STATEMENT OF WORK DONE ON THE CHEMICAL ASPECTS OF THE ROOT (WILT) DISEASE OF COCONUTS IN TRAVANCORE-COCHIN

by

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Results of investigations on the Root (Wilt) Disease of Travancore-Cochin have been reported in a series of publications from the Central Coconut Research Station, Kayangulam. A review of work done during the years 1937 to 1958 is also contained in The Coconut Palm - A Monograph by K.P.V. Menon and K.M. Pandalai. No attempt is, therefore, made here to present the problem in its different aspects, but the salient features of the work already done and the studies that have been carried out since the publication of the Monograph on the chemical aspects of the problem are presented in this note.

SOILS

I. Soil survey of Travancore-Cochin.

In order to assess the properties of the soil in relation to the disease, a reconnaissance soil survey of the coconut growing areas of Travancore-Cochin was conducted. The soils of Travancore-Cochin belong to four main types viz. (i) the sandy or sandy loam soils of the coastal tracts, (ii) the alluvial loams, (iii) the red loam and (iv) laterite soils. The coconut palm grows quite well in all these four main soil types, but the disease was also found to be prevalent in all the four.

During the soil survey 104 soil samples were collected from 50 representative sites where profile pits were dug upto a depth of six feet or upto the water table or upto any impermeable bottom layer, if this happened to be nearer the surface than six feet. The chemical and the physical properties of the samples collected were studied.

From the summary of results presented in Table I it could be seen that:-

Nitrogen.

In the soil samples from diseased areas of the sandy and alluvial loam types, there is a higher percentage of nitrogen than in the healthy areas, the reverse being the case with red loam. In laterite soils, healthy localities have a higher nitrogen status in the A horizon and a lower status in the B and C horizons.

Organic carbon and organic matter.

There is a higher content of organic carbon in diseased areas of both the horizons of sandy type, the A horizon of alluvial loam and the A and B horizons of the laterite type whereas the B horizon of alluvial loam, both horizons of red loam and the C horizon of laterite contain more of this constituent in the healthy areas.

The organic matter content is higher in samples belonging to (a) both horizons of the sandy type, (b) A horizon of alluvial loam type and (c) A and B horizons of the laterite type in the diseased group. Organic matter content is, however, lower in the samples from the diseased areas of both the horizons of red loam type, C horizon of the laterite type and the B horizon of the alluvial loam type.

Carbon nitrogen ratio.

The values of C/N ratios are higher in diseased areas of B horizon of sandy type and A and B horizons of laterite type, but it is lower in (a) both the horizons of red loam type, (b) the A horizon of the sandy type and (c) the C horizon of the laterite type. There is not much difference in the alluvial loam type.

Phosphoric acid.

There is a higher concentration of total and available phosphoric acid in the B horizon of the diseased areas of sandy soil. However, the A horizon of healthy areas contains slightly higher amount of available phosphoric acid. In alluvial loams, the total phosphoric acid is higher, but this difference is confined to the B horizon with regard to available phosphoric acid. Samples from the B horizon of healthy areas with red loam-soil have a higher total phosphoric acid content. No appreciable difference is noticed in the A horizon. The A horizon of healthy areas have a higher content of available phosphoric acid whereas there is no difference in the B horizon. In laterite soils, total phosphoric acid content is higher in healthy areas while available phosphoric acid content is higher in diseased areas.

Iron oxide.

There is, in general, a higher concentration of total iron in the soils of healthy areas. Available iron was not, however, determined.

Total, available and exchangeable potash.

There is a greater percentage of total potash in the soil samples from both horizons of the red loam type and the A horizon of the sandy type in the diseased group. In the case of laterite and alluvial loam types, samples from healthy areas have a higher status of total potash. Regarding available potash, all samples examined were found to be rather deficient. However, samples from healthy areas gave higher values. With regard to exchangeable potash, there is no difference between healthy and diseased areas of the sandy and laterite types, but samples from healthy areas of alluvial and red loam types contained greater quantities of this constituent than those from corresponding diseased areas.

The general conclusion appears to be that soils of the diseased areas have lower status of available and exchangeable potassium than soils from healthy areas and that a deficiency of this element in an available form might be one of the factors which favours the onset of pathological conditions.

Total and exchangeable calcium.

In general the total calcium content of the soils from healthy coconut areas is greater than those from the diseased areas. The exchangeable calcium of the sandy and alluvial loam types of soils is also higher, but there is no significant difference in the red loam. As regards the laterite soils, the A and B horizons exhibit no significant difference while in the C horizon, there is a slightly higher concentration of exchangeable calcium in the diseased areas.

Total and exchangeable magnesium.

There is a greater concentration of total magnesium in the soils from diseased areas of sandy and alluvial soils, the position being reversed in the other soil samples. The exchangeable magnesium content of soils from healthy areas is greater with the exception of sandy soils where the diseased areas contain more of this constituent.

Base exchange capacity, exchangeable hydrogen and percentage base saturation.

In soil samples from the healthy areas belonging to the sandy alluvial loam and red loam types, there is a greater amount of total exchange--able bases, lesser amount of exchangeable hydrogen and consequently a higher value of percentage base saturation.

The values for the samples from laterite areas are not so consistent. The total exchangeable bases are higher in diseased areas. The values for exchangeable hydrogen are comparatively lower for the samples from the A horizon of the healthy areas while for those from the B and C horizons they are higher. The percentage of base saturation values are higher in the samples from the A and C horizons of diseased areas while there is no significant difference between the B horizon samples.

With regard to values for the cation exchange capacity, samples from diseased areas belonging to both the horizons of the alluvial loam type, the A horizon of laterite and red loam type and the B horizon of sandy type have higher values than the corresponding samples from healthy areas. In the case of the A horizon of the sandy areas and the C horizon of the laterite areas, the samples from healthy localities have higher values. There is no difference between healthy and diseased areas as far as the samples from the B. horizon of the laterite are concerned.

pH.

There are significant differences between healthy and diseased areas, the former having definitely higher values.

The above summary would show that compared to healthy areas, soils from the diseased areas contain lower amounts of available potassium, total calcium and iron. Total exchangeable bases and percentage base saturation are also lower with higher values for exchangeable hydrogen. The diseased areas were invariably more acidic.

During the many surveys that have been undertaken to study the incidence and spread of the disease, it was found that a large proportion of the diseased areas had water table near the surface. Some of these areas were water logged or flooded with water many times during the year.

Mechanical composition.

The mechanical analysis of the samples disclosed that the silt and clay contents of the soils from the majority of the coconut growing areas are low. Appreciable difference was, however, noticed between healthy and diseased areas. The percentage of coarse sand fraction in diseased areas was thus comparatively greater in sandy and red loam soils, but generally lower in the alluvial loam and laterite with a corresponding change in the finer fractions. Thus, just as in the case of chemical properties, there are no differences between healthy and diseased areas common to all the soil types.

II. Soils of Central Coconut Research Station, Kayangulam.

The Central Coconut Research Station, Kayangulam is representative of a very large area where coconuts are grown in Travancore-Cochin and where diseases also are rampant. The soil of the station was, therefore, studied for fertility status and 438 samples drawn from the first, second and third foot layers of 0.3 acre plots were analysed. It was found that the soils were of low fertility status and that there was no appreciable plot to plot variation.

Subsequently a detailed soil survey of the Station garden was conducted and three series of soils were identified, which are defined as:-

Series 1 : $\dfrac{K\ P_1 lsd_5}{A\ e_1}$

Series 2 : $\dfrac{K\ P_2 fsd_5}{A\ e_1}$

Series 3 : $\dfrac{K\ P_3 fsd_5}{B\ e_1}$

where K P_1 refers to Krishnapuram Series 1
K P_2 " Krishnapuram Series 2
K P_3 " Krishnapuram Series 3
ls " loamy sand texture
fs " fine sand
d_5 " very deep
A " nearly level
B " gently sloping
e_1 " no erosion or slight erosion

Series 1 (K P_1)

This is the major soil series occurring in the Research Station garden occupying nearly 90 percent of the total area. It is uniformly loamy sand in texture, loose in consistency, structureless, well drained and very deep with very little erosion.

Series 2 (K P_2)

Only a small area is covered by this series which occurs in the low-lying regions. It is characterised by a horizon of imperfect drainage in the solum between the third and fifth foot, containing a mixture of sesquioxide and organic matter. It is fine sand in texture and very deep with good drainage in the top layers.

Series 3 (K P_3)

This series is also found in limited areas. Unlike the other two, this soil has a deep colour which changes from brown at the top to light red at the sub-surface and gradually fading to pale yellow further down. It is very deep and well drained with a fine sand texture for the surface soil and loamy sand for the sub-soil. The deepening of the colour in this series may be attributed to the eluviation of oxides and hydroxides of iron from the surface horizon and indicates the well drained nature of the soil and its good aeration.

The analytical values for fertility status indicate that the soils are generally poor in their nutrient status and organic matter content in spite of regular manuring and cultural operations. The highest values obtained are given in the table below:-

Series	Nitrogen (N)	Phosphoric acid (P_2O_5)	Potash (K_2O)	Lime (CaO)	Available P_2O_5	Available K_2O	Organic carbon.	C/N ratio	pH range	Cation exchange capacity m.e.
	%	%	%	%	%	%	%			%
K P_1	0.027	0.041	0.074	0.039	0.012	0.036	0.14	5.0	5.0 to 5.5	4.7
K P_2	0.028	0.023	0.058	0.022	0.018	0.019	0.50	19.0	5.2 to 5.6	4.0
K P_3	0.024	0.029	0.115	0.022	0.003	0.014	0.12	5.0	5.2 to 5.4	2.8

The maximum clay content in the three series were, 11.9 percent, 7.4 percent and 10.6 percent respectively.

Similar studies of other representative tracts have been started.

III. Strontium and Cadmium.

To study whether strontium or cadmium toxicity is a factor for disease incidence, representative soil samples were again drawn by another reconnaissance survey and type samples of soils and leaves were examined for these metals. The soils did not contain cadmium, but only minute traces of strontium. Field experiments disclosed that healthy trees treated with small amounts of cadmium wilted in about a fortnight's time, but did not produce any of the symptoms of the Wilt Disease. Trees treated with strontium were not affected and continue to be healthy. The leaf samples also did not contain cadmium but only traces of strontium.

IV. Sudden wilting of palms in Thottappally.

A case of sudden wilting of palms in Thottappally (Alleppey District) was reported due to the dumping of dredged sub-soil and sub-soil water into healthy coconut gardens. Investigations of the soil conditions of the affected area showed that the wilting was due to root injury caused by (i) the shift in pH due to the percolation of the sub-soil water on the surface of the soil during the process of dumping the subsoil on it, (ii) the presence of reduction products like sulphides, ferrous iron etc. in the dredged material, (iii) the presence of toxic factors such as soluble aluminium, (iv) the potential capacity of the dredged sub-soil for the formation of mineral acids by hydrolytic changes and (v) complete anaerobic conditions in the root rhizosphere causing intense root suffocation.

Manurial experiments.

The possibility of remedying the diseased conditions by manurial treatments was investigated. The following manures were tried:-

1. Lime and Ash.

Lime at 8.0 lb. and ash at 60.0 lb. (in two doses) over a basal dressing of groundnut cake 7.0 lb., bonemeal 3.0 lb., and muriate of potash 2.0 lb. per tree per year were applied for five years to 25 diseased trees while 25 trees were kept as controls. The trees were regularly observed for morphological diseased conditions and soil and leaf samples collected periodically were analysed for calcium and potassium. The mass of data obtained during the five year period on statistical analysis showed that the lime and potash levels of the soil deteriorated inspite of the yearly soil application. The potash content in the leaves increased irrespective of whether the trees were treated or not while an increase in calcium content was noticed in the treated. None of the trees, however, improved to any appreciable extent.

2. Chilean nitrate.

20 diseased trees were treated with chilean nitrate to supply 2.0 lb. nitrogen over a basal application of 0.75 lb. of phosphoric acid as bonemeal and 1.5 lb. of potash as muriate of potash per tree per year for a period of three years. Morphological condition of the trees were regularly observed. There was no improvement in the diseased condition.

3. Filter press mud.

Filter press mud containing 1.3% N, 1.8% P_2O_5, 0.3% K_2O, 3.7% CaO, 0.5% MgO and 31.0% organic matter and traces of iron, copper, manganese and boron was applied at the rate of 2 Cwts. per tree per year for a period of three years. There was no improvement in the diseased condition of the trees

4. Magnesium sulphate.

Surface roots were induced in heaps of soil around bases of diseased trees and magnesium sulphate at 2.0 lb. per tree over a basal dressing of NPK manures was applied for a period of five years. Leaf samples were analysed for nitrogen, phosphoric acid, potash, lime and magnesia. An increase in the nutrient content of leaves, particularly of magnesium was noted. Considerable improvement in the foliar condition of the trees was observed.

TISSUE ANALYSIS

1. Standardisation of leaf sampling technique.

A method of sampling leaves was standardised inorder to draw samples for comparative study. Moisture, phosphoric acid and chlorophyll were estimated in every 10th leaflet in the fully emerged leaves of 15 adult healthy trees and 40th to 50th leaflets in all the leaves of four trees. From the data, it was concluded that "in a tree with 'n' number of leaves, the $(\frac{n}{2} + 1)^{th}$ leaf has to be selected for sampling and that from the 40th to 50th leaflets of this leaf will give a representative sample".

2. Nutrient content of leaves.

During a soil survey, leaf samples were collected according to the above technique from healthy and diseased trees situated near the soil profile pits. They were analysed for nutrient content. The results are summarised in Table II.

It was found that compared to healthy leaves, the diseased leaves contained more of nitrogen, phosphoric acid, and potash to the extent of 5.0 to 13.0 percent, 0.0 to 21.0 percent and 7.0 to 48.0 percent respectively. Ash insoluble in hydrochloric of diseased leaves was higher by 22.0 to 134.0 percent. The values for calcium and magnesium were not consistent. Examination of the results for nutrient inter-relationship showed that the palms were in a state of unbalanced nutrition. There was more of nitrogen relative to potash, compared to the nitrogen potash ratio recommended for coconut manuring in the major coconut growing countries. The nitrogen/insoluble ash ratio was lower in diseased leaves irrespective of soil types.

3. Copra and coconut oil.

The general belief that the incidence of disease is accompanied by a lowering of the oil content of the nut was disproved by the determination of oil contents of nuts from healthy and diseased trees growing under indentical conditions. There was no appreciable difference in oil content. An investigation of the nutrient content of copra collected from trees under different manurial treatments showed that copra from trees treated with N, P and K contained greater amounts of these constituents. The physical and chemical characteristics of the oil were not, however, different.

STUDIES IN PROGRESS

Investigations which are now in progress on which conclusions cannot yet be drawn are briefly mentioned below:-

1. Collection of comparative analytical data on soil and plant material.

Expert soil scientists of India have advised that a detailed soil survey of the healthy and diseased areas should be conducted and soil characteristics studied in relation to the chemical constituents of leaf samples from healthy and diseased trees. This work is now in progress. A detailed soil survey of 28 villages comprising of 68,000 acres of coconut gardens has been conducted, according to the procedure laid down for the All India Soil and Land Use Survey.

261 soil samples from 81 soil profile pits and 88 leaf samples from trees situated near the pits have been collected. These samples are under investigation. The samples are being analysed for fertility status, base exchange properties, physical properties, content of free iron oxide, hydrochloric acid (1:1) soluble titanium etc. Since most of the area surveyed belongs to a completely healthy area, the analytical values cannot, at present, be compared.

Micronutrients.

Iron, Copper, Zinc, Manganese, Boron and Molybdenum are now being determined in the soil and leaf samples collected during the detailed soil survey. There are indications of manganese deficiency in the diseased conditions, but the results have to be confirmed by analysing more samples from the diseased group.

2. Manurial experiments.

i. Heavy doses of N.P.K. manures: Preventive and curative.

In a randomised and replicated trial, heavy doses of N P K manures maximum dose being N. = 3.0 lb., P_2O_5 = 2.0 lb. and K_2O = 6.0 lb. per tree per year, are applied to healthy trees in the pre-bearing age to see if supply of excessive nutrition just at this critical period in the plant's life could help to get over the disease. A similar trial is also in progress to study the curative effect of such nutrition in diseased trees.

ii. Sulphur.

Sulphur 2.0 lb. per tree per year as elemental sulphur and also as calcium sulphate and magnesium sulphate over a basal dressing of N P K manures have been applied to diseased trees to study the response compared to untreated controls.

Diseased coconut palms have been treated with:

iii. Plantomine)
iv. Fenugol)
v. Trigolene.)

Activated chemical fertilisers reported to have spectacular effects on diseased agricultural crops.

vi. Sterameal Green Label.

An organic manure supplemented with N.P.K. in the inorganic form.

vii. Sea magic.

This is a sea weed leaf spray containing nitrogen, phosphoric acid, potash, magnesium, trace elements, hormones etc. Diseased palms have been sprayed with this compound.

3. Effect of cover crop on disease.

In a plot containing diseased and healthy trees and underplanted seedlings of different ages, a cover crop, *Pueraria phaseoloides*, has been raised to study whether the cover crop has any effect in curing the disease or preventing its development.

Earlier studies showed that the cover crop in question helped considerably in reducing soil temperature. Compared to an adjoining uncropped fallow plot, the plot with a cover crop of *Pueraria phaseoloides* had the temperature of the surface soil lowered during the peak of summer by 17 to 22° C. At the same time, the moisture content was higher.

4. Reduction products formed under water logged condition.

Since the disease is found in a severe form in water logged situations, the possibility of toxic reduction products formed under water logged soil conditions being a factor for disease incidence is being studied. Dwarf green coconut seedlings grown in big sized pots containing soil from representative diseased sites are kept water logged and the leachates from the pots examined for reduction products.

5. Foliar yellowing.

Yellowing of leaves during periods of heavy rainfall have been noted in certain places. This is seasonal and naturally disappears with the advent of summer. It is, however, believed that this eventually brings in the disease. In certain other localities with high water table the yellowing is of a more or less permanent nature. These are under investigation by properly designed pot and field experiments. In pot culture studies, dwarf green coconut seedlings are subjected to water logging. In the field, trees, in water logged areas with severe yellowing of leaves are treated with micronutrients and urea spray. The level of the land has been raised in a few cases by forming mounds with river sand round the trees. The latter treatment has given very encouraging results.

6. Leaf sampling technique.

Work on this to confirm the earlier finding is in progress, since it is considered that foliar analysis is a very important corollary to soil tests and this technique, very much valued in disease investigations, cannot yield dependable results unless the sampling procedure is correct. In the expanded scheme now in progress, more trees have been selected for sampling. The analysis has been extended to cover the major nutrients, nitrogen, phosphoric acid, potash, lime and magnesia. The analysis of 1,048 samples has been completed.

Table I

Summary of Results of Studies on Coconut Soils - Healthy and Diseased Areas

		Soil type							
		Sandy		Alluvial loam		Red loam		Laterite	
	Horizon	Diseased	Healthy	Diseased	Healthy	Diseased	Healthy	Diseased	Healthy
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Nitrogen (N) %	A	0.049	0.030	0.091	0.069	0.034	0.070	0.094	0.107
	B	0.038	0.023	0.088	0.055	0.033	0.060	0.090	0.078
	C	...	...	...	...	...	...	0.074	0.046
Organic Carbon (C) %	A	0.236	0.222	0.847	0.645	0.179	0.717	0.792	0.754
	B	0.244	0.125	0.724	0.745	0.193	0.681	0.775	0.569
	C	...	...	...	...	...	...	0.439	0.554
Organic matter %	A	0.408	0.383	1.461	1.112	0.308	1.236	1.348	1.300
	B	0.421	0.216	1.247	1.284	0.332	1.174	1.335	0.982
	C	...	...	...	...	...	...	0.759	0.955

Table I (Contd.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Carbon	A	5.0	6.9	9.6	9.3	5.7	10.7	8.6	8.0
Nitrogen	B	7.4	4.9	8.2	8.5	6.0	10.2	9.2	7.1
Ratio C/N	C	...	...	...	...	...	...	5.5	22.0
Total Phosphoric acid	A	0.036	0.034	0.073	0.051	0.042	0.039	0.050	0.082
	B	0.036	0.028	0.068	0.042	0.036	0.042	0.030	0.078
(P_2O_5) %	C	...	...	...	...	...	...	0.028	0.085
Available	A	0.014	0.020	0.006	0.006	0.007	0.010	0.004	Trace
Phosphoric	B	0.018	0.009	0.007	0.004	0.006	0.006	0.006	Trace
acid (P_2O_5) %	C	...	...	...	...	...	...	0.002	0.001
Total	A	0.93	1.14	5.42	6.63	2.40	3.63	6.30	8.44
Ferric Oxide	B	0.88	0.98	6.03	6.01	2.84	3.90	5.50	8.89
(Fe_2O_3) %	C	...	...	...	...	...	...	6.85	8.73
Total	A	0.013	0.005	0.087	0.153	0.060	0.026	0.085	0.114
Potash	B	0.009	0.010	0.093	0.151	0.051	0.031	0.071	0.118
(K_2O) %	C	...	...	...	...	...	...	0.085	0.128
Available	A	0.001	0.002	0.002	0.008	Trace	Trace	0.004	0.007
Potash	B	Tracc	0.002	Trace	0.005	Trace	0.001	0.003	0.003
(K_2O) %	C	...	...	...	...	...	...	0.002	0.006
Exchangeable	A	Trace	Trace	0.21	0.81	Trace	Tracc	Trace	Trace
Potassium	B	Trace	Trace	0.28	0.87	Trace	0.11	Trace	Trace
m:e/100g.	C	...	...	...	...	...	...	Trace	Trace
Calcium	A	0.115	0.111	0.026	0.075	Traoe	0.026	0.004	0.015
(CaO) %	B	0.091	0.168	0.040	0.093	Trace	0.029	Trace	Trace
	C	...	...	...	...	...	...	0.004	Trace
Exchangeable	A	0.80	1.29	0.13	0.81	Trace	Trace	Trace	Trace
Calcium	B	0.64	0.75	0.37	0.89	Trace	Trace	Trace	Trace
m:e/100g.	C	...	...	...	...	...	...	0.004	Trace
Magnesium	A	0.055	0.025	0.108	0.073	0.012	0.017	0.025	0.086
(MgO) %	B	0.077	0.058	0.101	0.092	0.031	0.048	0.020	0.045
	C	...	...	...	...	...	...	0.024	0.076
Exchangeable	A	0.11	Trace	0.61	1.24	Trace	Trace	0.41	0.57
Magnesium	B	0.09	Trace	0.62	1.12	Trace	0.22	0.33	0.39
m:e/100g.	C	...	...	...	...	...	...	0.32	0.71
Total	A	1.63	2.49	2.83	4.18	1.08	2.62	2.69	1.73
Exchangeable	B	1.43	1.62	3.79	4.31	0.83	3.59	2.02	1.71
bases m:e/100g.	C	...	...	...	...	...	...	2.27	1.92
Base exchange	A	2.70	3.45	7.90	6.20	5.95	5.00	8.10	6.50
capacity	B	3.03	2.52	7.00	5.60	5.75	6.86	6.88	7.10
m:e/100g.	C	...	...	...	...	...	...	6.58	9.20

Table 1 (Contd.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Exchangeable Hydrogen m:e/100g.	A	1.07	0.97	5.08	1.90	4.86	2.37	5.41	4.77
	B	1.60	0.89	3.15	1.27	4.92	3.27	4.86	5.39
	C	...	...	...	...	...	...	4.32	7.28
Percentage base saturation	A	62.5	70.5	37.3	72.0	24.5	53.7	30.6	22.5
	B	60.1	67.4	52.5	78.4	13.7	59.4	24.8	25.9
	C	...	...	...	...	...	...	31.3	23.7
pH	A	7.0	7.2	5.6	7.2	5.0	6.5	5.0	6.4
	B	6.8	7.1	5.8	6.9	4.6	6.5	5.1	6.2
	C	...	...	...	...	...	...	4.7	6.2

Table II

Showing the average values for the nutrient content of leaves of healthy and diseased trees growing in four typical classes of soils.

	Sandy Soil		Loomy Soil		Clayey Soil		Laterite Soil	
	Healthy	Diseased	Healthy	Diseased	Healthy	Diseased	Healthy	Diseased
Nitrogen (N) %	1.88	2.12 (+12.76)	1.75	1.97 (+12.57)	1.81	2.00 (+10.50)	1.92	2.01 (+4.69)
Phosphoric acid (P_2O_5)	0.39	0.47 (+20.50)	0.41	0.41 ...	0.31	0.35 (+12.90)	0.39	0.40 (+2.56)
Potash (K_2O) %	1.53	1.67 (+9.15)	0.98	1.45 (+48.00)	1.51	1.61 (+6.62)	1.17	1.63 (+39.31)
Lime (CaO) %	0.44	0.49 (+11.36)	0.46	0.42 (-8.70)	0.35	0.49 (+39.99)	0.59	0.59 ...
Magnesia (MgO) %	0.34	0.26 (-23.53)	0.24	0.28 (+16.66)	0.31	0.47 (+51.60)	0.39	0.34 (-12.82)
Ash insoluble in Hydrochloric acid %	2.67	5.22 (+95.50)	1.94	4.53 (+133.60)	3.09	3.78 (+22.32)	3.44	5.46 (+58.72)

The figures in brackets represent the percentage increase (+) or decrease (-) of the nutrient element in the diseased leaf over its content in the healthy leaf.