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COPPER DEFICIENCY IN PINEAPPLES

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SUMMARY

Copper deficient pineapple plants showed the following symptoms: young leaves narrow with edges bent up so that the leaf is like the letter U in cross section; leaf tip at first drooped then later necrotic; lower side of leaves waxy and lacking bloom. A leaf sample from the middle third of the white basal tissue contained 3 ppm Cu in the dry matter.

I. INTRODUCTION

Copper has been widely used in the fertilizing of pineapples in Queensland because it was understood that this element was needed in addition to zinc to prevent the condition known as "Crookneck" (Aldridge 1960). Many growers included copper and zinc in the basal dressing of fertilizer as a matter of course. As a result, copper deficiency seldom occurred in Queensland and the symptoms have not been described in this state.

The regular application of copper to pineapples has now ceased because it is considered that copper deficiency is not a direct cause of "Crookneck" and growers can no longer afford to apply nutrients for which there is no proven need. As a result there have been a few instances where symptoms similar to those described for copper deficiency in pineapples have appeared in plants grown in infertile soils which have not received a copper application.

The symptoms of copper deficiency have not been clearly defined for pineapples however. Tisseau (1963) has described several distinctive symptoms from plants grown in solution culture but these do not correspond with those mentioned by Dunsmore (1957) for plants grown in the field in Malaya.

A trial was therefore established to determine the symptoms of copper deficiency for pineapples grown in the field in Queensland, and to determine the response of pineapples to applications of copper in the presence and absence of zinc.

II. MATERIALS AND METHODS

Soil and site

The trial was located on the property of G. Castle, Dundowran, near Maryborough, S.E. Queensland, on land which had grown pineapples 30 years previously. The light tree and shrub regrowth was cleared 6 months prior to planting.

The soil was a siliceous fine sand of coastal dune origin typical of the areas used for pineapple and citrus growing in the Dundowran–Toogoom–Burrum Heads area. It had the following chemical analysis:

pH: 3·5 (1 : 5 soil/water suspension)

Nitrate N: 3 ppm (1 : 5 soil/water extraction)

Available P: 12 ppm (extracted with 0·01 N H_2SO_4)

Replaceable K: 0·1 m equiv. per 100 g (extracted with 0·05 N HCl)

Exchangeable Ca: 1·0 m equiv. per 100 g (extracted with 1 N NH_4Cl)

Exchangeable Mg: 1·9 m equiv. per 100 g (extracted with 1 N NH_4Cl)

Available Cu: 0·23 ppm
Available Zn: 2·58 ppm
} (extracted with a combination of 0·005 M DTPA, 0·01 M $CaCl_2$ and 0·1 M triethanolamine)

Design and treatments

The trial compared the following treatments in a 3 x 3 complete factorial design with three replications.

Copper	Zinc
C_0: nil copper	Z_0: nil zinc
C_1: 25 g Cu ha^{-1}	Z_1: 25 g Zn ha^{-1}
C_2: 2·5 kg Cu ha^{-1}	Z_2: 2·5 kg Zn ha^{-1}

The copper and zinc were applied as $CuSO_4 \cdot 5\ H_2O$ and $ZnSO_4 \cdot 7\ H_2O$ dissolved in water and applied to the centre of the beds just prior to planting. This method of application was preferred to solid soil applications which are difficult to apply evenly, and to spray applications which contaminate leaves required for foliar analysis.

These treatments were reapplied when the trial was 16 months old after leaf analyses had shown low levels of copper in all treatments.

Cultural details

The trial was planted in March 1972, with summer tops of the Smooth Cayenne cultivar. This planting material was taken from an area which had not received a copper application, and in which occasional plants were showing symptoms suspected of indicating copper deficiency. The major fertilizer elements were applied according to the "balanced" fertilizer schedule (Black 1965) using monoammonium phosphate, potassium sulphate and ammonium nitrate. An additional 100 g magnesium as $MgSO_4$ per 1 000 plants was included in the pre-plant dressing. An extra 2 kg phosphorus per 1 000 plants was applied in October 1973, after symptoms of phosphate deficiency appeared.

Flowering for the plant crop was forced in August 1973 with a 20 ppm solution of the sodium salt of ANA applied at 60 ml per plant. The plant crop was harvested in March 1974.

The trial was moderately frosted in the 1972 winter, but the plants outgrew this setback. It was heavily frosted in the 1974 winter, and the trial was then terminated.

III. RESULTS AND DISCUSSION

Fruit yield

Mean fruit mass (tops off) was recorded from the plant crop. There was a trend towards increased fruit mass with increased copper, but the differences were not statistically significant. (Data not presented)

Growth differences due to treatment increased as the trial progressed and yield differences were anticipated in the ratoon crop, but unfortunately the trial was frosted out before this crop could be harvested.

Deficiency symptoms

Twelve months after planting, the first symptoms appeared in the nil copper plots. The most noticeable was a drooping of the terminal 3 to 5 cm of the young leaves (E leaves of Sideris *et al.* 1938). As these leaves matured and became D leaves their tips continued to curve down instead of standing erect (See figures 1 and 2).

Drooping of leaves and shoots is also a symptom of copper deficiency in other plants including potatoes, tobacco and lettuce (Bear *et al.* 1949). In some crops this has been described as wilting.

As these leaves aged further their tips died back (figures 1 and 2). During winter, the plants were producing very few new leaves so there were few leaves with the droopiness symptom, and only the tip dieback symptom was apparent.

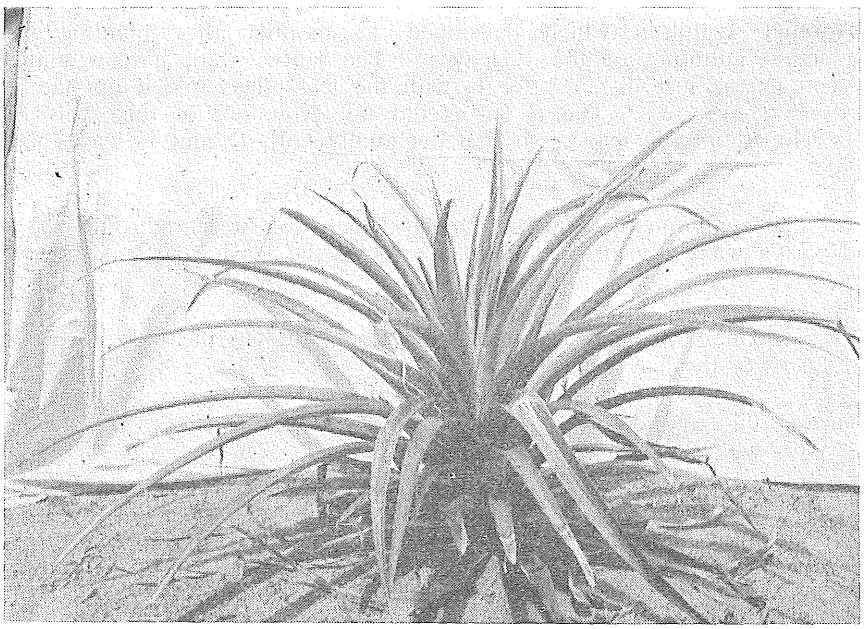

Figure 1. Pineapple plant showing moderate copper deficiency. Young leaves at centre show droopiness of the tips. Older leaves at upper left show tip dieback.

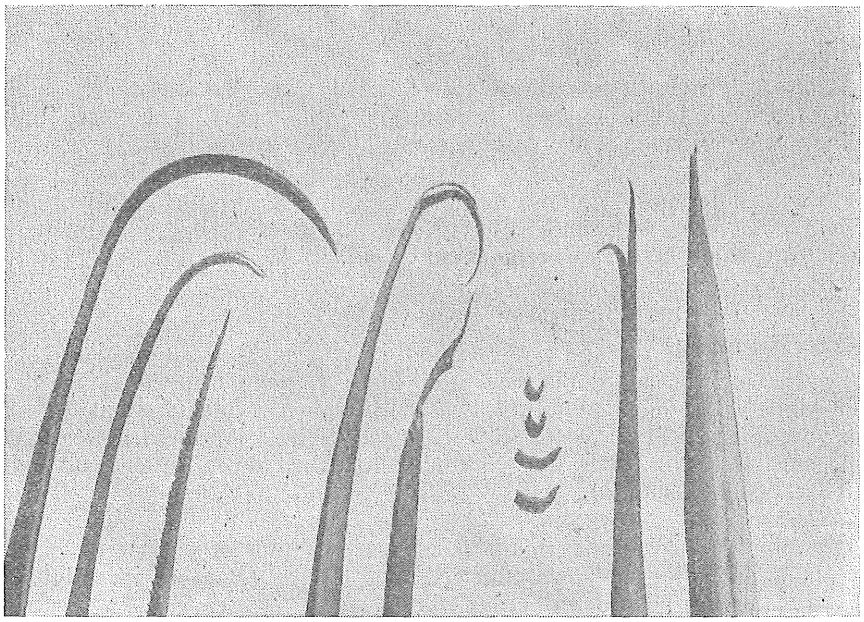

Figure 2. Symptoms of copper deficiency in pineapple plant. Leaf 1 (far left), extreme droopiness of leaf tip. Leaf 2, average droopiness of leaf tip. Leaf 3, normal leaf tip. Leaves 4 & 5, tip dieback. Leaf 6 (upper), cross section of leaf with guttering symptoms; (lower) cross section of normal leaf. Leaf 7, narrow, copper deficient leaf showing lack of bloom on underside. Leaf 8, normal broad leaf with bloom on underside.

Another symptom which developed 12 months after planting was a characteristic guttering of the E leaves. The leaves were narrow and their cross-section was just like a letter U with the leaf edges folded up parallel to each other (figure 2). The E leaves did not grow out of this symptom as they developed into D leaves, so that eventually both D and E leaves showed guttering.

Another symptom of copper deficiency which was present through the same period was a waxy appearance on the backs of the leaves particularly towards the tips.

This waxiness was actually a lack of bloom due to the lack of trichomes on the backs of the leaves (figure 2).

During the second summer of growth there were some plants in the nil copper plots which had not started to flower in response to the A.N.A. treatment. Some of these plants recommenced vegetative growth, and showed the droopiness symptoms in their recently matured leaves. Other plants which appeared to be more seriously affected by a deficiency of copper produced only small heart leaves showing the guttering and waxiness symptoms. The older leaves on these plants were almost completely necrotic (figure 3).

The symptoms described above appeared in the nil copper plots only, and not in those receiving copper applications.

Figure 3. Severely copper deficient pineapple plants showing short, guttered young leaves with some tip dieback, and necrotic older leaves.

Other workers have recorded the following symptoms of copper deficiency in pineapples:

Tisseau (1963): *'The general leaf colour was clear green. The habit tends to be floppy and soft. Most characteristic are the leaf margins which bend in on themselves to form a "gutter" with irregular twisted edges. The leaf tips are necrotic, twisted and kinked and the leaves practically fold over on themselves'. (Translation).*

Dunsmore (1957): *'Green die-back is often referred to as green wilt although the affected plant does not wilt. The leaves of affected plants are brighter green than the leaves of healthy plants, are thin and narrow and are held notably erect. Successive leaves produced by affected plants are shorter and narrower. There is no reddening of the leaves and no wilting of the younger leaf tip occurs. Affected plants may die if not treated. The application of copper as suggested in the section "Use of Fertilizers" will control the disease'.* (Although Dunsmore calls the condition Green die-back, there is no mention of necrosis of any part of the leaf in his description).

The symptoms noticed in the trial were similar to those obtained by Tisseau in water culture except that the leaf edges were not twisted and the leaves lacked bloom on their under side. Leaf colour was light green in all plots independent of copper treatment.

No evidence of crookneck or the leaf blisters associated with zinc deficiency in pineapples appeared in the trial area.

Leaf analyses

A sample of D leaves was collected from the trial in June 1973. The middle third of the basal white section of the leaves was cut out and analysed for copper and zinc with the following results:

—	C_0	C_1	C_2	Z_0	Z_1	Z_2
Cu (ppm d.m.)	3·0	3·6	3·1	3·1	3·2	3·3
Zn (ppm d.m.)	19·1	19·1	19·2	18·9	18·4	20·1

The zinc levels are in the range found in healthy plants by other workers (Lyman and Dean 1942).

There were no significant differences in copper levels between the treatments although only the nil copper plots showed deficiency symptoms. In one replicate where the nil copper plots showed no copper deficiency symptoms throughout the trial, the copper levels for these nil copper plots averaged 4·0 ppm.

The copper levels shown above are less than those found in healthy pineapple plants by other workers: 8 to 18 ppm by Marchal (1973) and 8·6 to 13·0 ppm by Steyn (1961).

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