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EFFECT OF MAGNESIUM AND CERTAIN MICRO-NUTRIENTS ON ROOT (WILT) AFFECTED AND HEALTHY COCONUT PALMS IN INDIA

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INTRODUCTION

About 40,000 hectares of coconut plantations in Central Kerala State, South India are affected by a serious disease known as the Root (wilt). The slow wilting of the foliage is associated with a gradual rotting of the root-system which is a striking feature of the Root (wilt). As per records, this disease was present more than 90 years ago in three foci of infection about 20 km from each other, but it is not clear how and from where the infection could have occurred [BUTLER, 1908 ; MENON and NAIR, 1949, 1951 ; MENON 1961]. The disease became significant after a severe flood in 1882 when the land was water-logged for a considerable time.

In the heavily infected tracts, about 80 % of the bearing palms are affected, nearly half of which has only 10-12 per cent of the original yield, thus accounting for a very heavy loss of revenue. Considering the seriousness of the problem, investigations to diagnose the disease and to evolve control measures were undertaken on the nutritional and biochemical aspects in relation to soil conditions, pathogenic aspects especially mycological and virological, and diagnostic tests. On the nutritional side, a large scale micro-nutrient manurial experiment on a 8 hectare plantation involving the use of magnesium and seven micro-nutrients was started at the Central Coconut Research Station, Kayangulam, to see whether these mineral nutrients could control the Root (wilt), improve the condition of the diseased palms, or prevent the healthy ones from contracting the disease. As the effect of the nutrients was recorded from the changes in the diseased condition of the palms leading to an increase or decrease in nut-yield, a brief knowledge on the main symptoms of the disease may be desirable.

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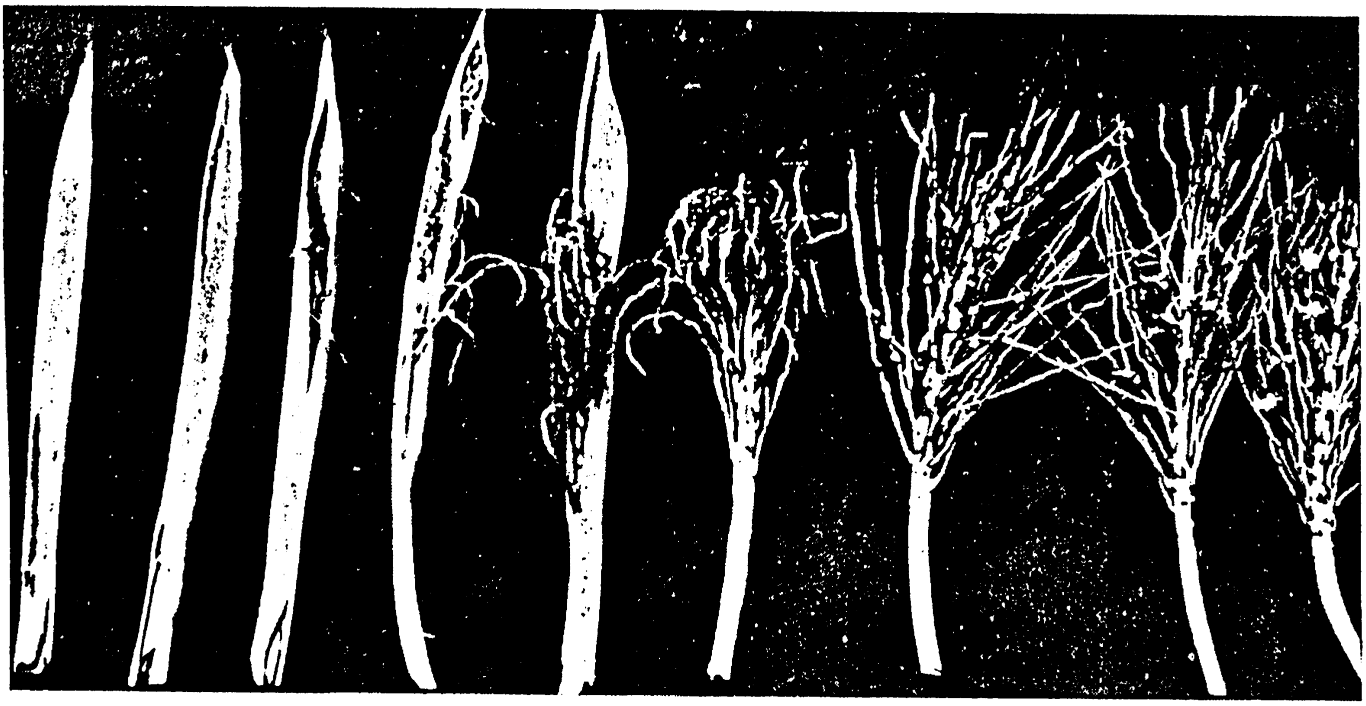

FIG. 1. — Nine successive inflorescences of a coconut palm affected by Root (wilt) disease. The young nuts and button-nuts have shed and the spadices of younger bunches failed to emerge.

SYMPTOMS OF THE COCONUT ROOT (WILT)

The several symptoms of the Root (wilt) disease of the coconut palm have been reported periodically. The most distinguishing symptoms are the generally slow wilting of the leaves ; flaccidity of the leaflets accompanied by an abnormal bending and often consequent breaking of the petiole ; marginal and tip necrosis of the leaflets ; abnormal button-shedding, and in many cases withering of the inflorescences of all stages (Fig. 1) [Davis, 1962, 1964 ; Maramorosch, 1964] ; production of a high percentage of sterile or dummy pollen grains, the normal ones losing viability and growth vigour early [Varkey and Davis, 1960] ; premature deterioration of the root system and poor root-production [Nagaraj and Menon, 1955, 1956 ; Menon *et al*, 1955] ; and yielding smaller quantity of root-exudation [Davis and Pillai, 1966]. The foliage in many palms become chlorotic, the discolouration usually developing from the oldest leaf. Conspicuous reduction in the nut-yield is an inevitable consequence, the nuts becoming smaller and their copra tending to be leathery and shrivelled as the disease advances. Many of the affected palms respond to manuring and cultural operations and some survive even 15-20 years after contracting the disease. The disease gradually spreads, and excessive nitrogen fertilising tends to accelerate the spread. Trials have proved that the disease is transmissible to healthy coconut palms through many agencies : sap transfusion, innoculation of sap and soil extract, root-grafting and insect vectors [Nagaraj *et al*, 1954 ; Radha and Menon, 1954, Shanta *et al*, 1960 ; Shanta and Menon, 1961 ; Menon and Shanta, 1962]. The disease is reproduceable on a few other palm species and many weeds and intercrops.

Fig. 3. — A coconut palm (centre) in the advanced stage of Root (wilt) disease.

In the early stage of the disease (Fig. 2), visible symptoms may appear singly or in combination, accompanied by chlorosis of the older leaves in the majority of the cases. But as the disease progresses, these symptoms become more pronounced. The leaves are shed in quick succession and the general growth rate of the palm is retarded so that the number of leaves produced becomes smaller, the leaves themselves becoming short and stunded. The production of female flowers is curtailed ; the spathes become much smaller in size, and accompanied by premature nutfall, the yield gets gradually reduced. In the late stage of the disease (Fig. 3), the palm bears a highly reduced crown of fewer stunted leaves and a few highly diminutive spathes. The foliar symptoms generally appear first on the younger leaves. Thus, although the yellowing appears to be on the outerwhorl, it starts as small specks or dots on a young leaf, later spreading and merging with other in the older leaves. Yellowing and sudden drying of intermittent leaves are also not uncommon just as blackening and shrivelling of spathes (Fig. 1). The natural resistance of the tree is broken and the foliage becomes susceptible to the attack of secondary parasites like fungi and bacteria that cause severe leaf-rot. Progressive deterioration of the root system takes place with the drying up of the majority of rootlets and roots from the tip backwards. The newly formed rootlets also get

Fig. 2. — A coconut palm showing early symptoms of Root (wilt) disease.

rotted due to the attack of soil parasites. A hard hypodermis is formed in many apparently healthy roots, thus preventing their normal functioning. Increased root production takes place in some case (Fig. 4) to counteract the abnormal root loss by rotting, but as the natural resistance of the tree is gradually lost, these newly formed roots are affected by soil parasites. Root production is highly curtailed in the late stages. Generally, palms that have just started bearing are most susceptible, infection on palms younger than three years being very rare.

FIG. 4. — A portion of the root system of a diseased palm exposed to show the many fresh roots emanating from the « bole » to replace the several older ones rotted due to the disease.

MAGNESIUM AND MICRO-NUTRIENTS ON COCONUT

Most of the earlier manurial experiments on the coconut dealt with macro-nutrients, especially N., P. and K. Coconut palm has not been given its due share in trials with micro-nutrients although there is extensive literature on derangements due to deficiency, toxicity and interaction of micro-nutrients in other plants [STILES, 1946 ; WALLACE, 1951 ; LAL and RAO, 1954]. The limited literature on coconut includes those of BODIN (1917, 1929), who found that iron salts could cure chlorosis in palms and increase the nut-yield, and DICKEY (1942) who stated that manganese deficiency in Florida was cured by soil or foliage application of manganese. PILLAI and DAVIS (1963) studied the magnesium requirement of the coconut by estimating the MgO available in the nuts, leaves and other organs produced by the palm during a year. Palms (Tall variety) growing in sandy soil of average fertility exhausted about 21 kg MgO per hectare. SALGADO and NETHASINGHE (1960) and NETHASINGHE (1960) corrected an intense yellowing of mature coconut leaves in Southern and Western provinces of Ceylon by the application of magnesium. According to JACOB (1958) oil and fibre-yielding plants have a relatively high requirement of magnesium, as such, they develop deficiency symptoms early. FRÉMOND (1964) did not find any favourable effects of magnesium even where there was a positive deficiency of magnesium (even below the level of 0.300) except in one case (P. B. CC.3) where the applicarion of magnesium sulphate increased the number of bunches and the number of female flowers per bunch. Application of iron and manganese to soils in Ivory Coast according to FRÉMOND was almost ineffective. On the other hand, in the case of young coconut palms in French Polynesia he found very small quantities of iron sulphate (10 gm) and manganese (5 gm) placed in the husk helping normal growth. FRÉMOND also studied the effects of molybdenum, boron, copper and zinc on leaf content and production in the Ivory Coast. But after three years no clear effect was noticed on the yieds. Other workers [BERTRAND and BENZON, 1928 ; NEWCOMB and SANKARAN, 1929 ; DODD, 1929 ; MORRIS, 1941 ; INNES, 1949 ; SANKARA SUBRAMONEY et *al*, 1951, 1954 ; VERGHESE, 1961 ; VERGHESE *et al*, 1957 ; SMITH, 1964] found no correlation between the micro-nutrient status and the productivity or disease conditions of palms. However, the micro-nutrients due to their vital functions as prosthetic groups in enzyme systems catalysing the metabolic activities might be expected to be linked up with most of the physiogenic and pathogenic diseases in the coconut or plants in general. Whith the above assumption, a well-planned field experiment supplemented by tissue analysis was started at Kayangulam (South India) to find out how far magnesium and certain micro-nutrients ameliorate or control the Root (wilt) disease of the coconut.

MATERIALS AND METHOD

384 coconut palms standing in the farm attached to the Central Coconut Research Station, Kayangulam, South India, were selected at random from among healthy trees (category I), trees in the early stage of Root (wilt) showing mild disease symptoms (category II) and trees in the advanced stage of Root (wilt) (category III) in a 8-hectare block. A 2^7 Factorial Confounded Design provided the layout of the experiment. The nutrients included magnesium, boron, copper, manganese, iron, molybdenum and zinc. The actual quantities of nutrients applied are furnished in table I.

TABLE I

Treatment and dose of individual micro-nutrients

Micro-nutrient — Symbol : In the form of	Dose/tree year (gm)	Quantity of micro-nutrient present (gm)
Mg* Magnesium sulphate.. ($MgSo_4.7H_2O$)	454	45.4 (magnesium)
B Borax .... ($Na_2B_4O_7.10H_2O$)	227	25.9 (boron)
Cu Copper suphate ..... ($CuSO_4.5H_2O$)	227	58.1 (copper)
Mn Manganese sulphate .. ($MnSO_4.4H_2O$)	227	55.8 (manganese)
Fe Ferrous sulphate .... ($FeSO_4.7H_2O$)	227	45.4 (iron)
Mo Ammonium molybdate ($(NH_4)_6 Mo_7 O_{24}.4H_2O$)	2	1.0 (molybdenum)
Zn Zinc sulphate .... ($ZnSo_4.7H_2O$)	227	51.3 (zinc)

* This element conventionally belonging to the macronutrient group is included on account of its beneficial effects to the diseased palms.

All possible combinations of the seven micronutrients, i. e. 0, 1, 2, 3, 4, 5, 6 & 7 at a time were applied to the trees, the total number of combinations amounting to 128. An individual tree was the ultimate unit of the experiment, and there were three trees for each treatment, one healthy and two diseased.

The micro-nutrients were applied in single annual doses at the end of the South-West monsoon (August-September). The first application was made in September 1953. Regular monthly observations made on the condition of the crown of the trees, detailed measurements on leaves and spadices and the nut-yield data were recorded in separate files maintained for each tree. Colour sketches of the crown of all the experimental trees were also prepared at the start of the experiment depicting the condition of trees for future comparisons.

RESULTS

In judging the improvement in the condition of trees due to the micro-nutrients, the yield of the trees has been taken as the main criterion. It has been observed with Root (wilt) diseased trees that the yield gradually goes down either due to the premature shedding of buttons and/or decreased production of female flowers and poor setting of the flowers. An improvement in the production of nuts can therefore be taken to indicate an improvement in the condition of the trees.

In tables II to IV are presented the average annual

TABLE II

Pre and post-treatment yields. Healthy trees

Treatment	Average annual yield per tree			
	With nutrient		Without nutrient	
	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment
1	2	3	4	5
Mg	40.4	57.6	42.3	55.7
B.........	39.2	54.3	43.5	58.9
Cu........	40.4	57.2	42.3	56.1
Mn	43.4	59.8	39.3	53.5
Fe	42.9	58.7	39.8	54.5
Mo	39.2	53.4	43.6	59.8
Zn........	40.5	55.8	42.2	57.4
Control ...	—	—	13.8	4.0

TABLE III

Pre and post-treatment yields
Trees in early stage of disease

Treatment	Average annual yield per tree			
	With nutrient		Without nutrient	
	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment
1	2	3	4	5
Mg	29.0	36.1	24.1	30.6
B.........	24.4	31.2	28.7	35.5
Cu........	30.6	37.4	22.5	29.3
Mn	27.6	36.1	25.5	30.6
Fe	28.0	32.7	25.1	34.0
Mo	26.7	38.0	26.4	30.7
Zn........	26.5	33.0	26.6	33.7
Control ...	—	—	9.8	22.8

TABLE IV

Pre and post-treatment yields
Trees in late stage of disease

Treatment	Average annual yield per tree			
	With nutrient		Without nutrient	
	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment
1	2	3	4	5
Mg	22.2	24.9	15.3	15.8
B	18.9	20.5	18.7	20.2
Cu	18.5	20.8	19.1	20 0
Mn	18.9	20.7	18.7	20.1
Fe	18.9	20.5	18.6	20.3
Mo	18.5	20.9	19.0	19.8
Zn	16.8	18.8	20.7	22.0
Control	—	—	14.5	5.0

yields of the three categories of trees which received and did not receive the micro-nutrients during the post-treatment period (1953-1957). The pre-treatment yield data of the same trees for four years from 1949-1952 have also been given side by side for comparison. The average annual increase in yield and production of leaves, spadices etc. have also been worked out.

Application of magnesium has improved the nut-yield in all categories, the healthy as well as the severely diseased palms showing greater response. Boron produced a small increase in the yield of the diseased trees. Copper increased the yield of healthy and severely diseased palms, the healthy trees responding more to the treatment. Manganese increased the yield of all trees, the maximum effect being found in trees mildly affected by the Root (wilt). Iron had no effect on the diseased trees, but increased the yield of healthy trees. A favourable response with the application of molybdenum is seen in the diseased trees. No significant favourable response was observed with zinc.

TABLE V

Summary of main effects

Category	Treatments						
	Mg	B	Cu	Mn	Fe	Mo	Zn
1. Healthy	xxx	–	xxx	xx	xx	–	x
2. Early stage of Root (wilt)	x	x	–	xxx	–	xxx	–
3. Advanced stage of Root (wilt)	xx	x	xx	x	–	xx	x

xxx = maximum effect (increase of yield by 3 to 6 nuts).
xx = moderate effect (increase of yield by 1 to 3 nuts).
x = negligible effect (increase of yield below 1 nut).
– = no or depressive effect (increase over pre-treatment yield negative).

TABLE VI

Percentage distribution of the 384 experimental trees (originally 128 healthy and 256 diseased)

Original condition of trees	Percentage of palms		
	improved	remained unchanged	deterio-rated
1. Healthy	12.5	62.5	25.0
2. Early stage of disease	31.8	48.2	20.0
3. Advanced stage of disease	15.0	60.3	24.7
4. Average	19.8	57.0	23.2

The main effects are further summarised and presented in table V.

From data given above, it is clear that 25 % of the trees which looked healthy in 1953 showed some symptoms of the disease and deteriorated in condition in the course of three years, while a number of trees, particularly those in the early stage of Root (wilt),

TABLE VII

Micro-nutrients in leaf tissues of healthy and diseased palms

Micro-nutrient	Condition of tree	Mean (p. p. m.)	Standard deviation	Statistical significance P = 0.05 (RW-H)
Boron (B)	H RW	7.0 15.4	2.3 3.2	significant
Copper (Cu)	H RW	21.7 38.8	9.3 11.5	significant
Manganèse (Mn)	H RW	68.4 155.9	21.2 19.6	significant
Iron (Fe)	H RW	270.3 256.4	71.5 73.1	not significant
Molybdenum (Mo)	H RW	0.2 0.4	0.1 0.3	not significant
Zinc (Zn)	H RW	34.8 51.6	10.4 12.5	significant

H = Healthy palms. RW = Palms affected by Root (wilt) improved their foliar conditions. In healthy trees, visible improvement was indicated by the leaves getting a darker green colour.

Micro-nutrient content of leaves.

On account of the above results, it was thought worthwhile to compare the micro-nutrient status of healthy and Root (wilt) diseased leaf tissues for a better interpretation of the results. Leaf samples collected from sixteen healthy and sixteen Root (wilt) diseased trees were analysed for boron, copper, manganese, iron, molybdenum and zinc. The data thus collected were analysed statistically and the results presented in table VII.

The results indicate that taken on a dry weight basis, the levels of boron, copper, manganese and zinc in the leaves of diseased trees are higher in comparison with those in healthy trees. The leaf tissues of healthy trees are found to contain a higher quantity of iron, though not significantly more. The higher status of micro-nutrients in diseased tissues may indicate metabolic derangements in the system which might have disturbed translocation and proper utilization of these nutrients. The exact nature of these metabolic blocks in reaction pathways require further careful investigation. Root exudations from diseased palms gave actually lower values for magnesium [Davis and Pillai, 1966] which may in part explain why further application of magnesium has been found to be beneficial.

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