Boron Deficiency in Bananas

K. R. NORTON
Central Research Laboratories, United Fruit Company, New Orleans, Louisiana

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IN RECENT years investigations into the nutritional needs of bananas have been intensified (HEWITT, 1955; FREIBERG, 1956; FREIBERG and STEWARD, 1960; MURRAY, 1959, 1960; JORDINE, 1962; MARTIN-PREVEL and CHARPENTIER, 1963). While the majority of work has been confined to the study of macro-elements, descriptions of some micro-element deficiencies and their corrections have been reported (MOITY, 1954, 1961; ZIV, 1954; JORDINE, 1962).

In comparison with other commercial crops, relatively little is known about the mineral requirements of bananas, particularly the micro-elements and an investigation of the micro-element nutrition of the banana was therefore undertaken. This communication reports the external symptoms of boron deficiency.

The author is unaware of earlier reports on boron deficiency of bananas.

MATERIALS AND METHODS

Plant material

Young banana plants (*Musa acuminata* L. cv ' Gros Michel ') were obtained by the technique of quartering. Small corms weighing approximately three-quarters to one pound were divided longitudinally through the growing point, into four equal parts. These sections were dried for 12 hours in the shade and then bedded in trays of sterilized sphagnum moss which had been soaked overnight. Excess water was gently squeezed from the moss prior to its use. After bedding, a cover of perforated aluminium foil was placed over each plastic tray to maintain a moist environment.

Plants thus produced were selected according to vigour and size, roots washed free of sphagnum moss and the adhering parent corm material cut away. This procedure produced plants relatively free of stored nutrients; a difficulty frequently encountered in micro-element studies. Further depletion can be accomplished by cultivating the new plants in a medium lacking nutrients.

Containers

Initially, the plants were small enough to fit into 9 in. plastic pots. Wooden covers were made to prevent aerial contamination of the solutions and to support the plants. Plants were transferred to larger plastic containers as needed.

Nutrient solutions

The nutrient solution employed was basically that of HOAGLAND and ARNON (1950) but somewhat modified (*Table 1*). Chelated iron was supplied

Table 1. Mineral concentration of nutrient solution

Macro-elements p.p.m.		*Micro-elements p.p.m.*	
N	210	Mn	0·501
P	61·8	Cl	3·296
K	273·7	B	0·40
Ca	200	Zn	0·05
Mg	48·6	Cu	0·05
SO_4	192	Mo	0·047
		Fe	2·00

to avoid a possible iron deficiency. All chemicals were c.p. grade with no additional purification. The test solution was identical to the control but lacking boron. Solutions were mixed in bulk, agitated thoroughly and transferred to the plastic pots. Solutions were constantly aerated by passing a gentle flow of filtered air into the bottom of each plant container. Demineralized water was added, as required, to maintain a pre-determined level. Solutions were renewed every fourteen days. Treatment and control were replicated five times, randomized and maintained in the greenhouse.

RESULTS

Throughout this experiment the control plants grew vigorously and remained healthy. However, 14 days after starting the experiment two plants receiving no boron showed a deficiency symptom in the youngest leaves. (Normally, banana plants produce one leaf every seven to ten days.) At the end of three weeks, all plants without boron were similarly affected. After five months this continued deficiency resulted in cessation of leaf and root production. At this time, three of these replicates were changed to a complete nutrient medium. The remaining two were maintained in boron deficient solutions; these latter plants eventually died. The former responded rapidly to the added boron and within three weeks produced leaves free of symptoms. Growth thereafter continued and the appearance of these plants was comparable to the control.

DISCUSSION

Leaves

The first symptom to appear on these deficient plants was a slight chlorotic streaking of the basal portions of new leaf lamina. Streaking resulted from a series of small perfectly aligned depressions on the upper leaf surface, oriented perpendicular to and crossing primary veins. Initially, these lines were short and few in number but became longer and more concentrated on succeeding leaves. With continued lack of boron this streaking extended through the entire thickness of the leaf, in some cases appearing as slight protrusions on the lower surface. Associated with this phenomenon were interveinal chlorosis (*Figure 1*) and malformation of leaf structure (*Figures 2* and *3*). These imperfections occurred while the leaves were in their developmental stage within the pseudostem.

Appearing on any one leaf were varying combinations of disorders: chlorotic streaking of the lamina; undulating lamina; general chlorosis

Figure 1. Young leaf of Gros Michel plant displaying early symptoms of boron deficiency

Figure 2. Advancing stages of deficiency. Note the incomplete development of the candle leaf just emerging

Figure 3. A boron deficient plant exhibiting severe symptoms

and extreme interveinal chlorosis; narrowing and shortening of the leaf blade; up-curled margins; and incomplete laminal development, ranging from acute marginal clefts to partial and/or complete absence of blade formation.

Occasionally, the midrib would branch at the tip giving rise to two midribs. Rhythm of leaf emission was disturbed in later stages, with an occasional leaf appearing out of emergence order. Gradually, leaf production ceased; undeveloped leaves decomposed within the pseudostem. Older leaves produced prior to the initial deficiency expression remained free of any apparent disorders.

It was clearly indicated that boron was essential for proper cell formation and development but apparently was not translocated from older to younger leaf tissue. SKOK (1957) reported similar findings with sunflower.

Root and follower formation

Root development was very poor in the nutrient solution lacking boron. Production consisted primarily of main roots, with little or no branching and very few hair or feeder roots. As the deficiency progressed, production declined and root necrosis increased. Eventually, all roots darkened and died.

' Followers ' were not produced by replicates lacking boron. In contrast, all control plants produced one or more healthy ' followers '. WHITTINGTON (1957) found that boron deficiency in field beans caused a rapid cessation of cell division in roots; also, ALBERT and WILSON (1961) reported that if boron were withheld from tomatoes, root elongation was inhibited within 24 hours.

Petiole and sheath

The petioles appeared less affected than other parts of the banana plant. They developed a general pale, yellow-green colour, accompanied by the absence of normal *bloom* (wax), both of which persisted as root and leaf deficiency symptoms became pronounced. As the petioles aged they tended to wither where they merged with the sheath; creases formed longitudinally gave the appearance of wrinkles. Brownish-purple spots, later coalescing into larger areas, followed the withering and extended primarily into the sheath. The sheaths tended to loosen and separate from one another, resulting in the pseudostem lacking its original firmness and becoming spongy.

SUMMARY

Boron deficiency in bananas produced distinct and readily recognizable symptoms which, during the initial stages, appeared as slight, scattered, chlorotic streaks aligned perpendicular to and crossing primary veins in the leaf lamina. In advanced cases, the symptoms progressed to severe interveinal chlorosis and incomplete leaf formation. Root and ' follower ' formation were definitely inhibited and prolonged deficiency resulted in death of the plant.

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