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Problem of seasonal foliar yellowing in the coconut palm

BY

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INTRODUCTION

It is well known that adverse soil conditions, likely to cause nutrient deficiency for plants, often induce visual foliar symptoms. The non-availability of one or the other of the macro or micro nutrient factors has been demonstrated (Wallace, 1944) as being responsible for the discolourations observed in the leaves of several plants. A coconut palm in the normal course of its growth sheds its oldest leaf one by one as it produces new leaves. The shedding is preceded first by a yellowing and later by a large or reddish brown colouration proceeding from the tip backwards towards the base. In a really well grown and healthy palm standing in normal environments only one leaf at a time shows the signs of senility, and the next one above remains green until it becomes the oldest in its turn, and sometimes even later. Apart from this, several workers in the different coconut-growing countries have discussed instances of foliar yellowing in the coconut palm, attributing specific causes for their occurrence.

FOLIAR YELLOWING CAUSED BY ROOT DAMAGE

Where there are chances of root damage and consequent unsatisfactory nutrient absorption, foliar yellowing has been observed. Thus, it is frequent in ill-drained and water-logged soils. Palms growing in permanently wet soils, naturally, suffer from the effects of water-logging. They are found to carry very few nuts, get progressively weakened, and ultimately wilt away. Such palms take a yellow colour affecting all the leaves, even the youngest, and appear as a lighter shade than the 'bronze leaf wilt' affected leaves.

Foliar yellowing in coconut palms is observed on certain eroded

hill sides in several localities. Root damage, due to exposure in the eroded range as well as loss of adequate plant food, may be the cause of this yellowing. Foliar yellowing, as a result of drought conditions is quite common in areas where there are long spells of dry season or in very deep soils where the water table recedes considerably beneath the reach of palm roots. Moisture availability appears to be the limiting factor causing root injury in such cases.

FOLIAR YELLOWING DUE TO DISEASE ATTACK

Distinct from these patterns of yellowing are the instances which result from disease (or pest) attack on the palms. Discolouration of the leaves, which is the primary and outstanding visual symptom, happens in the case of the 'bronze leaf wilt' disease as well as the 'red ring disease' of the coconut palms described by Briton Jones (1940). In the former, two or three oldest leaves may show the bronze yellowing, at the same time the tips of two or more leaves will be showing a yellow colour. In the condition called 'red ring' disease (Nowell, 1919) the lowest and oldest leaf turns yellow from the tips of the pinnae at the distal end of the leaf progressively backwards towards the mid rib. This discolouration later affects the pinnae towards the centre and base of the leaves. At a more advanced stage of wilting, the pinnae at the distal end turn reddish brown, and soon the leaf is shed. At the same time, the next oldest leaf undergoes the same cycle of discolourations and is followed by similar wilting of the still younger leaves with the exception of the central spindle of leaves. Ocfamia (1937) has reported that in the Philippines, palms suffering from 'cadang cadang' disease show yellow foliage. They appear chlorotic with numerous yellowish translucent spots which turn orange yellow, the crown of the affected palms appearing yellowish green from a distance. Ganarajah (1953) observed foliar yellowing in the coconut on account of moisture shortage caused by drought.

FOLIAR YELLOWING ASSOCIATED WITH SOIL CONDITIONS

Dwyer (1937) has associated three distinct types of foliar yellowing with soil conditions. He described these as conditions of chlorosis which has reference to the absence of green colouring matter and reduction of leaf absorbing surface. In the first type, usually seen in the water-logged areas, the colour of the outer leaves approximates to

shade 3 (aureolin) of the horticultural colour chart, as distinct from shades 5 and 6 of the bronze leaf wilt. The degree of yellowing fluctuates with the change from wet to dry seasons. He mentions the nutritional yellowing seen in the different soil types as the second type. Lack of adequate cultivation, dry spells of weather and a possible lack of iron availability, probably lime induced, are mentioned as the causes for this type of yellowing, which usually affects the older leaves of the palm at random and widespread during the low rainfall periods in dry areas. Another type of yellowing is observed on dark alkaline soils derived from soft lime stone or marl and usually deficient in available phosphoric acid. Leaves appear to have an average yellow shade comparable to bronze leaf wilt colour. Trees in good rainfed areas during drought periods manifest foliar yellowing, often in the whole crown including the central column. The inflorescences and nuts are, however, not affected. With the onset of the rains, the normal green colour of the foliage is restored. Since application of niciphos had helped to ameliorate the condition, it has been concluded that inadequate nitrogen utilisation by the palm, on account of low phosphate availability, acts as a limiting factor. Martyn (1948) has also favoured this view, and it is now generally recognised that nitrogen deficiency in soil induces foliar yellowing in palms.

FOLIAR YELLOWING IN RELATION TO NUTRIENT INTER RELATIONSHIPS

Narayanan (1948) has referred to nutritional yellows in the coconut palm in which the foliage turns yellow for no apparent reason. Martyn (1945) has described yellowing of coconut leaves as being caused by either loss of chlorophyll alone or by other changes in the leaf pigments. He cites instances in Jamaica where improper drainage of soil contributed to foliar yellowing in palms. He has suggested that toxic factors present in the subsoil water may upset normal physiological reactions in the leaf.

Cooke (1950) was inclined to believe that magnesium deficiency in the soil or its presence in it in unavailable forms would produce foliar yellowing in palms, since magnesium is an essential constituent of the green colouring matter of the leaves. He suggests that translocation of magnesium from the older parts of the palms to the younger parts during cell activities of the latter, provides an explanation for the yellowing and subsequent necrosis of the lower and

older leaves, the younger leaves still remaining green. This does not refer to the normal yellowing occurring in old leaves due to senility. More aspects in this connection are referred to later.

In general, in the low-lying coconut areas in several regions palms suffer from the effect of water logging of the soil. The lower leaves of the palms turn progressively yellow as the water table rises during the monsoon, and in two to three weeks' time most of the palms in the whole area get affected. Trees present a striking yellow appearance when seen from a distance. The healthiest leaves are of an unhealthy light green colour, especially along the edge and between the veins, and the worst leaves are almost completely yellow, the small amount of green colour being seen along the veins. With the close of the monsoons and with the availability of sunshine the leaves regain the lost green colour and the change of foliar colour is, therefore, a reversible phenomenon. This was being observed in the past few years in several water-logged areas during the rainy seasons.

The degree of importance of this trouble which may be referred to as "seasonal reversible foliar yellowing" cannot at present be assessed, but a decrease in the amount of the all important green colouring matter of the leaves can hardly fail to result in some measure of reduced vigour in the trees. A short account of the preliminary experiments so far carried out to ascertain the cause of this seasonal reversible foliar yellowing in the palm will, therefore, be given in this paper.

EXPERIMENTAL

The composition of the rising subsoil water as well as an evaluation of the status of plant nutrients in the soil in the areas where foliar yellowing is met with and in the leaf tissues, appear to be the main items on which information has to be gathered in order to elucidate the probable causes of the foliar colour change. Accordingly, the water table depth in several pits dug in the low lying areas of the research station, (Kayangulam), where the foliar yellowing was being noticed year after year was measured and the pH of the subsoil water determined and recorded from time to time during the entire period of the premonsoon, monsoon and post-monsoon months. June, July, October and November are typical heavy monsoon months in this area. Typical excerpt from the data is presented in Table I.

TABLE I

Showing typical data on the depth of water table and pH of the subsoil water (1954 June and July)

Pit No.	8/6/54		20/6/54		27/6/54		2/7/54		9/7/54		18/7/54	
	Depth	pH	Depth	pH	Depth	pH	Depth	pH	Depth	pH	Depth	pH
1	3′—3″	6.0	4′—3″	5.7	4′—2″	5.6	4′—1″	5.6	6′—5″	5.4	6′-10″	5.9
2	2′—9″	6.0	2′—7″	6.0	3′—0″	5.9	2′—6″	6.0	2′-10″	5.5	2′-10″	6.1
3	3′—4″	6.0	3′-10″	5.9	4′—4″	6.0	4′—2″	5.9	5′—4″	5.8	4′—8″	6.2
4	0′—4″	6.0	0′—6″	6.1	0′—4″	6.0	1′—1″	5.9	0′—9″	5.6	1′—0″	6.0
5	1′—0″	5.5	0′—7″	5.6	0′—7″	5.5	1′—5″	5.4	1′—0″	5.2	1′—7″	5.6
6	4′—0″	5.5	4′—6″	5.0	4′—6″	5.2	4′-11″	5.2	5′—0″	5.0	4′—7″	5.6
7	3′—5″	5.5	4′—3″	5.5	4′—3″	5.8	4′-11″	5.4	4′—6″	5.5	4′—3″	6.0
8	7′—0″	5.5	7′-10″	5.8	7′—8″	5.6	4′—4″	5.6	9′—2″	5.5	8′—1″	5.6
9	7′—2″	6.0	7′—0″	5.5	7′—4″	5.3	8′—0″	5.1	9′—0″	5.0	8′—9″	5.4
10	7′—9′	6.0	7′—8″	5.9	7′—6″	5.9	6′-10″	5.9	8′—9″	5.5	8′—6″	5.6
11	6′—0″	6.1	4′—6″	5.8	4′—0″	6.0	3′-11″	6.0	5′—5″	5.9	4′—7″	6.4

It is seen from the results, that the acidity of the subsoil water reaches a high value (the pH in some areas reached even up to 3.8). Usually, however, the pH of the subsoil water is of the order of 5.0 – 6.0.

2000 ml. of the subsoil water sampled from the different pits was distilled into 50 ml. of a decinormal solution of sodium hydroxide and the distillate was carefully tested. Sodium salts of acetic acid and lactic acid were found to be present. It was not found possible to detect any free mineral acid in the subsoil water. It is thus very interesting that organic acids cause a physiological disturbance which is only temporary and which appears to result in yellowing of leaves.

Soil samples were then collected from the base of trees with normal foliage and trees with yellow foliage. These were examined for their major nutrient contents. Typical results presented in Table II did not indicate any significant difference between these two sets of samples.

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3	3′—4″	6.0	3′-10″	5.9	4′—4″	6.0	4′—2″	5.9	5′—4″	5.8	4′—8″	6.2
4	0′—4″	6.0	0′—6″	6.1	0′—4″	6.0	1′—1″	5.9	0′—9″	5.6	1′—0″	6.0
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TABLE II

Showing the major nutrient contents in the soil samples collected from plots where the trees showed yellow foliage and from plots where trees were normal

(1st foot samples)

Plot showing	N%	P_2O_5%	K_2O%	CaO%	MgO%	pH
Foliar yellowing in the trees	0.028	0.020	0.037	0.039	0.034	6.2
Normal healthy trees	0.027	0.027	0.066	0.048	0.040	6.5

This indicates that the real cause does not lie in any actual difference in the nutrient status of the soils. Probably, physical soil conditions, moisture status, aeration, free lime content and other factors are involved, apart from the availability of major nutrients to the palms.

These aspects raise the question of the contents and inter-relationships of the nutrient ions in the leaf tissue as the possible orientating factor. Comparative data was, therefore, collected and typical results of analysis of normal and yellowed foliage are presented in Table III.

TABLE III

Showing the major nutrient contents in yellow and normal foliage

Sample from	No.	N%	P_2O_5%	K_2O%	COa%	MgO%	$\frac{K_2O}{MgO}$
Yellowed foliage	1	1.016	0.360	1.500	0.235	0.104	14.4
	2	1.008	0.360	1.491	0.168	0.160	9.3
	3	0.976	0.329	1.668	0.426	0.200	8.3
	4	1.012	0.498	1.546	0.314	0.176	8.8
Normal foliage	1	1.123	0.288	0.811	0.459	0.224	3.6
	2	0.017	0.431	1.144	0.347	0.256	4.5
	3	0.983	0.372	0.737	0.325	0.272	2.7
	4	1.206	0.369	0.223	0.403	0.216	1.0

The leaf tissues were collected and sampled according to the method standardised by Pandalai (unpublished). These results show that there is a higher K_2O/MgO ratio in the yellowed foliage. This ratio was generally less than 5.0 in the case of leaves from trees with green leaves and more than 5.0 in the leaves of palms showing yellowing. This condition may not be optimum for fresh chlorophyll synthesis in the leaves or for the stability of the chlorophyll already formed in the leaves. Preliminary chromatographic tests revealed that yellowed foliage had a higher amino acid concentration than the normal green leaves. Differences in leaf composition are being studied carefully, particularly during the different stages of yellowing of leaves in the palms met with on different soil types.

DISCUSSION

The cause and nature of the yellowing, its onset with the rising subsoil water level with high acidity, and its reversal with the onset of conditions when the roots are free from contact with the subsoil water which has got receded are rather interesting aspects which only results of further work can clarify. The phenomenon appears to be localised in areas subject to fluctuation of subsoil water level with the advent of the monsoons. Disturbances in optimum nutrient ratios on account of the fluctuating soil conditions and consequent root damage and the inability to translocate the necessary food factors are, among possible others, certainly responsible for the foliar colour changes.

Earlier workers have suggested an unsatisfactory nitrogen utilization by the palm, probably due to phosphate unavailability (Martyn *(loc. cit.)*, Dwyer *(loc.cit.)*, & Cooke *(loc. cit.)*). Cooke indeed suggested that since magnesium aids in the movement of phosphorus within the plant, magnesium deficiency can induce phosphorus deficiency which, according to Martyn and Dwyer, can reduce nitrogen uptake by the palm. Salgado (1952) found that potassium deficiency leads to chlorosis, leaf scorch and poor crowns with short fronds. According to Child (1950), palms which had received no potash from 1933 showed by 1940 definite signs of deficiency, yellowing of foliage, and later the development of gray blight symptoms, although, Cassidy (1952) states that potash deficiency does not appear to be the cause of foliar yellowing which he had observed at Viti Levu. A general yellowing of older living leaves and an abnormal number of browned dead leaves hanging

from the top of the tree around the trunk are described by Reinking (1950) in the Philippines as symptoms of soil deficiency. Bodin (1917) has reported that iron sulphate is able to change the chlorotic appearance of the foliage, probably by catalytic liberation of plant food factors in the soil which aids chlorophyll formation and stability. Dwyer has claimed *(loc. cit.)* that ferric citrate injections into the palm suffering from chlorosis restored the characteristic green colour to the foliage. Roach and Levy (1936) have reported similar experience in the case of plantation fruit trees. Neither the addition of lime to neutralise the acidity of the soil nor the application of nitrate to make good the possible loss by leaching seemed to give any ameliorating influence on the incidence of leaf yellowing.

The uncongenial root environments in water-logged soils and the consequent effects on palm health have been discussed by Pandalai (1953) and Pandalai *et.al* (1954). Emphasis was laid on the adverse effects on plant growth which anaerobic conditions in the root rhizosphere can bring about, particularly the possible accumulation of toxic substances such as sulphides, ferrous iron, nitrites, aluminium and manganese. Excess of aluminium in the soil, for example, tends to accumulate it in the roots and this is known to considerably reduce phosphorus translocation by the roots from the soil into the vascular system of the plant, thus bringing about phosphorus starvation (Russel 1954). The results presented have shown that anaerobic decomposition of organic matter in the water-logged soils produces organic acids in the soil, which, in the absence of sufficient supply of bases, lower the pH of the soil solution. These conditions appear to be of a temporary nature since the acidic subsoil water recedes with cessation of the monsoon and the onset of sunny days when the foliar yellowing also gets reversed. The situation, however, appears to cause temporary disturbances in the physiological processes which regulate chlorophyll formation and stability in the leaves. A higher K_2O / MgO ratio is one of the important factors which causes or which is the effect of the foliar yellowing. The low magnesium content of the leaves and the lack of available iron in the soil may also be contributory factors.

The experiments described above are still in the preliminary stage. None of the soil treatments tried offers any definite hope of a complete cure of the trouble in one season, but they do suggest the

possibility of a complete cure being obtained gradually. It is interesting that application of complete fertilizers and proper attention to soil drainage conditions do help the foliage to preserve the green colour even in the temporarily disturbed soil conditions. The soil treatments needed appear to be such as those which would be rapidly effective. Success reported by the several workers in the control, in general, of chlorotic conditions in plants by the use of chelate compounds suggests that the same may be a possible safe control measure to prevent foliar yellowing. Work on these and allied aspects is now in progress.

SUMMARY

The problem of the familiar phenomenon of seasonal reversible foliar yellowing in the coconut palm is described along with other conditions in which foliar discolourations appear as visual symptoms such as bronze leaf wilt, red ring disease, etc. Adverse soil conditions, which directly or indirectly affect the healthy root environment such as water logging, high acidity in the subsoil water, presence of toxic agents in the soil solution, among others, appear to cause foliar yellowing. Yellow foliage shows a higher K_2O/MgO ratio and higher amino acid content compared to normal green foliage. Continued spells of dry weather which limit moisture availability also cause foliar yellowing. Soil management designed to provide good drainage and therefore maintain healthy root growth and availability of balanced nutrients, appears to check and ameliorate seasonal foliar yellowing.

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