_1L_0$	$P_0K_0N_2F_1L_1$

SUB BLOCK IV

$P_2K_0N_1F_1L_0$	$P_2K_0N_1F_1L_1$	$P_2K_0N_2F_0L_0$	$P_2K_0N_2F_0L_1$
$P_0K_2N_1F_1L_1$	$P_0K_2N_1F_1L_0$	$P_1K_1N_2F_0L_1$	$P_1K_1N_2F_0L_0$
$P_0K_2N_2F_0L_0$	$P_0K_2N_2F_0L_1$	$P_1KN_1F_1L_1$	$P_1K_1N_1F_1L_0$

SUB BLOCK V

$P_2K_1N_1F_1L_1$	$P_2K_1N_1F_1L_0$	$P_0K_0N_1F_1L_1$	$P_0K_0N_1F_1L_0$
$P_2K_1N_1F_1L_0$	$P_1K_2N_1F_1L_1$	$P_0K_0N_2F_0L_1$	$P_0K_0N_2F_0L_0$
$P_2K_1N_2F_0L_0$	$P_2K_1N_2F_0L_1$	$P_1K_2N_2F_0L_0$	$P_1K_2N_2F_0L_1$

SUB BLOCK VI

$P_1K_1N_1F_0L_1$	$P_1K_1N_1F_0L_0$	$P_2K_0N_1F_0L_1$	$P_2K_0N_1F_0L_0$
$P_2K_0N_2F_1L_1$	$P_2K_0N_2F_1L_0$	$P_0K_2N_1F_0L_0$	$P_0K_2N_1F_0L_1$
$P_1K_1N_2F_1L_0$	$P_1K_1N_2F_1L_1$	$P_0K_2N_2F_1L_1$	$P_0K_2N_2F_1L_0$

Treatments (Concld)

	Fertiliser		Quantity in kg./tree
Nitrogen	N_1	...	0.68
	N_2	...	1.36
F.Y.M.	F_o	...	0.0
	F_1	...	45.5

These treatments have 36 combinations forming the main treatments which were randomised in each block.

There are two levels of lime split up in each sub block:

L_o	...	0.0 kg. of lime per tree.
L_1	...	Quantity sufficient to bring the pH of the soil to 6.5.

The layout plan is shown in Fig. 1.

Details of application of treatments.

The trees in the experiment were of six years age in the year 1965, when the differential treatments were started. However, as the trees were not fully grown, the adult dose was not given but smaller doses according to age of the trees were given as per the following schedule :

Mango (Manurial Experiment) Manurial Schedule

Treatments	Levels	1965	1966	1967	1968	1969
Nitrogen	N_1	0.25	0.30	0.34	0.55	0.61
	N_2	0.50	0.60	0.68	1.10	1.32
Phosphorous	P_0	0.00	0.00	0.00	0.00	0.00
	P_1	0.25	0.30	0.34	0.55	0.61
	P_2	0.50	0.60	0.68	1.10	1.32
Potassium	K_0	0.00	0.00	0.00	0.00	0.00
	K_1	0.23	0.27	0.32	0.36	0.40
	K_2	0.46	0.54	0.64	0.72	0.80
F.Y.M.	F_0	0.00	0.00	0.00	0.00	0.00
	F_1	45.5	45.5	45.5	45.5	45.5
Liming	L_0	0.00	0.00	0.00	-	-
	L_1	1 M.ton /acre	1.58 to 3.58 M.ton /acre	0.89 M.ton/ acre	-	-

All figures are in Kg.

Lime was applied to bring the pH of the soil to 6.5.

Source of Fertilisers

N : Ammonium sulphate throughout the year

P : Bonemeal - 1965

P : Super phosphate 1966 and 1967

P : Rock phosphate 1968 and 1969

K : Sulphate of potash throughout the year

Soil analysis

The soil samples from all the plots were taken in May, 1969 and they were analysed separately for the major nutrients as well as for mechanical analysis to determine the physical condition.

Leaf analysis

i) Sampling technique :

To secure accurate results, the leaves were selected from shoots spread all over the tree and last leaf which was just close to the fruit was taken for analysis. About 20 such leaves were sampled for each treatment at harvest time in May, 1969.

The samples were also drawn in November, 1969 prior to flowering from mature leaves from the apical portion of mature shoots.

ii) Pre-treatment :

The leaves after collection were wrapped in brown paper bags and brought to the laboratory. The leaves were washed in water and then wiped off with moist muslin cloth and kept in oven for drying for about 24 hours at 90° to 95° C. They were then ground in mortle with pestle and kept in air tight amber coloured bottles.

iii) Estimations :

Estimations were made for the following major and minor elements :

Major	Minor
Nitrogen	Iron
Phosphorous	Copper
Potassium	Boron and
Calcium and	Manganese
Magnesium	

iv) Procedure :

For estimations of major elements, the following method of analysis given by R.C. Lindner (1944) were used.

Aliquot was prepared by taking 100 mg. of the dry powdered leaf samples by digesting with concentrated sulphuric acid and 30 per cent hydrogen perioxide until it became colourless. Volume was made to 100 c.c. and stored in dark bottles.

Determination of Nitrogen

10 ml of aliquot was transferred to 50 ml volumetric flask, 2 ml of 2.5 N sodium hydroxide and 1 ml of 10 per

cent sodium silicate were added and volume was made up to 50 ml. 5 ml of this aliquot was transferred to colorimeter tube, four drops of Nessler's reagent was added and allowed to stand for several minutes and then the reading was taken on colorimeter by using blue filter No. 49.

Phosphoreus

10 ml of the perioxide digested material was transferred to 50 ml volumetric flask; 2.5 ml of 2.5 N, NaOH and 2 ml. of ammonium molybdate were added and volume made to mark. Two drops of stanous chloride solution were added and mixed well and was allowed to stand for a minute to develop maximum blue colour. The reading was taken on 5 ml. aliquot using green filter No. 54. Standard curve was prepared by taking analar grade potassium hydrogen phosphate.

Potassium

It was determined by the turbidity method based on the precipitation of potassium as the cobalt nitrate in a finely suspended form.

5 ml of the perioxide digested material was taken in an Erlenmeyer flask, one drop of methyl red indicatore was added, the solution was neutralised by saturated sodium carbonate and boiled for several minutes to expel ammonia. It was cooled and transferred with minimum washings, so that, the final volume did not exceed 6 ml in colorimetric tube. Two drops of 6 N HCl

were added to neutralise excess sodium carbonate, 0.5 gm of sodium nitrate crystals were added and dissolved by shaking 4 ml of 95 per cent alcohol mixed properly and volume made up to 10 ml. 0.17 gm of dry powdered sodium cobalti nitrate was added, shaken well and reading was taken after ten minutes using a red filter. Standard curve was prepared by using potassium chloride and percentage worked out.

Determination of Calcium

Turbidimetric method based upon the precipitation of calcium as an oxalate in the finely suspended state was used 5 ml aliquot was transferred to colorimetric tube. 0.12 gm of sodium carbonate powder was used to neutralise the solution partially, 1 ml of gumacacia reagent was added. Reading was recorded for reagent blank 0.1 gm of ammonium oxalate was added, shaken well and after ten minutes reading was taken on colorimeter by using green filter. Standard curve was prepared by taking analar grade calcium chloride and percentages were worked out.

Determination of Magnesium

This method is a modification of the colorimetric titan yellow, procedure of Gillum in which 5 ml aliquot was transferred to colorimetric tube, 1 ml of 4 per cent hydroxylamine hydrochloride solution was added and 10 drops of titan yellow was poured, mixed well and then 1 ml of 40 per cent NaOH solution added and mixed well, cooled to 20° C. in water and reading was taken by using green filter No. 54 (Wratten No. 54). Standard curve was prepared by taking analar grade magnesium sulphate and the percentages were worked out.

Micro-nutrients

Rigid precautions were observed to avoid contamination in the determination of trace elements. Copper tongues, copper water bath and iron stand were strictly excluded and were replaced by stainless steel tongues, alluminium water bath and wooden stands respectively. Highly pure grade (A.R.) reagents (B.D.H. or *E. Merck*) pyrex apparatus and glass - redistilled water were used. Except for boron, wet oxidation method was used. The elements were estimated colorimetrically using Klet Summerson photo electric, colorimeter.

For wet digestion, the samples were further dried at 105° C. to 110° C. for one hour. 1 gm sample was transferred to Kjeldahl's micro-digestion flask.

A micro-digestion method with sulphuric, nitric and perchloric acid was followed. The sample was digested with 15 ml. of nitric, 4 ml of perchloric and 5 ml of sulphuric acid, firstly on low flame till the dense brown fumes of nitric acid started, then the flask was removed for five minutes. The digestion was continued on low flame till the white fumes appeared. The process was further continued for 15 minutes and the flame was turned to full for two minutes. When digestion was completed, the liquid became colourless. Finally, volume was made to 100 ml with hot water and stored in bottles.

Determination of Iron

For this method, the potassium thio-cynate method (Piper, 1951) was used. 10 ml of the tri-acid extract was transferred to a separatory funnel. One drop of nitric acid was added, 35 ml of the water and 10 ml of amyl alcohol was added accurately. Then 5 ml of potassium thiocynate (20 per cent) was added and the funnel was shaken vigoureusly to extract the ferric thiocynate into amyl alcohol phase. When the supernalent amyl alcohol layer was clear, it was transferred to colorimetric tube and the reading was taken on colorimeter using green filter No. 54 (Wratten No. 54).

Standard curve was prepared by taking Analar grade ferrous sulphate.

Determination of Copper (Piper, 1951)

5 ml aliquot of the tri-acid digest was transferred to 100 ml beaker, 2 gms of citric acid was added, dissolved and a piece of litmus paper (red) was added. Then 1 : 1 ammonia solution was added till the content of beaker was just

alkaline. After adding 70 ml of water, the contents were transferred to separatory funnel. To the funnel, 10 ml of 0.25 per cent solution of sodium diethyl dithio carbamate was added. To the funnel, 5 ml of carbon tetra chloride (CCl_4) was poured and shaken well. The yellow colour was extracted in 25 ml volumetric flask. This was repeated till no yellow colour could develop. The volume was made to - 25 ml and reading was recorded on colorimeter by using blue filter (Wratten No. 49).

Manganese

The method given by Piper (1951) was used. 5 ml aliquot of the tri-acid was evaporated on water bath in a silica dish. 10 ml of 1 : 1 sulphuric acid was added to the dish and again kept on water bath for 10 to 15 minutes. Then the silica dish was transferred to sand bath till white fumes appeared. It was cooled and 2 ml of ortho phosphoric acid and a pinch of potassium periodide were added. After adding some water, the dish was kept on water bath for half an hour till the development of pink colour. The dish was removed, cooled and the supernatent liquid transferred to 100 ml volumetric flask, volume made to mark and reading was taken using green filter No. 54.

Boron

Boron was estimated by carmin method as outlined by John

T. Hatcher and L.V. Willcox.

2 gm of plant sample was weighed and transferred to a silica dish. To it, 0.2 gm of calciumoxide was added and mixed well, ignited well on a burner, cooled and moistened with water covered with watch glass. 6 ml of 6 N hydrochloric acid was introduced to make the solution strongly acidic. The dish was kept on the hot water bath for about half an hour, filtered and volume made to 50 ml.

2 ml of the above filtrate was taken in a boron free conical flask, two drops of water and 10 ml of pure concentrated sulphuric acid (Sp. gr. 1.84) were added, cooled and 10 ml of carmin solution added, mixed well and allowed to stand for 45 minutes for colour development. The reading was recorded on colorimeter using 600 mμ red filter.

Soil Analysis

Physical Properties of Soil.

1) Moisture :

It was estimated by dehydrating 5 gm of the soil at 105° C. in an oven for six hours and the percentage was worked out by loss in weight.

2) Mechanical Analysis :

It was carried out by Beaker method outlined by Piper (1951).

The ingredients estimated were coarse sand, fine sand, silt and clay.

10 gm of the soil was treated with hydrogen perioxide (6 per cent) for destroying organic matter. It was treated with 2 N hydrochloric acid. The coarse sand, fine sant, silt and clay were estimated by passing through 70 mm sieve after sedimentation.

Chemical Analysis

1) Total nitrogen :

The total nitrogen was estimated by Kjeldahl's method given by Piper (1951).

2) Available phosphoreus :

The method outlined by Bray (ammonium sulphate buffer method) was used.

3) Available K_2O :

Available K_2O was determined by VOLK and Troug (1934) method using neutral ammonium acetate as an extrastant. The readings were recorded from the extract on Perkin Elma falme photometer.

4) Exchangeable calcium and magnesium :

Estimated by ethylene diamine tertra acetic acid titration method.

5) pH : pH was measured by Beckman's pH meter.

The statistical methods employed were as suggested by Cox and Cocharen (1957).

Citrus

Two sets of mosambi plants (<u>Citrus sinensis</u>, Osbeck) were selected one each in declining condition and apparently healthy ones.

Six trees were used in each case. The healthy trees were selected from a cultivator's farm at Khed-Shivapur (Poona) and the declining trees from a private garden in Poona were used.

The trees were given fertiliser treatments as follows in both the groups :

1) Nitrogen + Phosphorous + Potassium
2) Nitrogen + Phosphorous
3) Nitrogen alone

In addition, two more trees in the healthy group were used as control. The trees received the normal cultivators' manurial treatments consisting of application of farm yard manure.

The area was divided into three blocks in case of declining trees and four blocks in case of healthy trees. Each block consists of two trees.

N was applied at the rate of 0.45 Kg per plant, 50 per cent of which was given as urea and the remaining in the form of Suphala, a complex fertiliser containing N and P in the proportion of 20 : 20.

The phosphorous was applied at the rate of 0.22 kg per

per plant as Suphala and potassium was applied at the rate of 0.11 kg per plant in the form of sulphate of potash.

The control treatment consisted of the dose normally given by the cultivators, i.e. 15 kgs of F.Y.M. per plant.

The doses were applied twice in January and June, 1969. In addition to the above treatments, foliar application of urea and micro nutrients was superimposed on declining trees. The sprays were given as detailed below :

1) Zinc sulphate	2.25 kgs
2) Copper sulphate	0.45 kgs
3) Magnesium sulphate	1.36 kgs
4) Ferrous sulphate	1.76 kgs
5) Boric acid	0.45 kgs
6) Urea	4.50 kgs
7) Lime	4.95 kgs
8) Water	460 litres

The above spray was given each month from February 1969 to June 1969.

Soil Analysis

Soil samples were collected in the month of December, 1968 (i.e. prior to the application of fertilisers and sprays) from the rootzone of the trees to the depth of about 60 cms. The samples were collected with the help of screw auger from both the gardens. They were dried under shade and ground in mortar with pestle and stored in bottles.

For estimation, the Olsen's colorimetric method (Olsen *et.al.* 1914) was used.

Leaf Analysis

1) Sampling technique :

Matured leaves of about 3 to 5 months' old from all round the tree crown within 3 to 6' from ground level were collected between 7.30 to 11.30 A.M. in specially prepared brown paper bags. Young and very old leaves as recognised by feel, appearance and texture were excluded as well as the leaves infected by insects. Sampling was carried out regardless of leaf symptoms such as mottling, yellowing etc. - Petioles were included in the samples and were treated along with blade as one unit. About 10 to 15 leaves were collected from each tree.

2) Sampling interval :

The leaves were sampled prior to treatment in December 1966, and every two months from April to August 1969.

3) Treatment to leaves :

Similar method as prescribed for mango was adapted.

4) Estimation :

Following major and minor elements were estimated :

Major	Minor
Nitrogen	Iron
Phosphorous	Manganese
Potassium	Boron
Calcium	Copper
Magnesium	

The methods used for estimation of macro and micro elements were the same described for mango.

CHAPTER IV

RESULTS AND DISCUSSION

a) Nutrient status of the trees in Mango manurial experiment

The data in regard to nutrient element status of the trees under manurial experiment at Vengurla is presented and discussed here under :

Nitrogen application

i) Effect of nitrogen application on the uptake of nitrogen

From the data in Table 1.4, it is observed that the mean nitrogen percentages in the leaves have not differed due to differing levels of nitrogen applications in the leaf samples collected in May 1969. However, in the leaf samples collected in November 1969 as seen from the data in Table 1.10, the leaf N status has significantly increased with the increased applications of nitrogenous fertilizer. 1.36 kg N dose has recorded 2.10 per cent leaf N as against 1.91 per cent at 0.68 kg N application.

The leaf N status is considerably lower in samples collected in May than in those sampled in November 1969.

ii) Effect of nitrogen applications on the uptake of other major nutrients :

The data in Tables 2.4, 3.4, 4.4 and 5.4 show that the nutrient status in respect of P, K, Ca and Mg has not been influenced significantly due to differing levels of N application during May 1969. However, the K status has substantially increased and Ca status substantially decreased with higher nitrogen application. It is seen from the data in Tables 2.10, 3.10, 4.10 and 5.10 that in November 1969 the uptake of P, K and Ca has been influenced significantly by the varying N levels of application, while the leaf Mg status has not differed significantly.

The leaf P content has increased significantly with increased doses of N application. The highest uptake of P is observed at 1.36 kg N application. However, it is observed that the leaf P status has decreased as compared to its status in May.

It is also observed that the leaf K content has decreased significantly with increased level of N application. The leaf K content is observed to be lower at the higher level of N application. The K content of the leaves has decreased in November in comparison to leaf K status in May 1969.

The leaf Ca content is higher at 1.36 kg N level, while it is lower at 0.68 kg N application. It seems that the leaf Ca content has increased at the higher dose of N during November 1969. Further, the leaf Ca status is much higher in November than in May.

Though the Mg content has not been influenced by leaf

leaf N status, it is observed that the leaf samples collected during May contained less Mg than that of November samples.

iii) Effect of Nitrogen application on the uptake of micro-nutrients :

The data in Tables 6.4, 6.10, 7.4, 7.10, 8.4, 8.10 and 9.4, 9.10 indicate that during May and November 1969 samples, the uptake of various minor elements such as copper, iron, boron and manganese has not been influenced significantly due to differing levels of N applications. However, the Cu and Mn status has increased substantially in the presence of higher N.

It is observed that the leaf Cu and Mn status is higher in November samples than in May, while leaf Fe and B status is lower in November than in May.

Uptake of Nitrogen

From the significant results obtained in respect of N content of leaves, it is evident that the leaf N has increased with higher dose of nitrogenous fertiliser. These observations agree with those reported by Sen, Roy and De (1947) in mango, Smith and Rasmussen (1962) in grape fruit, Jones and Embleton (1968) in Washington Naval orange, who observed that when nitrogen applications were increased, the uptake of N also increased.

The present experiment is conducted on the lateritic soils which are porous and having a very low pH. The data in respect of chemical constituents of the soil (given in Appendix I) shows that the soils are fairly well supplied with nitrogen but due to the high rainfall of about 2,776 mm. per annum and porous nature of soils, the nutrients are liable to leach heavily beyond the root zone of the plants. In the circumstances, increased application of N appears to have permitted better uptake of the element.

The significant higher uptake of N during November 1969 as compared to uptake in May 1969 seems to be logical inasmuchas the fertilisers were applied in September, i.e. just two months prior to the sampling of leaves in November 1969.

It is well known that nitrogen is responsible for vegetative growth and growth of fruits. It is also required in adequate quantities for fruit bud differentiation. The nitrogen applied in September seems to have had beneficial effect in fruit bud formation and also seems to have been utilised in the production of vegetative shoots during the October-November period. Phadnis and Sawant (1969) have reported that Alphanso mango trees under Vengurla conditions make maximum vegetative growth in October-November period. Besides, the N also seems to have been used for the development of fruit so that in May, the N content of the trees seems to have been depleted by this usage. It is, therefore, natural to expect a lower N status in May. Similar results were -

obtained by Zidan et.al.(1968), who observed increased leaf N during winter months and decreased level in spring and summer flush in Alphanso and Pairi varieties of mango.

The leaf N status ranges from 1.70 to 1.71 per cent in May and 1.91 to 2.10 per cent leaf N in November. The observed values of leaf N content in May and November are higher than 1.54 per cent leaf N reported by Smith and Scudder (1947). Young, Koo and Miner (1961) have observed 1.35 per cent leaf N as optimum and Sen et.al. (1947) have reported 1.82 per cent leaf N. It appears from the above that leaf N status appears to be optimum for Alphanso mango under local conditions even at lower levels of application for nitrogenous fertiliser.

This is supported by the performance of trees in respect of growth and fruiting. The data presented in Appendix III reveals that there are no significant difference between the two levels of N employed. It, therefore, appears that the lower level of N is quite adequate.

Uptake of Phosphoreus

The significant increase obtained in respect of P content of leaves in the presence of higher levels of nitrogenous fertiliser shows that leaf P is associated with the uptake of nitrogen. These observations are in agreement with those of Embleton et.al. (1958) who obtained increased leaf P content with increasing doses of nitrogenous fertiliser in Avocado. Heymann and Hershberg (1956) have also obtained similar results in citrus. It is observed that the leaf P content is high in the leaf samples collected in May 1969 than in leaf samples collected in November 1969. This is to be expected since phosphatic fertilisers added to the soils get converted into more complex forms and are not made readily available to plants and they are absorbed slowly. It, therefore, appears that the phosphatic fertilisers applied in September 1968 might have been built up slowly in the plants which has reflected in high leaf P status in May 1969. As against this in November 1969, as the phosphatic fertiliser was applied just two months prior to sampling, it would be reasonable to assume that the element was not readily absorbed by the plants and hence the low P status in November samples.

Uptake of Potassium

It is evident from the significant results obtained in respect of K status at different levels of N application that the leaf K has decreased significantly with higher dose of N applications.

Similar decrease in leaf K with increased application of N was observed by Lockard and Asomaning (1964) in Cacao, Smith and Rasmussen (1962) in grape fruit and Kumashiro (1965) in pear

It is also quite probable that due to higher uptake of Ca with increased application of N, the leaf K content might have been depressed due to antagonistic effects between K and Ca.

Fudge (1945) has reported that in citrus the leaf K content was strongly depressed by Calcium.

From the results, it is seen that the leaf K status is higher in May than in November 1969. This may be due to the slow availability of K.

The potashic fertilizers are not rapidly absorbed by the plants due to their complex forming nature with soil particles and, therefore, they are slowly taken up by the plants.

This may explain the high K content in leaves in May as compared to November 1969.

Uptake of Calcium

The observed increase in Ca with increased dose of nitrogen is in accordance with the report of Beeftink et.al. (1962) who obtained increasing leaf Ca content with increasing applications of nitrogen in citrus.

It is seen from the data in Table 4.10 that there is no increased uptake of Ca in liming treatment and that the increased dose of N alone has resulted in better uptake of Ca. It would thus appear that the uptake of Ca is associated with the uptake of N.

Uptake of other elements

It is observed from the non-significant differences in respect of other elements both major and minor, that in the presence of differing levels of N application and N uptake, the uptake of these elements is not affected by the N status. However, it is observed that the leaf Cu and Mn contents have increased substantially with higher dose of N. It is probable that the leaf N content might have been in some sort of association with Mn and Cu. As the leaf N status has increased in November, the leaf B and Fe have decreased whereas when the leaf N in May is lower the leaf Fe and B contents are slightly higher.

The leaf Ca and P has increased with higher leaf N. This high leaf Ca and P at higher leaf N levels might have depressed the uptake of B and Fe.

Chapman (1961) has reported low leaf B along with other elements due to high P content. Similarly, Bingham (1963) has also reported low B with high leaf P in citrus Ljones (1963) have reported low B due to calcium nitrate application in apple.

Phosphorous Application

a) Effect of phosphorous application on the uptake of phosphorous :

The perusal of the data in Table 2.2 shows that the differenced in the mean phosphorous content in the leaves due to various levels of P is not significant in the leaf samples collected during May 1969. However, it is seen from the data in Table 2.8 that in the leaf samples collected in November 1969, the mean phosphorous percentages due to various levels of P application are significant. 1.36 kg P treatment has recorded significantly more uptake of P than 0.68 kg P treatment and No P treatment. In the same manner, 0.68 kg P application has recorded significantly more P status over 0.0 kg P treatment. Thus, it appears that the leaf P content has increased in linear order with increased P application.

The leaf P content is observed to be higher in May samples than in November samples.

b) Effect of phosphorous applications on the uptake of other major elements :

The data in Tables 1.2, 1.8, 3.2, 3.8, 4.2, 4.8 and 5.2, 5.8 show that the nutrient status in respect of N, K, Ca and Mg. have not been influenced significantly due to varying levels of P applications in the leaf samples collected in May 1969 as well as in November 1969.

However, the calcium and nitrogen content has shown a trend towards increase with increased applications of P, while the uptake of K and Mg has shown a decreasing trend.

c) Effect of phosphorous applications on the uptake of minor elements :

From the data in Tables 6.2, 6.8, 7.2, 7.8, 8.2, 8.8

and 9.2, 9.8, it is observed that the differences in the mean content of copper, iron, boron and manganese has not differed due to differing levels of P applications in the leaf samples collected in May and November 1969.

However, B is the only element whose uptake has been significantly affected with varying levels of P applications as noticed from the data in Table 8.8 in November samples.

The leaf B uptake has significantly decreased with - increasing levels of P applications. Highest B status is observed at 0.0 kg P application whereas it is significantly lowest at 0.68 kg and 1.36 kg P applications.

Uptake of Phosphoreous

The significant results obtained in respect of P content of leaves due to differing applications of P show that increased application of P results in better uptake of the element. These results are in agreement with those of Embleton (1958) in Avocado, Kumashiro (1965) in Pears, Mirza and Khalidy (1964) in Banana, who obtained increasing leaf P content with increasing applications of P fertilisers.

The chemical analysis data (given in Appendix I) shows that the soils on which the present experiment was laid out are deficient in P due to porosity, high acidic reaction and high precipitation. Thus, the significant response obtained by the application of phosphatic fertiliser seems logical.

The increased P status observed in May as compared to November, though the fertiliser was applied in September appears to be due to slow availability of the nutrient and its gradual uptake and build up in the plant.

From the growth and yield data (given in Appendix III), it is observed that there are no significant differences in the performance of trees under various levels of P application. This would lead one to believe that even without applying phosphorous the same results could be had. Further, the leaf P status in the absence of application of phosphatic fertiliser is quite high. It is observed that the leaf P status at 0.0 kg P treatment is 0.19 per cent in November and 0.31 per cent in May which is higher than 0.128 per cent reported by Sen et.al. (1947). It appears that the optimum leaf P level is reached in the absence of phosphatic fertilisers. A perusal of data in Table 2.8 shows that the uptake of P in the absence of phosphatic fertilisers and in the presence of FYM has considerably increased. Similarly, in the presence of phosphatic fertilisers also, the P uptake has increased in the presence of FYM. This would indicate that probably FYM supplied adequate P even though phosphatic fertiliser has not been applied.

Uptake of Boron

It is observed from the significant results in respect of B content of leaves due to varying levels of P, that the leaf B content is depressed with increasing application of phosphorous. These results agree with those of Bingham (1963) who observed depressed intake of B in citrus with increasing application of P. The antagonistic effect of P with some micro-nutrients is well known. Nagpal (1963) has reported that various types of malnutrition symptoms in citrus were associated with excess K and P. Phadnis and Divate (1967) have noticed that high P induces certain disorders like mottling symptoms of leaves and consequent water berry symptoms in grape, probably due to depressed intake of Fe and Zn.

Uptake of other elements

The non-significant differences in respect of uptake of other major and minor elements in the presence of differing levels of P application shows that uptake of other elements is not significantly influenced by the P status of the plants.

Potassium Application

a) Effect of potassium applications on the uptake of potassium :

The data in Table 3.1 shows that the uptake of K due to differing doses of potassium has not been influenced significantly in the leaves collected in May 1969. But it is observed from the data in Table 3.7 that the leaf K status in November

1969 due to differing levels of potassium though not differing significantly has somewhat depressed with increased application of K. The leaf K status, in general, is more in May than in November.

b) Effect of Potassium applications on the uptake of other major elements :

The data in Tables 1.1, 2.1, 4.1 and 5.1 indicate that the uptake of N, P, Ca and Mg due to varying levels of K application is not significantly affected in the leaf samples collected in May 1969.

The data in Tables 1.7, 2.7, 4.7 and 5.7 show that the uptake of N, P, Ca and Mg due to varying levels of K application has not likewise been influenced significantly in the samples collected in November 1969.

Leaf N, Ca and Mg has been observed to be somewhat depressed due to increased application of K, while P has slightly increased with increasing doses of K in the samples collected in November 1969.

c) Effect of Potassium application on the uptake of micro-elements :

A persual of the data in Tables 6.1, 6.7, 7.1, 7.7, 8.1, 8.7 and 9.1, 9.7 show that during May 1969 and November 1969 samples, there is no significant difference in the uptake of various minor elements such as Fe, Cu, B and Mn due to varying levels of potassium applications.

Uptake of K

From the results in the mean percentage of potassium due to differing levels of K, it is observed that the K uptake is more in May samples than in November samples. The K content ranges from 1.92 per cent to 2.32 per cent in May and 1.08 to 1.26 per cent in November. Even so, it is higher than the level of 1.0 per cent reported for normal mango tree by Smith and Scudder (1951). This would indicate that though K supply from the soils is not satisfactory, yet the K status of plants even in the absence of potasic fertilisers is quite adequate.

This again seems to have resulted due to FYM. A perusal of the data in Table 3.5 reveals that the K uptake in the absence of potasic fertilisers but in the presence of FYM has increased considerably. The adequate K status as influenced by FYM (even though potasic fertiliser was not applied) seems to have resulted in non-significant differences in the growth and yield of trees in the various potasic treatments.

The observed K content varies from 1.92 per cent to 2.32 per cent which seems to be quite adequate. Sen et.al. (1947) has noticed 0.539 per cent K for field trees and Smith and Scudder (1951) has reported 1 per cent. The observed value of K at both the periods of sampling are higher than the reported.

F.Y.M. Application

a) Effect of F.Y.M. application on the uptake of major elements :

The data in Tables 1.3, 2.3, 3.3, 4.3 and 5.3 indicate that the uptake of various major elements due to differing levels of F.Y.M. is not significantly affected in the samples collected in the month of May 1969. In the samples collected in November 1969, it is seen from the data in Table 2.9 that the leaf P status has significantly increased with increasing applications of F.Y.M. The 45.5 kg F.Y.M. application has recorded 0.22 per cent leaf P as against 0.19 per cent at 0.0 kg F.Y.M. application. There is no significant difference in the leaf content of other elements.

The leaf P content is high in May than in November samples.

Though the data in Table 5.3 shows that the uptake of Mg due to differing levels of F.Y.M. is not significant in the samples collected in May 1969, in the November samples, the leaf Mg content has significantly increased with increased application of F.Y.M. The 45.5 kg F.Y.M. application has recorded 0.77 per cent leaf Mg as against 0.71 per cent Mg in the 0.0 kg F.Y.M. application.

It appears that the leaf Mg has increased substantially with increased F.Y.M. applications during May 1969, while it has shown significant rise with higher doses of F.Y.M. -

application in November 1969 samples.

It is observed that leaf Mg status is low in May than in November.

The data in Tables 1.9, 3.9 and 4.9 indicate that the uptake of N, K and Ca has not been influenced significantly in the leaf samples collected in November due to application of F.Y.M.

b) Effect of F.Y.M. application on the uptake of micro-nutrients :

The data in Tables 6.3, 7.3, 8.3 and 9.3 show that the uptake of various minor elements such as copper, iron, boron and manganese is not significant due to varying levels of F.Y.M. in the samples collected in May 1969. However, it is observed from the data in Tables 6.9, 7.9 and 9.9 that the uptake of various minor elements such as copper, iron and manganese due to F.Y.M. application is likewise not significant. But B is the only element whose uptake has been - influenced significantly due to varying levels of F.Y.M. - application.

The data in Table 8.9 indicates that the high boron status is at 0.0 kg of F.Y.M. application whereas it is low at 45.5 kg F.Y.M. application.

Thus, it appears that the leaf B has decreased with application of F.Y.M. during November 1969, leaf B status is higher in May samples than in November 1969 samples.

Uptake of Phosphorous

It is noticed from the significant results in respect of P content of leaves that the P status has increased with F.Y.M. application. This is but natural as F.Y.M. contains about 0.5 per cent phosphorous and is a good source of the element. As the level of F.Y.M. application is 45.5 kg, about 0.225 kg of P per tree has been supplied and this appears to have reflected in higher P status in the leaves at 45.5 kg F.Y.M. application as compared to 0.0 kg F.Y.M. application.

The higher P content of leaves with F.Y.M. application is in agreement with the finding of Embleton et.al. (1958) who noticed that as the applications of steer manures increased, the leaf P content increased in Avocado.

Uptake of Mg

From the significant results obtained in respect of leaf Mg content, it is observed that the leaf Mg has increased significantly with F.Y.M. dose. As F.Y.M. is a good source of micro-nutrients as reported by Daji and Iyengar (1964), it is natural to obtain higher leaf Mg due to F.Y.M. application.

The leaf Mg ranges from 0.57 percent to 0.77 per cent in May and November, respectively, which appears to be an optimum level. These Mg levels are higher than those reported by Smith and Scudder (1951) and Sen et.al.(1947) who observed 0.26 per cent and 0.137 per cent leaf Mg, respectively.

Uptake of B

The significant results in respect of B content of leaves show that with increasing application of F.Y.M., the B status of the leaves has depressed. This appears to be the result of increased uptake of P which seems to have a depressing effect on the uptake of B. Bingham (1963) has noticed that higher P content reduced the B uptake in citrus. Chapman (1961) has also obtained similar results in the same crop.

It is seen from the growth and yield data that the F.Y.M. dose has not resulted in significantly better growth and yield of plants. This may be due to the reason that the local soils are rich in organic matter and addition of F.Y.M. may, therefore, have a limited value. However, application of F.Y.M. in the absence of phosphatic and potassic fertilisers seems to have had a good effect. It may be safe to assume that in the absence of fertilisers, F.Y.M. gives good results.

Uptake of other elements

The non-significant differences in respect of uptake of other major and minor elements in the presence of F.Y.M. application shows that uptake of other elements is not significantly affected.

Application of lime

a) Effect of liming on the uptake of Calcium

From the data in Tables 4.6 and 4.12, it is observed that Ca uptake due to various levels of lime has not been influenced significantly in the leaf samples collected in May and November 1969.

It is observed that during May and November, the uptake of Ca depressed with increasing dose of liming.

The leaf Ca status is high in November samples than in May samples.

b) Effect of lime application on the uptake of other major nutrient elements

The data in Table 2.6 indicate that the mean percentage of P in the leaves is not significant, due to lime application in the samples collected in May 1969. Similarly in November, 1969, samples, no significant differences in the uptake of major elements was observed as seen from the data in Tables 1.12, 2.12, 3.12 and 5.12 except in P, where in the mean percentage of the element in the leaves which differed significantly due to liming treatment.

It is observed that liming treatment has recorded significantly high P content as against no lime treatment.

P status is more in the leaves collected in May whereas it is less in leaves collected in November 1969.

e) Effect of lime on the uptake of minor elements

The data in Tables 6.6, 7.6, 8.6 and 9.6 show that the difference in the mean content of Cu, Fe, B and Mn due to lime application is not significant in leaf samples collected in May 1969. However, the data in Tables 6.12, 8.12 and 9.12 indicate that the uptake of various minor elements such as Cu, B and Mn due to lime application is significant. While the data in Table 7.12 shows that the iron is the only minor element whose uptake has not been affected significantly due to differing levels of lime application in the leaf samples collected in November 1969.

The data in Tables 6.12, 8.12 and 9.12 show that the uptake of Copper and Mn has significantly decreased whereas the B uptake has increased significantly by liming.

Uptake of Calcium

The non-significant results obtained in respect of uptake of Ca shows that the leaf Ca status is not materially affected by liming.

From the growth and yield data (Appendix II), it is observed that the liming has not resulted in significant - difference. Liming was being carried out with the objective of increasing the pH. This seems to have been achieved as seen from the general increase in pH of the soil.

The leaf Ca contents which varies from 2.27 per cent to 2.63 per cent in November and from 1.64 per cent to 1.94 per cent in May compares well with the figures of Sen et.al. (1947) who have reported 1.89 per cent Ca for field trees.

Uptake of Phosphorous

It is observed from the significant results obtained in respect of P content of leaves that the leaf P has increased with liming treatment at the higher level of P. The increase in pH, as a result of liming, seems to have helped in better uptake of P.

Uptake of minor elements

From the significant results noticed, it is seen that Cu and Mn content of leaves has decreased with liming whereas that of B has increased. Chapman (1961) has stated that at pH 5.0 or below the availability of B is difficult, whereas there is every possibility of toxicity of Mn and other elements. It is seen from the soil pH value data that due to liming, pH has increased and it is probable that due to this increase, the availability of B might have improved, whereas that of Mn might have decreased. The decrease in Mn content due to liming is in agreement with those obtained by Fuick (1964), who reported that Ca application not only reduced Mn absorption but also causes its retention in the roots. He further states that application of calcium hydroxide to soils at the rates equivalent to 4 tons of calcium carbonate per acre reduced Mn availability in apple. Lockard (1964) has also obtained similar results in Cacao.

The decreased Cu uptake with liming may have been influenced by the increased P uptake. Spencer (1966) has reported that in citrus, high P levels reduced the uptake of Cu. Bingham (1963) has also reported that in citrus increasing P reduced leaf content of Cu and Mn.

Uptake of other elements

From the non-significant differences in respect of other major and minor elements, it is observed that uptake of other major and minor elements has not been significantly influenced by the application of lime.

Effect of liming on the pH

It is observed from the soil pH data (Appendix IV) that before applying the lime to the soils, the average pH of the soil was 4.2 in the year 1965. The liming carried out throughout the years has helped to increase the average pH to 5.7. There has been a gradual increase to 4.7 in 1967 and to 6.7 in 1968. A slight decrease in 1969 to 5.7 is due to the liming not being carried out in 1968.

It, therefore, appears that liming helps to increase the pH which in turn influences better uptake of elements like P and B.

From the above results, it would, in general, seem that the nitrogen and phosphorous status of the trees increases with each additional dose of nutrient applied (in the form of fertiliser), but there seems to be a decrease in leaf K with additional dose of potassium. Further with F.Y.M. application, the N, P, K, Ca and Mg status of the tree has increased. In all, these cases, the increased consumption of nutrients at higher applications of fertilisers have not reflected in increased yields and, therefore, the increased uptake appears to be a case of unnecessary consumption and the~~i~~re appears to be no need for higher levels of fertilisers.

The application of F.Y.M. seems to have provided the necessary nutrients and additional applications of phosphatic and potassic fertilisers also do not seem to be necessary, when F.Y.M. is provided. Liming seems to be beneficial in raising the pH and in increasing the availability of nutrients.

MEAN NITROGEN PERCENTAGE IN THE LEAVES OF MANGO, MAY, 1969, SAMPLES.

Table 1.1

N/K	0	1	2
1	1.69	1.66	1.75
2	1.73	1.72	1.67
Mean	1.70	1.69	1.72

Table 1.2

F/P	0	1	2
0	1.64	1.69	1.68
1	1.74	1.78	1.70
Mean	1.69	1.73	1.69

Table 1.3

N/P	0	1	-
1	1.67	1.73	-
2	1.67	1.75	-
Mean	1.67	1.74	-

Table 1.4

L/N	1	2	-
L_0	1.69	1.70	-
L_1	1.70	1.71	-
Mean	1.70	1.71	-

Table 1.5

F/K	0	1	2
0	1.68	1.64	1.68
1	1.73	1.74	1.75
Mean	1.70	1.69	1.72

Table 1.6

F/L	L_0	L_1	-
F_0	1.66	1.68	-
F_1	1.74	1.74	-
Mean	1.70	1.71	-

		S.E.	C.D.	Sig.
N, F.Y.M.	..	0.025	-	N.S.
P, K	..	0.030	-	N.S.
Lime	..	0.022	-	N.S.

MEAN NITROGEN PERCENTAGE IN THE LEAVES OF MANGO, NOVEMBER, 1969 SAMPLES

Table 1.7

N/K	0	1	2
1	1.95	1.91	1.88
2	2.15	2.07	2.08
Mean	2.05	1.99	1.97

Table 1.8

F/P	0	1	2
0	1.95	2.01	2.00
1	2.00	2.03	2.05
Mean	1.98	2.02	2.03

Table 1.9

N/F	0	1	-
1	1.92	1.91	-
2	2.06	2.14	-
Mean	1.99	2.03	-

Table 1.10

L/N	1	2	-
L_0	1.88	2.16	-
L_1	1.95	2.05	-
Mean	1.91	2.10	-

Table 1.11

F/K	0	1	2
0	1.99	2.00	1.98
1	2.11	1.99	1.96
Mean	2.05	1.99	1.97

Table 1.12

F/L	L_0	L_1	-
F_0	1.99	1.99	-
F_1	2.04	2.01	-
Mean	2.02	2.00	-

		S.E.	C.D.	Sig.
N, F.Y.M.	..	0.022	0.066	Sig. N
P, K	..	0.027	-	N.S.
Lime	..	0.023	-	N.S.

MEAN PERCENTAGE OF P IN THE LEAVES OF MANGO, MAY, 1969.

Table 2.1

N/K	0	1	2
1	0.32	0.32	0.31
2	0.30	0.29	0.23
Mean	0.31	0.30	0.27

Table 2.2

F/P	0	1	2
0	0.31	0.27	0.34
1	0.31	0.26	0.30
Mean	0.31	0.26	0.32

Table 2.3

N/F	0	1	-
1	0.30	0.34	-
2	0.31	0.24	-
Mean	0.31	0.29	-

Table 2.4

L/N	1	2	-
L_0	0.32	0.28	-
L_1	0.31	0.28	-
Mean	0.32	0.28	-

Table 2.5

F/K	0	1	2
0	0.32	0.34	0.26
1	0.30	0.28	0.29
Mean	0.31	0.30	0.27

Table 2.6

F/L	L_0	L_1	-
F_0	0.32	0.29	-
F_1	0.28	0.30	-
Mean	0.30	0.29	-

		S.E.	C.D.	Sig.
N, F.Y.M.	..	0.027	-	N.S.
P, K	..	0.033	-	N.S.
Lime	..	0.024	-	N.S.

MEAN PERCENTAGE OF P IN THE LEAVES OF MANGO, NOVEMBER, 1969.

Table 2.7

N/K	0	1	2
1	0.19	0.20	0.19
2	0.21	0.22	0.23
Mean	0.20	0.21	0.21

Table 2.8

F/P	0	1	2
0	0.17	0.19	0.21
1	0.21	0.23	0.23
Mean	0.19	0.21	0.22

Table 2.9

N/F	0	1	-
1	0.18	0.20	-
2	0.20	0.24	-
Mean	0.19	0.22	-

Table 2.10

L/N	1	2	-
L_0	0.19	0.21	-
L_1	0.21	0.23	-
Mean	0.19	0.22	-

Table 2.11

F/K	0	1	2
0	0.18	0.19	0.21
1	0.23	0.23	0.21
Mean	0.20	0.21	0.21

Table 2.12

F/L	L_0	L_1	-
F_0	0.18	0.20	-
F_1	0.21	0.23	-
Mean	0.20	0.22	-

		S.E.	C.D.	Sig.
N, F.Y.M.	...	0.0033	0.0098	Sig. N, FYM
P, K	...	0.0040	0.011	Sig. P
Lime	...	0.0044	0.013	Sig. L

MEAN PERCENTAGE OF K IN THE LEAVES OF MANGO, MAY, 1969.

Table 3.1

N/K	0	1	2
1	2.00	2.13	1.83
2	1.84	2.52	2.57
Mean	1.92	2.32	2.20

Table 3.2

P/K	0	1	2
0	2.29	1.58	2.17
1	2.23	2.44	2.17
Mean	2.26	2.02	2.17

Table 3.3

N/F	0	1	-
1	2.05	1.92	-
2	1.98	2.64	-
Mean	2.02	2.28	-

Table 3.4

L/N	1	2	-
L_0	1.56	2.28	-
L_1	2.41	2.34	-
Mean	1.99	2.31	-

Table 2.5

F/K	0	1	2
0	1.77	1.96	2.32
1	2.07	2.68	2.09
Mean	1.92	2.32	2.20

Table 3.6

F/L	L_0	L_1	-
0	1.85	2.18	-
1	1.99	2.57	-
Mean	1.92	2.38	-

		S.E.	C.D.	Sig.
N, F.Y.M.	..	0.250	-	N.S.
P, K	..	0.307	-	N.S.
Lime	..	0.174	-	N.S.

MEAN PERCENTAGE OF K IN THE LEAVES OF MANGO, NOVEMBER, 1969.

Table 3.7

N/K	0	1	2
1	1.65	1.18	1.12
2	0.87	1.09	1.03
Mean	1.26	1.14	1.08

Table 3.8

F/P	0	1	2
0	1.31	1.29	1.14
1	1.06	1.05	1.16
Mean	1.16	1.17	1.15

Table 3.9

N/F	0	1	-
1	1.46	1.17	-
2	1.03	0.97	-
Mean	1.25	1.07	-

Table 3.10

L/N	1	2	-
L_0	1.27	1.07	-
L_1	1.36	0.93	-
Mean	1.32	1.00	-

Table 3.11

F/K	0	1	2
0	1.22	1.32	1.20
1	1.30	0.95	0.95
Mean	1.26	1.14	1.08

Table 3.12

F/L	L_0	L_1	-
0	1.24	1.26	-
1	1.10	1.04	-
Mean	1.17	1.15	-

		S.E.	C.D.	Sig.
N, F.Y.M.	..	0.063	0.248	Sig. N
P, K	..	0.1010	-	N.S.
Lime	..	0.081	-	N.S.

MEAN PERCENTAGE OF CALCIUM IN THE LEAVES OF MANGO, MAY, 1969 SAMPLES

Table 4.1

N/K	0	1	2
1	1.74	1.91	2.14
2	1.67	1.84	1.68
Mean	1.70	1.87	1.91

Table 4.2

F/P	0	1	2
0	1.67	1.80	1.91
1	1.75	1.90	1.96
Mean	1.71	1.85	1.92

Table 4.3

N/F	0	L_1	-
1	1.91	1.95	-
2	1.68	1.77	-
Mean	1.80	1.86	-

Table 4.4

L/N	1	2	-
L_0	1.94	1.82	-
L_1	1.92	1.64	-
Mean	1.93	1.73	-

Table 4.5

F/K	0	1	2
0	1.74	1.69	1.95
1	1.67	2.05	1.86
Mean	1.70	1.87	1.91

Table 4.6

F/L	L_0	L_1	-
0	1.85	1.74	-
1	1.91	1.81	-
Mean	1.88	1.78	-

		S.E.	C.D.	Sig.
N, F.Y.M.	..	0.1034	-	N.S.
P, K	..	0.1267	-	N.S.
Lime	..	0.0701	-	N.S.

MEAN PERCENTAGE OF CALCIUM IN THE LEAVES OF MANGO, NOVEMBER, 1969, SAMPLES

Table 4.7

N/K	0	1	2
1	2.36	2.39	2.19
2	2.73	2.44	2.48
Mean	2.55	2.42	2.33

Table 4.8

F/P	0	1	2
0	2.25	2.47	2.41
1	2.47	2.44	2.54
Mean	2.36	2.45	2.47

Table 4.9

N/F	0	1	-
1	2.28	2.35	-
2	2.48	2.62	-
Mean	2.38	2.48	-

Table 4.10

L/N	1	2	-
L_0	2.34	2.63	-
L_1	2.27	2.46	-
Mean	2.31	2.55	-

Table 4.11

F/K	0	1	2
0	2.53	2.39	2.21
1	2.56	2.44	2.45
Mean	2.55	2.42	2.23

Table 4.12

F/L	L_0	L_1	-
0	2.35	2.41	-
1	2.64	2.32	-
Mean	2.50	2.37	-

		S.E.	C.D.	Sig.
N, F.Y.M.	..	0.067	0.2024	Sig. N
P, K	..	0.0828	-	N.S.
Lime	..	0.0503	-	N.S.

MEAN PERCENTAGE OF MAGNESIUM IN THE LEAVES OF MANGO, , 1969 SAMPLES.

Table 5.1

N/K	0	1	2
1	0.56	0.56	0.55
2	0.53	0.59	0.54
Mean	0.54	0.58	0.55

Table 5.2

F/P	0	1	2
0	0.55	0.52	0.57
1	0.57	0.56	0.56
Mean	0.57	0.54	0.56

Table 5.3

N/F	0	1	-
1	0.52	0.60	-
2	0.57	0.54	-
Mean	0.54	0.57	-

Table 5.4

L/N	1	2	-
L_0	0.60	0.56	-
L_1	0.52	0.55	-
Mean	0.56	0.55	-

Table 5.5

F/K	0	1	2
0	0.52	0.59	0.52
1	0.57	0.56	0.57
Mean	0.54	0.58	0.55

Table 5.6

F/L	L_0	L_1	-
0	0.56	0.53	-
1	0.60	0.54	-
Mean	0.58	0.53	-

		S.E.	C.D.	Sig.
N, F.Y.M.	..	0.023	-	N.S.
P, K	..	0.028	-	N.S.
Lime	..	0.020	-	N.S.

MEAN PERCENTAGE OF MAGNESIUM IN THE LEAVES OF MANGO, NOVEMBER, 1969, SAMPLES

Table 5.7

N/K	0	1	2
1	0.75	0.75	0.75
2	0.77	0.70	0.69
Mean	0.76	0.73	0.73

Table 5.8

F/P	0	1	2
0	0.70	0.69	0.72
1	0.83	0.78	0.71
Mean	0.77	0.73	0.72

Table 5.9

N/F	0	1	-
66866	0.73	0.77	-
2	0.68	0.77	-
Mean	0.71	0.77	-

Table 5.10

L/N	1	2	-
L_o	0.79	0.69	-
L_1	0.71	0.76	-
Mean	0.75	0.73	-

Table 5.11

F/K	0	1	2
0	0.73	0.67	0.71
1	0.79	0.78	0.74
Mean	0.76	0.73	0.73

Table 5.12

F/L	L_o	L_1	-
0	0.69	0.72	-
1	0.79	0.75	-
Mean	0.74	0.74	-

		S.E.	C.D.	Sig.
N, F.Y.M.	..	0.0179	0.0535	Sig. FYM
P, K	..	0.022	-	N.S.
Lime	..	0.0243	-	N.S.

MEAN PPM OF COPPER IN THE LEAVES OF MANGO, MAY, 1969 SAMPLES

Table 6.1

N/K	0	1	2
1	28.7	37.3	23.6
2	30.8	29.2	33.5
Mean	29.8	38.2	28.5

Table 6.2

F/P	0	1	2
0	29.8	26.4	44.6
1	31.1	29.6	31.6
Mean	30.5	28.0	38.1

Table 6.3

N/F	0	1	-
0	29.4	30.3	-
2	37.8	31.3	-
Mean	33.6	30.8	-

Table 6.4

L/N	1	2	-
L_0	27.5	32.4	-
L_1	32.2	36.6	-
Mean	29.9	34.5	-

Table 6.5

F/K	0	1	2
0	26.6	49.8	24.3
1	32.9	26.7	32.7
Mean	29.8	38.2	28.5

Table 6.6

F/L	L_0	L_1	-
0	33.7	33.5	-
1	26.2	35.3	-
Mean	30.0	34.4	-

		S.E.	C.D.	Sig.
N, F.Y.M.	...	3.25	-	N.S.
P, K	...	3.98	-	N.S.
Lime	...	3.20	-	N.S.

MEAN PPM OF COPPER IN THE LEAVES OF MANGO, NOVEMBER, 1969 SAMPLES

Table 6.7

N/K	0	1	2
1	43.33	47.82	27.92
2	39.17	43.75	40.42
Mean	41.25	45.83	34.17

Table 6.8

F/P	0	1	2
0	41.25	38.33	32.50
1	40.00	50.83	39.58
Mean	40.62	44.58	36.04

Table 6.9

N/F	0	1	-
1	47.22	32.22	-
2	27.50	54.72	-
Mean	37.36	43.47	-

Table 6.10

L/N	1	2	-
L_0	35.28	59.17	-
L_1	44.17	23.06	-
Mean	39.72	41.11	-

Table 6.11

F/K	0	1	-
0	34.17	42.81	35.00
1	48.33	48.33	33.33
Mean	41.25	45.83	34.17

Table 6.12

F/L	L_0	L_1	-
0	31.11	43.61	-
1	63.33	23.61	-
Mean	47.22	33.61	-

		S.E.	C.D.	Sig.
N, F.Y.M.	..	3.10	-	N.S.
P, K	..	3.80	-	N.S.
Lime	..	3.22	9.28	Significant

MEAN PPM OF IRON IN THE LEAVES OF MANGO, MAY, 1969, SAMPLES

Table 7.1

N/K	0	1	2
1	222.9	208.7	172.5
2	228.3	241.1	206.3
Mean	225.6	224.9	189.4

Table 7.2

F/P	0	1	2
0	218.1	196.0	227.5
1	209.2	201.5	227.7
Mean	213.6	198.7	227.6

Table 7.3

F/K	0	1	2
0	222.7	229.9	188.9
1	228.5	219.9	189.9
Mean	225.6	224.9	189.4

Table 7.4

L/N	1	2	-
L_0	198.0	216.2	-
L_1	204.9	234.3	-
Mean	201.4	225.2	-

Table 7.5

N/F	0	1	-
1	206.7	196.1	-
2	221.1	229.4	-
Mean	213.9	212.8	-

Table 7.6

F/L	L_0	L_1	-
0	211.5	216.2	-
1	202.6	223.0	-
Mean	207.0	219.6	-

		S.E.	C.D.	Sig.
N, F.Y.M.	..	9.28	-	N.S.
P, K	..	11.38	-	N.S.
Lime	..	10.48	-	-

MEAN PPM OF IRON IN THE LEAVES OF MANGO, NOVEMBER, 1969, SAMPLES

Table 7.7

N/K	0	1	2
1	164.7	181.6	145.4
2	129.3	159.2	136.1
Mean	147.0	170.0	140.7

Table 7.8

F/P	0	1	2
0	149.4	167.5	141.0
1	140.0	141.0	177.4
Mean	144.7	154.3	159.2

Table 7.9

F/K	0	1	2
0	152.1	168.3	137.5
1	142.0	172.4	144.0
Mean	147.0	170.4	140.7

Table 7.10

L/N	1	2	-
L_0	170.3	145.2	-
L_1	157.6	137.9	-
Mean	163.9	141.5	-

Table 7.11

N/F	0	1	-
1	166.9	160.9	-
2	138.3	144.7	-
Mean	152.6	152.8	-

Table 7.12

F/L	L_0	L_1	-
0	152.3	152.9	-
1	163.1	142.5	-
Mean	153.7	147.7	-

		S.E.	C.D.	Sig.
N, F.Y.M.	..	7.76	-	N.S.
P, K.	..	9.50	-	N.S.
Lime	..	10.07	-	N.S.

MEAN PPM OF BORON IN THE LEAVES OF MANGO, MAY, 1969, SAMPLES

Table 8.1

N/K	0	1	2
1	26.00	32.00	33.60
2	31.40	28.30	32.40
Mean	28.70	30.20	33.00

Table 8.2

F/P	0	1	2
0	30.60	35.00	37.90
1	25.90	24.80	29.60
Mean	28.30	29.90	33.70

Table 8.3

F/K	0	1	2
0	30.20	31.80	41.40
1	27.20	28.50	24.60
Mean	28.70	30.20	33.00

Table 8.4

L/N	1	2	-
L_0	35.60	29.90	-
L_1	25.40	31.50	-
Mean	30.50	30.70	-

Table 8.5

N/F	0	1	-
1	36.60	24.20	-
2	32.20	29.30	-
Mean	34.50	26.80	-

Table 8.6

F/L	L_0	L_1	-
0	36.80	32.10	-
1	28.70	24.80	-
Mean	32.80	28.50	-

		S.E.	C.D.	Sig.
N, F.Y.M.	...	2.72	-	N.S.
P, K	...	3.33	-	N.S.
Lime	...	3.42	-	N.S.

MEAN PPM OF BORON IN THE SAMPLES OF MANGO LEAVES, NOVEMBER, 1969.

Table 8.7

N/K	0	1	2
1	31.00	26.08	29.50
2	27.86	24.36	27.50
Mean	29.43	25.22	28.53

Table 8.8

F/P	0	1	2
0	35.27	27.62	28.01
1	27.93	22.90	24.60
Mean	31.60	25.26	26.30

Table 8.9

F/K	0	1	2
0	34.59	27.61	28.71
1	24.27	22.82	28.34
Mean	29.43	25.22	28.53

Table 8.10

L/N	1	2	-
L_0	29.25	17.10	-
L_1	28.50	36.04	-
Mean	28.88	26.57	-

Table 8.11

N/F	0	1	-
1	32.29	25.47	-
2	28.31	24.83	-
Mean	30.30	25.15	-

Table 8.12

F/L	L_0	L_1	-
0	25.33	35.27	-
1	21.02	29.28	-
Mean	23.18	32.27	-

		S.E.	C.D.	Sig.
N, F.Y.M.	..	1.10	3.29	Sig. FYM
P, K	..	1.35	4.04	Sig. P
Lime	..	1.40	4.32	Sig.

MEAN PPM MANGANESE IN THE LEAVES OF MANGO, MAY, 1969 SAMPLES

Table 9.1

N/K	0	1	2
1	556.7	540.0	620.0
2	551.7	636.6	795.0
Mean	554.2	588.3	707.5

Table 9.2

F/P	0	1	2
0	720.0	750.0	570.0
1	615.0	626.6	418.3
Mean	667.5	688.3	494.4

Table 9.3

F/K	0	1	2
0	641.7	623.3	775.0
1	466.6	553.3	640.0
Mean	554.2	588.3	707.5

Table 9. 4

L/N	1	2	-
L_0	643.3	684.5	-
L_1	501.1	637.8	-
Mean	572.2	661.1	-

Table 9.5

N/F	0	1	-
1	652.2	492.2	-
2	707.8	614.4	-
Mean	680.0	553.3	-

Table 9.6

F/L	L_0	L_1	-
0	741.1	618.9	-
1	586.7	520.0	-
Mean	663.9	569.4	-

		S.E.	C.D.	Sig.
N, F.Y.M.	..	64.82	-	N.S.
P, K	..	79.38	-	N.S.
Lime	..	45.21	-	N.S.

MEAN PPM OF MANGANESE IN THE LEAVES
OF MANGO, NOVEMBER, 1969 SAMPLES

N/K	0	1	2
1	1036.7	986.6	910.0
2	1015.0	940.0	1333.3
Mean	1025.8	963.3	1121.7

Table 9.9

F/P	0	1	2
0	965.0	975.0	1070.0
1	990.0	1136.6	1085.0
Mean	977.5	1055.8	1077.5

Table 9.10

F/K	0	1	2
0	953.3	931.7	1125.0
1	1098.3	995.0	1118.3
Mean	1025.8	963.3	1121.7

Table 9.11

L/N	1	2	-
L_0	1056.7	1291.1	-
L_1	898.9	901.1	-
Mean	977.8	1096.1	-

Table 9.12

N/F	0	1	-
1	1083.3	872.2	-
2	923.3	1218.9	-
Mean	1003.3	1070.6	-

F/L	L_0	L_1	-
10	1056.7	1291.1	-
1	1306.7	834.4	-
Mean	1173.9	900.0	-

		S.E.	C.D.	Sig.
N, F.Y.M.	..	63.27	-	
P, K	..	77.49		
Lime	..	68.83	198.23	Sig.

b) Nutrient status of the affected and healthy Mosambi trees

The results obtained in respect of nutrient element status of both the types of trees is presented and discussed herewith.

Nitrogen

From the data in Table 10.1, it is seen that the average N percentage in the leaves of healthy trees receiving N alone and combined treatment of NPK is higher than the status of control trees. Further, the trees in NP treatment have recorded more N status. This would indicate that the treatments have helped in better uptake of N. The reported N content of mature sweet orange leaves according to Good all and Gregory (1947) is 2.3 per cent to 2.7 per cent which is a satisfactory range and at this level, no N deficiency symptoms were produced. Thus, it appears that the observed N status for normal trees after giving the treatment is optimum. However in the control trees, the N status is marginal and somewhat on the low side. It, therefore, seems reasonable to assume that the cultivators normal dose is not sufficient and the trees need more fertilisation.

The diseased trees have registered even better N status than the normal ones right from the beginning, _i.e._ even before the manurial treatments were applied. This would indicate that N status of these plants is satisfactory and deficiency of N as a cause of decline can be overruled. It is observed from the data in Tables 10.1 and 10.2 that the N content of the affected trees prior to treatment compares favourably with the N through area, therefore, does not seem to have had any beneficial effect.

Phosphorous

It is observed from the data in Tables 11.1 and 11.2 that the mean phospherous percentage in healthy trees ranges from 0.20 per cent for control treatment to 0.27 per cent for NPK treatment, while there is a gradual rise in P status of the trees receiving the treatment N, NP and NPK.

The critical levels of P content reported by Chapman (1961) are 0.12 per cent to 0.15 per cent for narmal healthy trees. The observed values for healthy trees are considerably higher than the reported ones. Even in the cultivators treatment the P status is higher.

The diseased trees have shown a still higher P status in the NPK and N alone treatment. Though, the figure for NP is comparatively low, it is much higher than the reported figures of Chapman and also higher than the control tree.

It is quite possible that the high P noticed may have interfeared with the uptake of other nutrients notably the micro-nutrients.

MEAN NITROGEN PERCENTAGE IN THE LEAVES OF HEALTHY AND DISEASED MOSAMBI TREES

Table 10.1 : HEALTHY

Treat-ments	Dec. 1968	April 1969	June 1969	Aug. 1969	Mean
NPK	2.6	2.5	2.5	2.4	2.4
NP	2.6	2.7	2.4	3.2	2.9
N	2.9	2.8	2.5	2.0	2.4
Control	2.5	2.4	1.8	2.0	2.1
Mean	2.6	2.6	2.3	2.4	-

Table 10.2 : DISEASED

Treat-ments	Dec. 1968	April 1969	June 1969	Aug. 1969	Mean
NPK	2.9	3.2	2.8	2.7	2.9
NP	3.0	3.1	3.3	2.2	3.2
N	2.8	2.1	2.5	2.4	2.3
Control	-	-	-	-	-
Mean	2.9	2.8	2.8	2.4	-

MEAN PHSOPHOROUS PERCENTAGE IN THE LEAVES OF HEALTHY AND DISEASED MOSAMBI TREES

Table 10.3 : HEALTHY

Treat-ment	Dec. 1968	April 1969	June, 1969	Aug., 1969	Mean
NPK	0.31	0.32	0.24	0.17	0.27
NP	0.32	0.24	0.26	0.22	0.26
N	0.24	0.23	0.26	0.23	0.22
Control	0.21	0.17	0.22	0.21	0.20
Mean	0.27	0.25	0.24	0.21	-

TABLE 11.2 : DISEASED

Treat-ment	Dec., 1968	April 1969	June, 1969	Aug. 1969	Mean
NPK	0.36	0.34	0.30	0.18	0.29
NP	0.16	0.36	0.23	0.14	0.22
N	0.34	0.27	0.27	0.20	0.26
Control	-	-	-	-	-
Mean	0.28	0.32	0.26	0.17	-

Potassium

It is observed from the data in Tables 12.1 and 12.2 that the K status in healthy trees is higher than in control treatment. The K level has increased successively in NP, N alone and NPK treatments. It appears that when K supply is made along with N and P, the K uptake is enhanced.

The reported K content by Chapman et.al. (1961) is 1.50 per cent which is optimum for good growth. The observed K values in healthy trees is much more than Chapman's figure.

In the case of diseased trees, the K uptake is considerably higher. It would, therefore, seem that this very high amount of K may have something to do with the declining condition of the trees.

Calcium

It is seen from the data in Tables 13.1 and 13.2 that the calcium status of healthy plants in all the treatments is much higher than the Ca status of the control trees.

The Ca content of healthy trees is more or less similar to that reported by Chapman (1961) who has stated that 2 to 5 per cent Ca is normal in citrus, while if it is more than 7.00 per cent, it might indicate the K or Mg deficiency. The declining trees have registered more Ca than the control trees but less than the normal trees receiving normal treatments.

It appears that the high Ca in all the treatments is probably conditioned by N application, since N application

MEAN PERCENTAGE OF POTASSIUM IN THE LEAVES OF HEALTHY AND DISEASED MOSAMBI TREES

	Table 12.1 : HEALTHY					Table 12.2 : DISEASED				
Treatment	Dec., 1968	April, 1969	June, 1969	Aug., 1969	Mean	Dec., 1968	April 1969	June 1969	Aug., 1969	Mean
NPK	3.80	3.97	2.67	2.15	3.15	4.35	4.47	2.02	1.70	3.13
NP	2.55	3.50	2.10	1.80	2.49	2.38	4.00	3.75	1.40	2.88
N	2.73	4.55	2.02	1.35	2.66	3.10	4.02	2.32	2.12	2.89
Control	2.80	2.05	2.00	2.00	1.92	2.24	-	-	-	-
Mean	2.97	3.52	2.20	1.80	-	2.46	4.16	2.69	1.74	-

MEAN PERCENTAGE OF CALCIUM IN THE LEAVES OF HEALTHY AND DISEASED MOSAMBI TREES

	Table 13.1 : HEALTHY					Table 13.2 : DISEASED				
Treatment	Dec., 1968	April 1969	June, 1969	Aug., 1969	Mean	Dec., 1968	April 1969	June, 1969	Aug., 1969	Mean
NPK	5.57	5.82	6.02	5.25	5.66	5.42	5.62	5.52	6.00	5.39
NP	5.62	4.55	5.70	4.25	5.03	2.90	5.05	5.45	4.60	4.50
N	4.20	6.32	6.27	5.50	5.57	3.90	5.40	4.71	4.30	5.57
Control	4.20	3.80	4.20	3.00	3.80	-	-	-	-	-
Mean	4.89	5.10	5.55	4.50	-	4.07	5.35	5.22	4.96	-

increases leaf Ca status as reported by Beeftink et.al. (1962) in citrus.

Magnesium

The data in Tables 14.1 and 14.2 show that the Mg status of healthy trees ranges from 0.39 per cent to 0.45 per cent in the different treatments as compared to 0.25 per cent in control. Though the status of manured trees is higher, there is not much difference in the levels as influenced by N, NP or NPK.

The critical levels of Mg as reported by Chapman (1961) is 0.50 per cent for normal healthy trees. The observed value for healthy trees are slightly lower and in the cultivators treatment, the Mg value appears to be deficient.

The observed low Mg value in healthy trees may be due to increased leaf K status. Fudge (1945) observed depressed intake of Mg in the presence of high K.

The diseased three have shown a better Mg status and the values are comparable with the optimum ones reported by Chapman (1961). The value has increased by N alone but gradually reduced with the application of P and PK.

Copper

It is noticed from the data in Tables 15.1 and 15.2 that the Cu status of healthy trees in the manurial treatment is higher than control treatment. The Cu level has increased from N alone to NP and NPK treatments.

The satisfactory range of Cu content reported by Chapman

(1961) is 5.1 to 15.0 ppm. The observed Cu content in healthy trees including control is more than reported ones.

In case of diseased trees also, the Cu uptake is higher in all the treatments than reported though the levels are lower than in the healthy trees. Thus, it would appear that the Cu content is not associated with declining condition of trees. The spray of Cu on the foliage in declining trees does not seem to have helped in better uptake of Cu.

MEAN PERCENTAGE OF MAGNESIUM IN THE LEAVES OF HEALTHY AND DISEASED MOSAMBI TREES.

Table 14.1 : HEALTHY

Treatment	Dec., 1968	April, 1969	June, 1969	Aug., 1969	Mean
NPK	0.47	0.47	0.32	0.29	0.39
NP	0.62	0.52	0.27	0.24	0.41
N	0.61	0.64	0.33	0.23	0.45
Control	0.20	0.40	0.22	0.18	0.25
Mean	0.47	0.51	0.28	0.24	-

Table 14.2 : DISEASED

Treatment	Dec., 1968	April 1969	June, 1969	Aug., 1969	Mean
NPK	0.60	0.34	0.54	0.29	0.49
NP	0.54	0.72	0.48	0.47	0.55
N	0.40	0.43	0.60	0.52	0.59
Control	-	-	-	-	-
Mean	0.51	0.50	0.54	0.43	-

MEAN COPPER CONTENT IN THE LEAVES OF HEALTHY AND DISEASED MOSAMBI TREES (IN PPM)

Table 15.1 : HEALTHY

Treatment	Dec., 1968	April, 1969	June, 1969	Aug., 1969	Mean
NPK	15.00	15.00	22.00	30.00	22.30
NP	25.00	25.00	30.00	25.00	26.66
N	10.00	10.00	20.00	15.00	15.00
Control	5.00	15.00	15.00	15.00	15.00
Mean	13.75	16.25	21.75	21.25	-

Table 15.2 : DISEASED

Treatment	Dec., 1968	April 1969	June, 1969	Aug., 1969	Mean
NPK	10.00	30.00	15.00	15.00	20.00
NP	5.00	30.00	7.00	10.00	15.60
N	40.00	30.00	10.00	25.00	21.60
Control	-	-	-	-	-
Mean	18.30	30.00	10.66	16.66	-

Iron

The data in Tables 16.1 and 16.2 indicate that the iron status of healthy plants in all the manurial treatments is much higher than control treatment.

The reported iron status by Chapman (1961) in citrus is 60 to 150 ppm which is a satisfactory range for citrus.

The Fe content of healthy trees on the whole appears to be satisfactory.

The declining trees have registered more Fe content than control and other treatments in healthy trees as well as more than the reported ones.

The leaf iron status of the affected plant as seen from the data in Table 16.2 does not seem to have been - influenced by the foliar application of the micro-nutrient. The Fe content in December (before applying sprays and fertilisers) is more or less the same as that of average Fe content of the other months.

Boron

It is seen from the data in Tables 17.1 and 17.2 that the leaf B content in healthy trees in the manurial treatments is observed to be somewhat higher than the control trees.

The critical levels of B content reported by Chapman (1961) are 50 and 200 ppm for normal healthy trees. By this standard, the observed B values for the healthy trees are somewhat low. In general, low B status in healthy leaves may be due to increased leaf P status in healthy trees as reported by Bingham (1963) that increased P status in citrus reduces the availability of B to the plants and, therefore, less uptake of boron.

The diseased trees have shown a higher B status in all the treatments in comparison with healthy ones, and is in the satisfactory range.

It appears from the Leaf B content of affected plants especially during April and June that due to macro-nutrients sprays the B status has increased to a considerable extent. The boron status in healthy trees has actually decreased during the period in comparison with December samples. It appears that the foliar application of B has helped in improving the B status of the affected Mosambi trees markedly to a satisfactory range.

MEAN IRON CONTENT IN THE LEAVES OF HEALTHY AND DISEASED MOSAMBI TREES (IN PPM)

Table 16.1 : HEALTHY

Treat-ment	Dec., 1968	April, 1969	June, 1969	Aug., 1969	Mean
NPK	145.0	135.0	150.0	160.0	149.0
NP	140.0	120.0	190.0	180.0	163.0
N	205.0	150.0	195.0	180.0	175.0
Control	100.0	150.0	125.0	120.0	131.0
Mean	147.2	138.7	165.0	160.5	-

Table 16.2 : DISEASED

Dec., 1968	April, 1969	June, 1969	Aug., 1969	Mean
265.0	220.0	167.0	275.0	227.3
240.0	262.0	178.0	340.0	257.3
205.0	200.0	160.0	310.0	223.3
-	-	-	-	-
236.6	227.3	172.3	308.3	-

MEAN BORON CONTENT IN THE LEAVES OF HEALTHY AND DISEASED MOSAMBI TREES (IN PPM)

Table 17.1 : HEALTHY

Treat-ment	Dec., 1968	April, 1969	June 1969	Aug., 1969	Mean
NPK	58.0	70.4	45.1	38.5	51.3
NP	77.0	69.4	50.0	33.0	50.8
N	56.3	56.1	51.7	26.4	44.7
Control	55.5	55.4	45.1	24.2	41.5
Mean	62.2	62.8	47.9	40.5	-

Table 17.2 : DISEASED

Dec., 1968	April, 1969	June, 1969	Aug., 1969	Mean
68.7	91.3	79.2	70.4	80.3
56.3	68.7	100.4	50.6	73.1
68.7	77.1	123.2	58.2	86.2
-	-	-	-	-
65.0	79.0	100.8	59.7	-

Manganese

It is observed from the data in Tables 16.1 and 16.2 that the Mn status in healthy trees is higher than that in control. The Mn level has increased successively in N, Np and NPK treatments. It appears that when nitrogen is applied along with P and K, the Mn uptake is enhanced.

The reported Mn content by Chapman (1961) is 25 to 100 ppm which is a satisfactory range for citrus. The observed Mn values are much higher in healthy trees including control.

In case of diseased trees, the Mn uptake is more or less similar to those of healthy trees.

The increased values in healthy as well as deseased trees in all the treatments containing N indicate that uptake of Mn is increased in the presence of N. Labanuskas et.al. (1961) observed that 3 lbs per tree per year of actual N from urea applied usually for 19 consecutive years significantly increased Mn and Fe concentrations in the leaves. The Mn seems to have been absorbed by the plants in increasing quantity on its application as a foliar spray.

From the above results, it appears, in general, that amongst the healthy trees, the cultivators dose which consists of 15 kg F.Y.M. and is not sufficient to maintain the optimum nutrient requirement of the trees, and therefore, there appears to be need for applying fertiliser, especially the nitrogenous one, to build up proper nutritional balance. Secondly, it appears that in the diseased trees, all the nutrients both major and minor are optimum and more or less according to the levels reported as satisfactory. There is also a possibility that the high P and K status might have something to do with the malnutrition of the Mosambi trees. Nutritional deficiency, however, does not appear to be the main cause of declining condition of the trees, and it appears that malady is caused by factors other than nutritional.

MEAN MANGANESE CONTENT IN THE LEAVES OF HEALTHY AND DISEASED MOSAMBI TREES

(IN PPM)

Table 18.1 : HEALTHY

Treatment	Dec., 1968	April, 1969	June, 1969	Aug., 1969	Mean
NPK	220.0	375.0	260.0	300.0	331.6
NP	300.0	220.0	260.0	220.0	233.3
N	300.0	220.0	105.0	300.0	208.3
Control	200.0	200.0	150.0	220.0	190.0
Mean	255.0	254.0	193.6	260.0	-

Table 18.2 : DISEASED

Dec., 1968	April, 1969	June, 1969	Aug., 1969	Mean
300.0	220.0	187.0	375.0	260.6
140.0	300.0	180.0	220.0	233.3
145.0	180.0	225.0	240.0	233.0
-	-	-	-	-
195.0	233.3	197.3	278.6	-

CHAPTER V

SUMMARY AND CONCLUSIONS

The mango is considered as the national fruit of India, and the crop accounts for nearly 80 per cent of the world acreage. The fruit has a good demand in foreign markets both in the fresh as well as processed form.

In spite of this importance, the crop has not been given the attention it deserves and it is well-nigh being cultivated in a semi-wild state. Manures and fertilisers are seldom applied and the nutrition of the tree is little understood.

With a view to have a better understanding of the nutritional status as conditioned by the fertilisation practices, studies were undertaken to find out the nutritional levels of the trees in the N, P, K, FYM-cum-liming experiments already laid out at the Regional Fruit Research Station, Vengurla and to assess the uptake of N, P, K and to know the effect of the status of these individual elements on the uptake of other major or minor elements.

Studies were also undertaken to determine the nutritional status of declining citrus trees in a private garden in Poona, along with the apparently healthy trees from those cultivators field in an effort to find out whether nutritional disorder is associated with tree decline.

The manurial experiment on the mango was laid out in 1959-60 with three levels each of P and K and two levels of N, FYM and liming. Leaf samples were collected from each treatment at two different periods, *viz.* in May 1969, *i.e.* after the crop was picked and in November 1969, *i.e.* before the blossoming of trees.

Similarly, in Mosambi, four samples of leaves were drawn in December 1968, *i.e.* prior to spring growth and again in April, June and August 1969, *i.e.* during the active growth stage and after in both the types of trees (healthy and declining). The declining trees were sprayed with a composite micro-nutrients and urea spray to see whether the declining trees could improve.

The macro-elements were estimated by the method outlined by Lindner, R.C. (1944), while Cu, Fe and Mn were estimated as per method described by Piper (1950) and boron was determined by the method given by John Hatcher and Wilcox (1950).

The soil samples from mango manurial experiment were taken and analysed for the physio-chemical properties.

The growth and yield data previously recorded at the station were made use of for assessing the effect of nutritional status.

The results obtained are summarised hereunder :

(1) Nutrient status of Mango trees in manurial experiment

Effect of application of N - In November samples, the leaf N has increased significantly with increased application of N fertilisers. However, this increased uptake of N has not resulted in better yield and growth of the trees and it appears that they have consumed the additional N without converting it to production. It, therefore, appears that the lower level of N applied, i.e. 0.68 kg N per tree is quite adequate for 10 year old tree under Vengurla condition. The leaf N level of 1.70 to 1.91 per cent observed appears to be optimum. The level was observed to have fallen in May consequent on its utilisation in fruit development.

The uptake of P and Ca was observed to have increased while K significantly decreased in the presence of N. The uptake of remaining major and minor elements at various levels of N application was not, however, affected.

Effect of application of P

In November samples, P content increased in linear order with increase in the application of P. The increased consumption of P with increased application of phosphatic fertilisers has not been utilised for production as no corresponding - increase in yield and also growth was observed. It is - doubtful, therefore, if P application is at all necessary, since the leaf P level of 0.19 to 0.31 per cent was observed which compares well with the optimum figures reported by other workers. The May samples showed more uptake of P in contrast to the uptake of N. This seems to have resulted due to slow availability of P.

The uptake of boron was observed to have reduced significantly with increased uptake of P in November but the same was not significantly influenced in May samples.

The uptake of other major and minor elements remained unaffected by the P application and leaf P status.

Effect of application of K

The leaf K content decreased substantially with the amount of fertilisers added, though the differences were not significant. In the no K treatment, the leaf K content was higher than the critical levels reported by other workers. There appears to be no significant influence of K status on the uptake of other elements both major and minor, but leaf N, Ca and Mg were observed to be somewhat depressed due to increased application of K, while P has slightly increased with increasing doses of K in the samples collected in November 1969.

The adequate K status even in the no K treatment seems to have been influenced by FYM application. The differential application of K did not affect the growth and yield of trees.

Effect of application of FYM

The leaf P has increased significantly with increasing applications of FYM. This increased P in the presence of FYM has, however, not been reflected in better production. Thus, it seems that in the absence of phosphatic and potassic fertilizers FYM gives good results.

The leaf Mg status has increased significantly with higher dose of FYM applications in November 1969 samples, whereas there is a substantial increase in the leaf Mg status in May 1969 samples.

Boron content of leaves has depressed with FYM application which may be due to increased uptake of P. The uptake of other major and minor elements have not been influenced by the FYM application.

FYM has not resulted in better growth and, therefore, addition of FYM appears to have limited use in the local soils which are rich in organic matter.

Effect of application of lime

Liming has increased the soil pH. It has resulted in significant decrease in Cu and Mn content and significant increase in P and B uptake in November samples.

Lime application has not influenced the uptake of other major and minor elements including Ca. However, leaf Ca varied from 1.70 to 2.55 per cent which is quite satisfactory as compared to the levels reported by other workers.

The leaf Mg range observed was 0.57 per cent to 0.77 per cent which appears to be quite adequate in comparison with the levels reported by others.

The leaf copper ranges from 28.00 to 47.22 ppm. The uptake of copper is observed to be depressed with lime application.

The uptake of Fe has not been influenced by various levels of N, P, K, FYM and liming. The leaf iron ranges from 170.0 to 229.6 ppm.

The leaf boron content varied from 23.18 to 34.5 ppm.

The leaf Mn content varied from 492.2 to 1173.9 ppm.

The levels of micro-nutrients observed here are probably the first record in the crop and it is difficult to say whether they are optimum. However, as the trees have shown no deficiency symptoms or any other abnormality, it may be concluded that the quantities noted may be adequate.

(2) Nutrient status of the affected and healthy mosambi trees.

Uptake of nitrogen

The average leaf N content of affected trees was observed to be satisfactory and comparable to apparently healthy plants right from the beginning, i.e. even prior to the manurial treatments being applied.

The N status of the trees under cultivators treatment was less than the fertilized trees and also less than the critical one reported by other workers. It, therefore, seems reasonable to assume that the cultivators normal dose is not adequate and the trees need fertilisation.

The foliar application of N through urea along with micro-nutrients on diseased trees does not seem to have had any beneficial effect in increasing the leaf N.

Uptake of Phosphoreus

The P status of healthy trees was higher than the reported ones and it further increased with the application of fertiliser. The P status of diseased trees is very much higher than the figures of Chapman (1961) and also higher than the control trees. Applications of phosphatic fertilisers does not appear to be necessary under local conditions and on the contrary may be contributing to the decline as seen from high P content of affected plants.

Uptake of Potassium

The K status in healthy trees is higher than in the control treatment. It appears that when K supply is made along with N and P, the K uptake is enhanced .

In diseased trees, the K uptake is considerably higher which may have something to do with the declining condition of trees.

Uptake of Calcium

The Ca status of healthy trees is more than control treatment and is more or less similar to that reported by other workers. The declining trees have more Ca status than control but less than the normal trees receiving - various manurial treatments.

This high Ca status in all the treatments is probably conditioned by N application.

Uptake of Magnesium

Observed values for healthy trees are somewhat lower and in the cultivated treatment, it appears to be deficient.

The diseased trees have a better Mg status in comparison with optimum ones reported by others.

Uptake of Copper

Cu content of healthy trees in the manurial treatment is higher than control treatment and is more than reported ones.

In diseased trees also, the Cu content in all the treatments is higher than reported ones but lower than healthy trees with fertilizer treatment.

Uptake of Iron

Iron status of healthy plants in all the treatments is much higher than in control and it appears to be quite satisfactory.

The declining trees have registered more Fe content than control and other healthy trees as well as more than reported ones.

The iron uptake of diseased plants have not been - affected by the foliar application of the micro-nutrients.

Uptake of Boron

The B content of healthy trees in manurial treatments is somewhat higher than in the control trees. These values are somewhat lower than the reported ones. This low B content may be due to increased P status of the healthy trees.

The diseased trees have shown a higher B status in all the treatments in comparison with healthy ones.

The increased Boron status of affected trees seems to have resulted from foliar application of micro-nutrients.

Uptake of Manganese

The high Mn status of healthy trees as well as diseased trees in the treatments N, NP and NPK as compared to control seems to be due to the nitrogen application. Thus, it seems that Mn increases in the presence of N.

From the above results, it appears, in general, that amongst the healthy trees, the cultivators dose of 15 kg of FYM is not sufficient for good growth and, therefore, they need to be fertilized especially with nitrogenous ones to build up proper nutritional balance. It appears that in diseased trees both major and minor nutrient status is optimum. Nutritional deficiency, therefore, does not appear to be the main cause of declining condition of the trees, though high P and K are associated to some extent into diseased trees and the malady appears to be due to factors other than nutritional.

BIBLIOGRAPHY

Abdulla, D.A. & Safie, H.J.	(1965)	Influence of N, P and K levels on yield, petiole nutrient composition and juice quality of newly established Concord grapes in South Carnolina. Proc. Ame. Soc. Horti. Sci., 1965, 87 : 253-8, bibl. 13.
*Alim Aliz & Musahb	(1955)	Vigour and productivity as affected by trace elements in citrus. Punjab Fruit Journal, 1955 : 19 : 53-6.
Batjer, L.P.	(1956)	Application of tissue analysis to nutritional problems of fruit trees. Proc. Seventh Annual Fert. Conf. of the Pacific North West, Pp. 99-104.
Beattie, J.M.	(1953)	Ohio grapes suffer from nutrient deficiencies. Better crops with p,ant food, April, 1953.
Beeftink, W.G., Kenlis, M. & Bulijn.	(1962)	Tien Juar Onderzoek op NPK bemesting met cox's orange pippin in Zeeland. (Ten years trials on N, P, K manurial trial plots with cox's orange).
*Bingham, F.T.	(1963)	Relation between Phosphorous and Micro-nutrients in plants. Proc. Soil Sci. Soc. Ammeri., 1963 : 289-91, bibl. 7.
Cameron	(1937)	The effect of fertilization, ringing, blossoming and fruiting on the nitrogen content of Avocado leaves. Califo. Avocado Assn. Year Book, 142-148.
*Chapman & Brown	(1941)	Effect of sulphur deficiency on Citrus. Hilgardia (14) : 185-201.
*Chapman, H.D.	(1961)	The status of present criteria for the diagnosis of nutrient conditions in citrus. Plant analysis and fertilisation problems, 75-106, Publi. 8, Ameri. Insti. of Biological Science, Washington 6, D.C. 454, Pp. (1961).

*Childer, N.F.	(1954)	Nutrition of Avocado fruit nutrition. Horticultural publications. Rutgers University, New Brunswick, N.J.
*Cox and Cocharen	(1957)	Experimental Design.
Cunningham, R.K.	(1964)	Micro-nutrient deficiency in Cacao in Ghanan to Eup. Expt. Agric. (1964) 32:42-50 Pp.
Daji, T.A. & Rajagopal Iyenger, T.	(1964)	Organic manures. Hand Book of manures and fertiliser., I.C.A.R. Publications
Demitrides, S.D. Holevas, C.D. & Gavalad, N.A.	(1963)	Manganese deficiency in apple and Medlar tree in Greece. Ann. Inst. Phyto. Path. Benabi. 1963(5) 204-206, bibl. 8, illust.
DeMello, F.A.F. & others	(1967)	The K/Mg ratio in young orange plant (Citrus sinensis, var D.A.C.). An Esc. Sup. Agric. Queiroz., 1966, 23 : 95-107. (bibl. 19, English Summary).
*Divate, M.R.	(1967)	Studies on the nutrient element status (with reference to major element) of Selection-7 grapevines (<u>Viris vinifera</u>, Linn.) in some vineyards in the Poona Region).
Drosdoff, M.	(1944)	Importance of leaf analysis. Plant analysied and fertiliser problems, Vol. I.
*Embleton, T.W. & Others	(1958)	Influence of sampling date, season and fertilisation on macro-nutrients in Fuerta Avocado leaves. Proc. Amer. Soc. Horti. Sci., 1958, 72 : 309-20, bibl.20.
Emmert	(1954)	The influence of variety, tree age and mulch on the nutritional composition of Citrus leaves. Proc. Ameri. Soc. Horti. Sci. 64 : 9-14.
*Embleton, T.W. & Jones, W.W.	(1965)	Potash hunger in lemons. Better Crops. (1964)(48) 4 : 2-5.
Fremond, Y. & Villeman, G.	(1964)	Fumure minerals' Sur. Cocosteriae Agee en cote d, Ivoire (Mineral fertilising of old coconut groves in the ivory coast) Oleagineux, 19, 403-9.

*Ferwerda, J.E.	(1961)	Growth, production and leaf composition of the African oil palm as affected by nutritional deficiencies. Plant analysis and fertilizer problems, Pp. 148-158.
Fusik, J.E.	(1964)	The relationships between calcium and manganese, I - In their absorption and translocation in young apple seedlings. II - In their ability and movement in the soil. Diss. Abstr. 1964, 25 : 737-being order No. 64 - 8377 of 228 Pp.
Fudge, B.R.	(1945)	The effect of applications of calcium and manganisuim upon absorption of potassium by citrus. Proc. Fla. State Horti. Soc. 59 : 46-51.
Gartel, W.	(1965)	Uber den diagnostieschen West der Blattantyre-beider Identifizierung Von - Ernahrung asterungun, bei Feben. (The diagnostic value of leaf analysis for identifying nutritional disorders in vines for) French summary 18 lines. C.R. College, eur. Control. Nutr, Min. Fert. Vitic Arboric, Montpelier (1964-65), Pp. 197-200.
*Garg, M.L.	(1960)	Tending alternate bearing mango trees to regular bearing habit. Punjab Fruit Journal (1960), 23 : 149-50.
*Gotmare, S.B.	(1960)	Studies on the seasonal variation in leaf mineral composition of Chikoo. A thesis submitted to the University of Poona for M.Sc.(Agri.) Degree.
Goodall & Gregory	(1947)	Chemical composition of plants as an index of their nutritional status. Tech. Comm. No. 17, Imp. Bur. Horti. and Plant Crops.
Hanman	(1904)	Zit Beitrage Zur, Pflanzenalyse, Z. Liandw. Verswer Ost. 7-805-18. (Quoted by Goodall and Gregory)
Hance	(1937)	Soil and plant material analysis by rapid chemical methods. II Hawaii Plant Rel. 45 : 265-296.

Hass, A.R.C.	(1945)	Nitrogen, Phosphorous and Potassium content of Fuerte Avocado fruits from different orchards. (California Avocado. Soc. Year-Book, 101-104).
Heymann & Herschberg	(1955)	Nitrogen and phosphorous content of citrus leaves in Israeli. Ktavium, 1954: 5:19-27.
Haymann & Herschberg	(1956)	A survey of the effect of fertilizing practices on the macro-nutrient composition of Citrus leaves in Israel. (Ktavium 1956(6) : 17-33, bibl. 30).
Hiroyasu	(1962)	Nutritional and physiological studies on the grape vine. II seasonal variation in the inorganic nutrient contents. J. Jap. Soc. Horti. Sci. 30 : 111-116, bibl. 24.
Ishihara, M. Hax, Y & Sato, K.	(1965)	Studies on the potassium nutrition of Satsuma orange. I. The interaction between N and K on the growth, leaf analysis, tree analysis and fruit quality of Satsuma orange. Bull. Hort. Res. Sta. Hiratsuka, 1965 No. 4, Pp. 19-44.
*John T.Hatcher & Wilcox	(1950)	Colorimetric determination of Boron using Carmin, Anal. Chem. 22: 567-69.
*Jones, et.al.	(1955)	Leaf analysis, a guide to fertiliser need. Calif. Citrugr. 40 : 9.
Joshi, A.T.	(1966)	Unpublished data.
*Jones, W.W. & Embleton, T.W.	(1968)	Yield and fruit quality of Washington Naval orange trees as related to leaf nitrogen and nitrogen fertilization. Proc. Ameri. Soc. of Horti. Sci., 1967 (9) : 138-42, bibl. 8).
Kanwar, J.S. & Dhingra, D.R.	(1963)	Effect of micro-nutrient sprays in the chemical composition of citrus leaves and incidences of chlorosis. Ind. Jour. of Agric. Sci., 1962 : 32-209-14.
Kumashiro, K.	(1965)	Studies on (Joyo) abnormal leaves of Nijisseiki Pears developed as a result

Kumashiro, K. (Camald.)	(1965)	of certain training systems. Effect of different fertiliser treatments on tree growth and the development of abnormal leaves. J. Jap. Soc. Horti. Sci. 34 : Pp. 286-90.
*Labanauskas, C.K., Jones, W.W. & Embleton, T.W.	(1960)	Seasonal changes of micro-nutrient in Naval orange leaves. Calif. Citrog., 1960 : 45 : 66-76.
*Labanauskas, C.K., Jones, W.W. & Embleton, T.W.	(1960)	Seasonal changes in concentration of micro-nutrient (Zn, Cu, B, Mn and Iron) in leaves of Washington Naval Orange. Proc. Ameri. Soc. Horti. Sci., 1959, 74: 300-307. Bibl. 16.
*Labanauskas, C.K., Jones, W.W. & Embleton, T.W.	(1960)	Influence of soil application of N, P and K in the micro-nutrient concentration in Washington Naval Oranges. Proc. Ameri. Soc. Horti. Sci. 1960, 75 : Pp. 230-35.
*Lindner, R.C.	(1944)	Rapid analytical methods for some of the more common inorganic constituents of plants tissues. Plant Physiology, 19 : 441-465.
Liebig, J.	(1850)	Chemistry in its application to Agriculture and Physiology. Play fair L and Gregory, W. Eds. John Wibey, New York.
Lockard, R.G. & Asomaning	(1964)	Mineral nutrition of Cacao deficiency symptoms and nutrient levels in plant grown in sand culture. Plant and Soil Analysis, 1964 : 21 : 142-52, bibl. 16.
Lockard, R.G. & Asomining	(1965)	Mineral nutrition of Cocoa (Theobroma Cacao) II Effects of swollen shoot. Virus on the growth and nutrient contents of plants grown under nutrient deficient excess and control conditions in sand culture. (IV) Effect of nitrate and ure, nitrogen on deficiency symptoms of phosphoreus, potassium, calcium and magnasium in sand culture. Trop. Agriculture Trinn., 1965 : 42 : 39-53.

*Ljonese, B. (1963) Leaf composition in apple rasberry and black current as related to nutrient elements in the soil. Proc. Ameri. Soc. Horti. Sci. 82 : 503-506.

Lundegardh (1951) Leaf Analysis. Translated by Mitchell, Hilger and Watts Ltd., London.

Mallic, P.C. & DE, B.N. (1952) Manures and manuring of the mango and the economics of Mango culture. Indian J. Agric. Sci., 1952 : 22 : 151-66, bibl. 7.

Mirza, B. & Khalidy (1964) Uptake of magnesium through foliar spray in Banana. W. Pakist. J. Agric. Res. 2(3) : 81-82, bibl. 5.

*Mohamed Baker, Ahmed & Magdi Twefik (1956) Study of the rootstock of Pear with special reference to the incidence of iron chlorosis. Indi. J. Horti. Sci. 13 : 2.

*Nagpal, R.L. (1963) Principles and methods of fruit culture and fruit preservation. Agric. Dept., Maharashtra Stat.

*Narke, A.D. (1969) Studies in the effect of 2,4-D on the flowering, fruit set, fruit drop, fruit development, yield and quality of - Chikoo (Achras Sapota, L.) and preliminary observations on the nutritional status of healthy and declining chikoo trees. A Thesis submitted to the Mahatma Phule Krishi Vidyapeeth for M.Sc.(Agri) Degree.

Olsen, S.R.& et.al. (1914) Estimation of available phospherous in soils by extraction with sodium bicarbonate. Circular, U.S.D.A., 1939.

*Openheimer, C. & Gazit, S. (1963) Zinc deficiency in mango groves in Israel and its correction. Horti. Adv. (1961) 5 : 1-12, bibl. 16, illust.

Pennisi, L. & Scuderi, A. (1961) Investigation on the mineral composition of Sicilian citrus. Tech. Agri., 1959, 11 : 516-31.

Pfaff	(1963)	Weitar Ergemnisse aus Dungungraves Suchen mt Apfelbumen in grafossen (Further results from manurial treatments with apple trees in pots). Gart en bamsiss 1963, 28 : 245-50, bibl. 5.
*Phadnis, N.A.	(1963)	Role of potash in the fertilisation of (*Citrus reticulata*, Blanco) in Maharashtra State. Role of potash in plant nutrition. Seminar held at Poona, May, 1963.
*Phadnis, N.A.& Divate, M.R.	(1967)	Preliminary investigation in the nutritional disorders of the Selection-7 - grapes (*Vitis vinifera*, L) in Maharashtra. Paper presented at F.A.O. Conference on Horticulture, held in Delhi, December, 1967.
*Phadnis, N.A.& Sawant, R.Y.	(1969)	Preliminary studies in the growth of shoots and their relation to cropping in the Alphanso Mango under Vengurla conditions. International symporisum on Mango and Mango culture, held at Delhi in June, 1969.
Piper, C.S.	(1951)	Plant and Soil Analysis
✓ Proloran, J.C. & Minot, F.	(1957)	The mineral nutrition of orange trees as determined by leaf analysis. Plant analysis and fertilizer problems, I.R. No. Pairis, 1957, Pp. 322-35, bibl. 9.
*Ranga Rao, D.S.	(1960)	Estimation of production of oranges. A pilot sample survey. First Report, Dept. of Agric., M.S., Poona.
*Reuther & Smith P.F.	(1952)	Relation of fertiliser treatment to fruit quality of Valancia orange. Pro. Amer. Soc. of Horti. Sci., 48 : 1-12.
*Reuther & Smith	(1950)	Seasonal changes in leaf of Valancia orange trees. I. Changes in leaf dry weight, ash and macro-nutrient elements. Proc. Amer. Soc. Horti. Sci., 1950, 55: 61-72, bibl. 18.
Ruehle, G.D.	(1952)	Fertiliser practices for the mango. Florida, Mango, Fourm, 1949, Pp. 6, bibl. 10.

*Roy, R.S., Mullik, P.C. & DE, B.N.	(1956)	Manuring of mango. Proc. Ameri. Soc. of Horti. Sci. Vol. 57, Pp. 1-6.
Samoldas, T.H.	(1965)	The effect of micro-nutrient elements on the yield and metabolism of the unshiue mandarine citrus unshiue mare., Bot. Jour. 49 : 428-32., bibl. 8.
Saresi	(1965)	Studies in Hungary on the control of vine nutrition by Foliar analysis. Mitt. Klosterneuburg Ser. A. 15A, 51-62, bibl. 5.
Sato, K. & Ishihara, M.	(1957)	Studies on leaf analysis of fruit trees. IV. Part 13-15.
Sato, K., Ishihara, M.& Kurihara, A.	(1960)	Studies on the leaf analysis of fruit trees. Effect of fruiting on the leaf analysis. Jap. Potassium Symposium, 1957, Pp. 103-16.
Sato, K. & others	(1961)	Effect of nitrogen, phospharous and potassium on the growth leaf and tree composition and fruit quality of pear trees (Fertiliser experiment, 1954-59). Bull. Nat. Inst. Agric. Sci. Heiratsuka, Ser. No. 9. Pp. 195-213, bibl. 16.
Sakamota, T. & Okuchi, S.	(1967)	The effect of physical and chemical properties of soils derived from different materials on the growth of Satsuma orange trees. IV on difference in the constituents of inorganic macro-elements in Satsuma. orange leaves growing on six different soils in a nine year Frame experiment. J. Jap. Soc. Horti. Sci., 1967, 36. Pp. 151-60.
Saussure	(1804)	Chemische Untersuchungen ubal die. Vegetation 2. German translation by A. Wieler, Wilhelm Engelmann, Leipzig.
*Sen, et.al.	(1954)	Nutrition of Mango. Fruit nutritio A Horticultural Publications. Rutgers University, New Brunswick, N.J.
*Sen, et.al.	(1947)	Hunger signs on Mango. Indian Journal of Horticulture. 5 : 35-44.

*Shaulis, N.J. (1960) Association between symptoms of K deficiency, plant analysis, growth and yield of concord grapes. Plant Analy. & Ferti. Probl. 44-58.

Shaulis & Kimball (1956) The association of nutrient composition of Concord grape petioles with deficiency symptoms growth and yield. Proc. Ameri. Soc. Hort. Sci. 68, 141-156.

Singh, M.P. (1961) Phosphorous, potassium and Magnesium deficiencies in mango, their prevention and control. A.R. Horti. Res. Inst. Saharanfone, U.P., India, 1961, Pp. 152-156.

*Singh, R.S. & Randhawa, G.S. (1961) Seasonal changes in the mineral composition of twigs of different growth flushes in sweet orange. Horti. Adv. 1961, 5 : 25-56.

*Smith, P.F. & Scudder, G.K. (1947) Nutrition of Mango fruit nutrition A Horticultural Publication, Rutgers University, Brunswick, N.J. (Quoted by Childer, 1954).

Smith, P.F. & Scudder, G.K. (1951) Some studies of mineral deficiency symptoms in mango. Pro. Florida Sta. Horti. Soc., 1951, 64 : Pp. 243-248, bibl. 6, illus.

Smith, P.F. (1956) Studies in relation to Boron level to the production of fruit quality of grape fruit and oranges. Citrus Indus. 1956(37)3, 5-8, 18 bibl. 10.

Smith, P.F. & Rasmussen, G. . (1962) Eight year study on N source for grape fruit reveals secreties. Citrus Veg. Magz., 1961, 25(3), 32-4, 6, 8, bibl.8.

Spencer, W.F. (1966) Effect of copper on yield and uptake of phosphorous and iron by citrus seedlings growth at various phosphorous levels. Sool Sci., 1966, Pp. 102-296.

Trezinski <u>et</u>.<u>al</u>.(1963) Conclusion de la annees ac recherche Surla Fummedes arbers fruiters (Conclusion from ten year research on the manuring of fruit trees) Com. Nat. St. Culi. Fruit (I.[illegible].I.A.) 1963, Pp. 1-84 (French) 85-115.

APPENDIX I

Soil analysis data of Mango Manurial Experiment, Vengurla.

I Chemical properties of the soil

S.No.:	Constituent	
1	Total nitrogen	0.075 %
2	Available P	Traces
3	Available K	0.0025 %
4	Exchangeable Ca	4.20 ME/100 gm of soil
5	Exchangeable Mg	1.66 ME/100 gm of soil
6	pH	5.4

II Physical properties of the soil

S.No.	Constituent	Percentage
1.	Moisture	6.62
2.	Organic matter	4.49
3.	Silt	19.58
4.	Clay	48.76
5.	Silt + Clay	68.34
6.	Coarse sand	6.27
7.	Fine sand	22.64
8	Total sand	28.22
9	Calcium carbonate	0.12

*Tripathi, R.D. & Sharma, K.N. (1963) Effect of spreader and pH on the absorption of urea by mango foliage. Indian Journal of Horticulture (1963)20:38-42, bibl. 9.

Volk, N.T. & Trong, E. (1934) Rapid chemical method for determining the readily available potash of soils. J. Amer. Soc. Agro. 2-C, 537-546.

Woodbridge, C.G.(1940) The boron content of Okanagan soils. Sci. and Agric. 20 : 257-265.

Woodbridge, C.G. (1951) Mag Manganese deficiency in peach and apple in British Columbia. Sci. Agri. 31 : 435-438.

Woodbridge, C.G. (1955) Mangesium deficiency in apple in British Columbia. Can. J. of Agri. Sci. 35 : Pp. 350- 357.

Woodbridge, C.C., Benson, N.R. & Batjar, L.P. (1961) Nutrition of fruit trees in the semi-arid regions of the Pacific North-West. Plant analysis and fertilizer problems. American Institute of biological - Sciences, Washington, 6, D.C.

Young, T.W., Koo and Miner, J.T. (1961) Effect of nitrogen, phosphorous and calcium fertilization on Kent mangoes on deep acid sandy soils. Proc. Flo. St. Horti. Soc. 75 : Pp. 364.

Young, T.W. & Miner, J.T. (1960) Response of Kent Mango to nitrogen fertilization. Proc. Flo. St. Horti. Soc., 1960, 73 : 334- 6, bibl. 6.

Yuda, E. & Okamoto, S. (1966) The effect of soil reaction on the growth of Young Citrus plants. II) Fomm of N and K fertilizers. J. Jap. Soc. Horticultural Science, 1966, 35, 19-28.

Zidan, Z.I. & Mobeimos, S.E. (1966) Seasonal changes in the chemical composition of mango leaves. Ann. Agric. Sci. Cairo, 1962 7(2) : 337-51.

* Originals seen.

APPENDIX II

Soil analysis data of Healthy and Diseased Mosambi Gardens.

I. Chemical properties of the soil.

Sr: No:	Constituent	Healthy	Diseased
1	Total nitrogen	0.074 %	0.071 %
2	Available phosphorous	0.0043 %	0.0062 %
3	Available potassium	0.065 %	0.028 %
4	Exchangeable calcium	52.40 ME/100 gm of soil	29.87 ME/100 gm of soil
5	Exchangeable magnesium	9.6 ME/100 gm of soil	17.40 ME/100 gm of soil
6	pH	8.1	7.8

II. Physical properties of the soil

S.No.	Constituent	Healthy	Diseased
1	Moisture	7.60	5.40
2	Organic matter	1.18	1.65
3	Silt	20.38	23.75
4	Clay	40.32	32.60
5	Silt + Clay	60.70	56.35
6	Coarse sand	8.89	8.82
7	Fine sand	17.64	22.24
8	Total sand	26.23	30.76
9	Calcium carbonate	4.48	3.25

APPENDIX III

Yield and growth data of Mango Manurial Experiment.

Season : 1969.

Sr: No:	Item	N		P			K			FYM		Lime	
		N_1	N_2	P_o	P_1	P_2	K_o	K_1	K_2	F_o	F_1	L_o	L_1
1	Average volume of tree in cubic meters.	124.67	105.82	115.03	106.47	124.25	113.18	119.80	112.83	106.19	124.31	118.00	112.50
2	Average number of fruits,1969	33.48	34.11	36.14	33.66	31.59	35.93	35.89	29.58	36.01	31.58	33.64	33.92
3	Average weight of fruits,1969	9.67	9.86	10.71	9.65	8.93	9.92	10.93	8.44	10.31	9.22	9.61	9.92
4	Progressive cummulative no.of fruits	65.65	61.65	58.36	70.99	61.60	69.42	71.17	50.36	65.19	62.11	62.89	64.41
5	Progressive cummulative wt.of fruits	19.66	17.63	18.37	20.31	17.25	19.23	21.01	15.89	19.51	17.77	18.15	18.64

The results are non-significant in case of all the items.

		Volume	No. of fruits	Weight	Cummulative no.of fruits	Cummulative wt.of fruits
S.E. for NP	..	8.04	6.10	1.94	7.32	6.58
S.E. for PK	..	10.00	7.35	2.70	8.97	6.05
S.E. for interaction.	..	14.00	10.52	3.39	12.65	11.01

APPENDIX IV

Soil pH data before and after application of lime to soils.

Year		L_0	L_1
1965	..	4.2	4.2
1967	..	4.5	4.7
1968	..	5.5	6.6
1969	..	5.1	5.7