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DEPARTMENT OF PRIMARY INDUSTRY
P.O. BOX 384,
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IN
PAPUA NEW GUINEA

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ABSTRACT

Present knowledge on micronutrient deficiencies in crops in Papua New Guinea is reviewed. Deficiencies of iron, manganese, zinc, boron, copper and molybdenum have been reported following field fertilizer trials and foliar analyses. Deficiencies occur on a range of crop species including various brassicas, arabica and robusta coffee, various citrus species, coconuts, pyrethrum, rice, rubber, sweet potato, tea and a number of tree species grown for timber and shade. Boron deficiency appears to be the most serious economically of the crop micronutrient deficiencies.

INTRODUCTION

Papua New Guinea (PNG) contains many diverse agricultural environments. Agriculture is practised from sea level to an altitude of 2850 m. Mean annual rainfall ranges from 1000 mm to over 8000 mm. Soil types are equally diverse and are derived from numerous parent rocks. Many soils contain volcanic ash. Consequently it is to be expected that the micronutrient deficiency problems are quite varied. Foliar and soil analyses and field trials by Department of Primary Industry staff have given a good indication of the major nutrient deficiencies likely to be problems for the export tree crops (see the papers by Southern and Hart). The situation for the food crops is less clear as less research has been conducted on their nutritional problems.

Known deficiencies of seven micronutrients are summarized below.

IRON

Lime induced chlorosis is common in crops planted on sandy soils derived from young coralline limestone. Presumably this is iron deficiency, although it may also be manganese deficiency. For example, I have noted lime induced chlorosis on sweet potato near Kavieng (New Ireland) and on hibiscus shrubs in Madang. Southern and Dick (1967) note that Mn and Fe deficiency symptoms occur on coffee, cocoa, legumes and ornamentals on soils derived from coral limestone at Finschhafen.

Arabica coffee. Hart (1966) reported that iron deficiency symptoms were noted on over 50 per cent of arabica coffee plantations surveyed in the Western Highlands, Eastern Highlands and Morobe Provinces. However he considered it to result from low mobility and did not consider this to be of great economic significance. Southern and Dick (1969) reached the same conclusion.

Citrus. Citrus seedlings on a well drained colluvial soil at Aiyura often display mild Fe deficiency symptoms. In a spray trial with oranges (*Citrus sinensis*), mandarins (*C. reticulata*) and lemons (*C. limon*), symptoms were lessened after spraying with iron sulphate (T. Tarepe, pers.comm.). I have noted iron deficiency symptoms in the Waghi Valley (Western Highlands Province) on the same soil type.

Cocoa. Iron deficiency symptoms are very prevalent in cocoa, although in most cases they occur spasmodically and in a mild form. Foliar analyses have indicated that low iron contents are associated with mild iron deficiency symptoms (Southern and Hart, 1969).

Maize. In a trial at Yambi on the infertile Sepik Plains on a podsolic in 1962, iron increased the weight of maize crops (DASF, 1965 p127).

Pastures. In a trial at Aiyura on Desmodium uncinatum/grass mixture, there was an indication that Fe depressed grass and legume yield by about 4 per cent (DASF, 1972 p108).

Tea. In a survey of tea plots in the highlands, Southern (1969b) suggested that a pale green colour of recently matured leaves might indicate a mild iron deficiency. This was not confirmed by foliar analyses.

MANGANESE

Arabica coffee. In a survey of arabica coffee plantations, Hart (1969) recorded that manganese deficiency was not common. In the Morobe Province (Wau-Bulolo area), foliar analyses suggested that eight per cent of samples were deficient.

Citrus. Deficiency symptoms on pomelo (Citrus grandis) and other citrus species growing on a young volcanic ash soil at Keravat (New Britain) disappeared after foliar application of a combined manganese and zinc spray (J. Morris and R. M. Bourke, unpubl. data). Application of Zn or Mn singly did not remove the symptoms completely.

Cocoa. Leaf analyses have indicated some low manganese levels. Most of these low levels were found in cocoa growing in soils of neutral to slightly acid reaction (Southern and Dick, 1969).

Maize. A trial on an infertile soil on the Sepik Plains indicated a response to manganese (DASF, 1965 p127).

Pastures. In the Desmodium uncinatum/grass trial at Aiyura, plots receiving Mn in the absence of Fe gave a small increase in yield (DASF, 1972 p108).

Robusta coffee. Manganese deficiency symptoms on robusta coffee associated with very low foliar Mn contents have been observed at various locations in the lowlands. This deficiency is common in alkaline alluvial soils of the Markham Valley, neutral to alkaline alluvial soils at Cape Rodney and Brown River (Central Province), soils developed on volcanic ash at Keravat (New Britain), and soils developed on coral soils at Finschhafen (Southern and Dick, 1969).

Rubber. Suspected manganese deficiency has occurred in young rubber in the coastal areas of Central Province (Southern and Dick, 1969).

Sweet potato. Top growth responses to Mn occurred in pot trials with sweet potato at Keravat. However, no tuber or top growth responses were recorded in subsequent field trials (Bourke, 1977).

Tea. A manganese deficiency has been confirmed by fertilizer application on an experimental plot of tea at Keravat (Southern, 1969b).

ZINC

Arabica coffee. In a survey of coffee plantations in the Waghi Valley of the Western Highlands and the Kainantu area of the Eastern Highlands, Southern (1969a) found that field evidence of zinc deficiency was widespread. Symptoms were observed on almost all plantations in the Kainantu area. Following these field surveys, a zinc fertilizer trial was conducted at Aiyura. A zinc sulphate spray treatment was used. The zinc application reduced the Zn deficiency symptoms but resulted in a dramatic depression in coffee yields (6.8 t/ha of cherry in control; 2.2 t/ha in zinc treatment) (DASF, 1972 pp52-55). Study of the yield pattern over time in treated and untreated plots indicated that zinc application was followed by yield reduction within the following few months, suggesting that it must have caused shedding of maturing cherries, not simply a reduction in crop setting (A. E. Charles, pers.comm.). It has been suggested that the zinc promoted leaf growth through auxin development and this interfered with cherry production (A. J. Kimber, pers.comm.).

Citrus. Zinc deficiency symptoms are very widespread on citrus throughout all of PNG. It occurs on oranges, lemons, limes, pomelo, mandarins and grapefruit. At Keravat a combined zinc plus manganese treatment cured leaf symptoms on various citrus species. A zinc only treatment reduced the symptoms to some degree (J. Morris and R. M. Bourke, unpubl. data). In a trial at Aiyura, symptoms on orange, mandarin and lemon were reduced after spraying with zinc sulphate (T. Tarepe, pers.comm.).

Cocoa. In the Markham Valley, where alluvial soils often reach a pH of 8.5, zinc deficiency is prevalent in cocoa. The deficiencies have been confirmed by the use of zinc foliar sprays (Southern and Dick, 1969; DASF, 1963 pp66-67).

Peanuts. In a pot trial with peanuts that tested four micronutrients in a Markham Valley soil, there was evidence of a response to zinc (DASF, 1972 p113).

Rice. Experimental work in the Markham Valley has established that zinc deficiency occurs in irrigated rice. This is especially so if the irrigation water is high in bicarbonate. Only slight zinc deficiency symptoms have been noted with dry land rice and then only at the seedling stage (Sumbak, 1977a). In a fertilizer trial with irrigated rice on a calcareous soil of high pH in the Markham Valley, marked responses occurred to zinc and nitrogen. Nitrogen applied alone significantly depressed yields below the control level (Hunter and Singh, 1972). Applications of 50 kg/ha of zinc sulphate are recommended for irrigated rice where the deficiency is severe (Sumbak, 1977b).

Robusta coffee. A number of instances of zinc deficiency have been observed in robusta coffee. In nearly every case, the deficiency occurred in conjunction with manganese deficiency (Southern and Dick, 1969).

Rubber. Zinc deficiency symptoms were very common in rubber nurseries at Cape Rodney and Kapogere (Central Province) on coastal alluvial soils of neutral reaction. The deficiency was very severe in some cases with severe growth depression and even death of plants (Southern and Dick, 1969). Southern and Dick suggest that Zn deficiencies do not appear to be a problem in rubber except in nurseries where it can best be cured by acidification of the soil.

Tea. Southern (1969b) reports that zinc deficiency occurs in tea in drained swamp soils in the Waghi Valley of the Western Highlands. Treatment by soil application was ineffective, but foliar sprays were very beneficial.

BORON

Arabica coffee. Field symptoms of boron deficiency in arabica coffee occur in the highlands, particularly in the Banz area of the Western Highlands and the Kainantu area of the Eastern Highlands (Southern and Dick, 1969). In a fertilizer experiment at Aiyura (ACA32), a soil application of borax increased the yield by 35 per cent in one year and 64 per cent in the following year (A. E. Charles, pers.comm.). A compound fertilizer which is widely used for arabica coffee contains small amounts of boron.

Broccoli, cabbage, cauliflower. Boron deficiency occurs on these crops on alluvial soils at Wapenamanda in Enga Province (M. Herman, pers.comm.). This has been confirmed on cabbage in an omission type trial at Wapenamanda (T. Aldous, pers.comm.). Suspected deficiency symptoms have been observed by the author on broccoli and cabbage at Aiyura. Possible boron deficiency symptoms on cauliflower have been observed at Laloki near Port Moresby on an alluvial soil but the deficiency has not been clearly established (P. Bull, pers.comm.).

Cape gooseberries (*Physalis peruviana*). In a trial at Aiyura on a soil with a known B deficiency, boron fertilizer removed B deficiency symptoms and increased berry yield by over 50 per cent (Bourke, 1980).

Pawpaw (*Carica papaya*). Boron deficiency symptoms occur on pawpaw in the Wau-Bulolo area (Simpson and Arentz, 1982). These authors report that boron is inadequate for vigorous growth of fruit trees in general and that an initial application of 20-50 g of borax satisfies the trees' requirements for at least a decade.

Pyrethrum (*Chrysanthemum cinerariaefolium*). In a factorial fertilizer trial at Tambul, Solubor (21% B) at 0, 11 and 22 kg/ha applied to newly planted seedlings caused a negative yield response in the first six months of flowering, but a positive response in the second and third years, giving a 6 per cent increase from the higher levels in 2½ years of production. This indicates that there would probably be an economic response to lower levels or alternative methods of application which avoided initial toxicity (A. E. Charles, pers.comm.).

Sweet potato. Boron deficiency is suspected in sweet potato on the Nembi Plateau (Southern Highlands Province) on an ash soil where typical B deficiency symptoms have been observed. Susceptible crops such as *Casuarina oligodon* display very marked deficiency symptoms in this area. However in a fertilizer trial boron fertilizer applied at 1.5 and 3.0 kg B/ha significantly depressed tuber yield and increased top growth (D'Souza and Bourke, in press). B deficiency symptoms have also been seen in sweet potato tubers in village gardens in the Aiyura area.

Tree crops. Boron deficiency has occurred on pine trees (*Pinus caribaea* and *P. patula*) wherever they have been grown in PNG in both the highlands and lowlands. Locations include the Bulolo-Wau area (700 to 1200 m), Lelet Plateau of New Ireland (950 m), Markham Valley (0 to 400 m), Kainantu and Goroka areas of the Eastern Highlands (1400 to 1700 m) and the Sirunki Plateau of Enga Province (2700 m). Together with *Eucalyptus torelliana* these two species of *Pinus* are excellent indicators for identifying boron deficiency sites in the Wau and Bulolo valleys (Simpson and Arentz, 1982). All pine trees planted by the Office of Forests are given an application of 50 g of borax per tree (7 kg B/ha) as a standard dressing six months after field planting.

In parts of the highlands boron deficiency symptoms have been observed in the shade trees *Albizia stipulata* and *Grevillea robusta* (Southern, 1969a).

Boron deficiency is very widespread on *Casuarina oligodon* throughout the highlands (Bourke, 1980). It is particularly severe in the Southern Highlands, fairly bad in the Enga and Western Highlands and less severe in Simbu, Eastern Highlands and the Wau-Bulolo area of Morobe Province. At Aiyura it has been found necessary to apply 5 g of borax to casuarina seedlings at field transplanting (2.5 kg B/ha) (W. van Hecke, pers.comm.). Dramatic increases in growth have occurred on casuarina fertilized with borax on the Nembi Plateau (D'Souza and Bourke, in press).

Deficiency symptoms on hibiscus hedges (*Hibiscus rosa-sinensis*) at Aiyura have been removed following application of boron fertilizer (Bourke, 1980).

Tomatoes. In a trial at Wapenamanda with tomatoes, there were indications of a yield response to boron fertilizer (T. Aldous, pers.comm.). During the 1982 drought, typical deficiency symptoms as described by Shorrocks (1974) were observed by the author at Aiyura.

COPPER

A survey of copper levels in cattle plasma indicated that copper deficiency occurs in cattle at two locations in the Markham Valley near Lae (Mayall, 1973). Copper deficiency in crops at these locations is therefore possible.

Rubber. It is possible that a copper deficiency occurs in rubber nurseries in the Papuan alluvial soils in conjunction with a zinc deficiency. The only evidence for this is from the very low leaf copper contents found (Southern and Dick, 1969).

Sorghum. In a factorial fertilizer field trial at Keravat on a volcanic ash soil, sorghum yields were significantly higher in plots receiving copper sulphate (Bourke, 1977). However in the absence of responses in numerous other trials at this location, this result must be considered with caution.

Tea. Southern (1969b) suggested that Cu deficiencies could exist in tea plantations in the highlands, as 7 per cent of samples in a survey contained 3 to 5 ppm Cu. Foliar analysis at Mendi Tealands in the Southern Highlands has indicated severe deficiency to subnormal levels of copper (M. Anders, pers.comm.).

MOLYBDENUM

Cauliflower. A Mo deficiency occurs on cauliflower on alluvial soils at Wapenamanda (1760 m) in Enga Province (M. Herman, pers.comm.).

Maize. In a trial at Yambi on the Sepik Plains, molybdenum increased the cob weight and plant height of maize (DASF, 1965 p127).

COBALT

There have been no reports of Co deficiency in PNG. Cobalt is needed by some plants. It is essential to fixing of nitrogen by bacteria, including *Rhizobium*. If cobalt is deficient, legumes may show nitrogen deficient symptoms. Only a limited number of trials with cobalt have been done on leguminous species in PNG, so Co deficiency has not been tested for adequately.

DISCUSSION

A broad picture of micronutrient deficiencies on tree crops in PNG has emerged through the pioneering work of P. Southern, G. Hart and K. Dick. The situation with the food crops is not so clear. A number of deficiency problems reflect the poor ability of certain crops to extract nutrients or problems associated with high soil pH. These include iron deficiency on arabica coffee, zinc deficiency on various citrus species, molybdenum deficiency on cauliflower and iron deficiencies on various crops on coral sand soils. Much more detailed research is needed before an accurate picture of micronutrient deficiency problems in the country emerges. The situation with micronutrient deficiencies in PNG may be summarized as follows:

Iron deficiency is widespread on sandy coral soils. It has been reported for arabica coffee, citrus and cocoa, but is probably not very serious economically. Manganese deficiency has been reported on a range of crops, mostly in the lowlands. It appears to be most widespread on robusta coffee. On a young volcanic ash soil at Keravat, it occurs on a number of crops and is likely to occur on similar soils in West New Britain and in the Northern Province.

Zinc deficiency is widespread on arabica coffee and tea in the highlands, and on citrus everywhere in PNG. It also occurs on rice and cocoa in the Markham Valley and in rubber nurseries in Central Province. Boron deficiency is widespread in the highlands, especially on tree crops (pine trees, casuarina and arabica coffee). It occurs on brassicas, sweet potato, pyrethrum, tomatoes and other crops at certain locations in the highlands (for example, Aiyura, Nembi Plateau and Wapenamanda). It has only been definitely reported from the lowlands on pine trees. Boron deficiency appears to be the most important economic micronutrient problem in PNG.

There are a number of reports of possible copper deficiency but none is very conclusive. No convincing responses to copper application have been obtained in fertilizer trials. The only reports of molybdenum deficiency have occurred on cauliflowers at Wapenamanda and on maize on the Sepik Plains. No cobalt deficiency has been found.

Most fertilizer recommendations include only the macronutrients, especially nitrogen, potassium and phosphorus. The only published recommendations made for micronutrients in PNG are for zinc on irrigated rice (Sumbak, 1977b) and a

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