BORON AND MOLYBDENUM REQUIREMENTS OF THE TOMATO CROP IN THE GRANITE SOILS OF THE STANTHORPE DISTRICT.

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SUMMARY.

Increased yields of tomatoes were obtained from boron (borax applied both as a soil dressing and as a foliage spray), from molybdenum (ammonium molybdate applied as a foliage spray), and from molybdenum plus boron. The increases were of the same magnitude in all three treatments.

No additive effects were noted in plants receiving both molybdenum and boron. It is postulated that a deficiency of some other element restricted the yield potential of the crop and masked the additive effect expected from the combined boron-molybdenum treatments.

I. INTRODUCTION.

The Granite Belt, an elevated plateau some 2,000–3,000 ft. high in south-eastern Queensland, is an important source of supply of tomatoes, beans and other small crops during the summer months. The soils, which are derived from granite, are typically infertile, are not always well drained, and tend to become highly acid when continuously cropped. Complete fertilizers containing nitrogen, phosphorus and potassium are therefore essential for normal production. Trace element deficiencies, though common in pome fruits (Ward 1946), have only recently attracted attention in vegetable crops in this district.

This may be due partly to the fact that, in the absence of irrigation facilities, production is somewhat speculative and crop failures are indiscriminately attributed to soil moisture deficiencies or excesses, or alternatively to the inroads of disease. In any case, gross abnormalities in plant growth such as those associated with deficiencies of boron in beetroot and cauliflower are virtually unknown, as these crops are not grown on a commercial scale. However, symptoms of molybdenum deficiency have been recorded in some plantings of beans and cucumbers.

The available soil analytical data suggested that boron and molybdenum were, at best, present only in marginal amounts and that a response might be obtained to treatment in crops such as tomato, which do not exhibit conspicuous reactions to soil deficiencies of these trace elements.

Accordingly, trials were established in 1953-54 at Bapaume and in 1954-55 at Amiens to determine, among other things, the effect of molybdenum, boron, and molybdenum plus boron on plant growth and yield in the tomato crop.

II. 1953-54 TRIAL.

(1) Treatments.

A. *FTE**.—Applied in the drill two weeks before planting at the rate of 1 cwt. per acre.

B. *Boron.*—Borax applied as a soil dressing in the drill one week before planting at the rate of 15 lb. per acre.

C. *Boron plus molybdenum.*—Borax applied as a soil dressing in the drill one week before planting; ammonium molybdate (1/1,600) applied as a foliage spray two weeks after transplanting.

D. *Molybdenum.*—Ammonium molybdate (1/1,600) applied as a foliage spray two weeks after transplanting.

E. *Urea*†.—Applied as a 1 per cent. foliage spray shortly after fruit set in the first hand and again two weeks later.

F. Control.

(2) Procedure.

The experiment was laid down as a 6 x 4 randomised block with eight plant plots, the plants being established on the square at a 6 ft. x 6 ft. spacing.

Seed of the variety Q2 (a certified strain of Grosse Lisse) was sown on Nov. 11 and the seedlings were transplanted into the field on Dec. 28. Fertilizer schedules were those normally used in the district, viz., basal 5:13:5 at 8 cwt. per acre; side 5:13:5 at 2 cwt. per acre.

The crop was grown without irrigation and encountered dry conditions during the early stages. Heavy rain fell in February (Table 1) and from then on until the end of the harvesting period soil moisture was more than adequate for plant development.

Table 1.

RAINFALL AT STANTHORPE.

Month.	1953–54.	1954–55.
	in.	in.
December	·46	3·22
January	1·24	·98
February	11·93	2·43
March	1·15	3·11
April	·91	2·56
Total	15·69	12·30

* FTE is a commercial preparation of ground glass containing 10 per cent. ferric oxide, 2 per cent. boric oxide, 4 per cent. zinc oxide, 4 per cent. cuprous oxide, 4 per cent. manganese oxide and 0.2 per cent molybdenum trioxide.

† The urea treatment was included as a matter of convenience to assess the effect of supplementary nitrogen applied as a foliage spray on plant growth and yields.

Flowering commenced on Jan. 25 and the first pick was made on Mar. 3. Harvesting continued until Apr. 15. All fruit exceeding 2 in. in diameter was classed as marketable.

(3) Results.

The results of the 1953-54 trial are recorded in Table 2.

Table 2.

EFFECT OF TREATMENT ON YIELDS OF MARKETABLE FRUIT (1953–54).

Treatment.	Yield.		Significantly Exceeds at.	
	Lb./Plot.	Equiv. Cases/ac.	5% Level.	1% Level.
D. Mo	202·2	1,273	A	F
C. Bo + Mo	199·5	1,257	F	
B. Bo	188·6	1,189	F	
E. Urea	186·0	1,172		
A. F. T. E.	171·5	1,081		
F. Control	158·2	997		

III. 1954-55 TRIAL.

Although responses were obtained from molybdenum, boron, and boron plus molybdenum in 1953-54, no significant differences between the three treatment schedules were recorded. A somewhat similar trial was therefore carried out in 1954-55, an additional treatment in this case being the trace element cobalt.

(1) Treatments.

A. Control.

B. *Molybdenum.*—Ammonium molybdate (1/1,600) foliage spray applied two weeks after transplanting

C. *Molybdenum.*—Ammonium molybdate (1/1,600) foliage spray applied two weeks after transplanting and again two weeks later.

D. *Boron.*—Borax (1/250) foliage spray applied two weeks after transplanting.

E. *Boron plus molybdenum.*—Ammonium molybdate plus borax (1/6/1,600) foliage spray applied two weeks after transplanting.

F. *Cobalt.*—Cobalt chloride (1/1,600) foliage spray applied two weeks after transplanting.

(2) Procedure.

The experimental layout and fertilizer schedules were identical with those of the 1953-54 trial. The crop was, however, planted a little earlier—on Dec. 30—and harvesting began on Feb. 24, as against Mar. 3 in 1954. Growing conditions were relatively good during the growing period (Table 1).

(3) Results.

The results are presented in Table 3.

Table 3.

EFFECT OF TREATMENT ON YIELDS OF MARKETABLE FRUIT (1954–55).

Treatment.	No. of Fruit.	Significantly Exceeds at 1% level.	Yield.		
			Lb./ac.	Equiv. cases/ac.	Significantly Exceeds at 1% level.
B. Mo (single)	900	F, A	238·0	1,499	F, A
D. Bo (single)	889	F, A	234·2	1,475	F, A
E. Mo + Bo (single) ..	854	F, A	232·2	1,462	F, A
C. Mo (double)	828	A	225·2	1,418	F, A
F. Co (single)	690		184·8	1,164	
A. Control	602		168·2	1,060	

IV. DISCUSSION.

(1) General.

In these two trials, responses were obtained from boron, molybdenum and boron plus molybdenum. Mean yields per plot from these treatments in each year were as follows:—

1953–54—Mo (single spray), 202·2 lb.; Mo plus Bo (soil dressing), 199·5 lb.; Bo (soil dressing), 188·6 lb.; control, 158·6 lb.

1954-55—Mo (single spray), 238·0 lb.; Bo (spray), 234 lb.; Mo plus Bo (spray), 232·2 lb.; Mo (double spray), 225·2 lb.; control, 168·2 lb.

The overall higher yields in 1954–55 can be ascribed to the better growing conditions during the early stages of plant development.

The results from both trials, however, indicate that:—

(1.) Even in the absence of typical symptoms of deficiencies in boron and molybdenum, treatment with these trace elements increased production in the tomato crop.

(2.) A response to boron occurred in the absence of additional molybdenum and a response to molybdenum in the absence of additional boron. There were, however, no additive effects when both were applied to the crop.

(3.) The response to a single application of molybdenum was comparable to that obtained with two sprays applied at an interval of two weeks. The second treatment was therefore redundant.

(2) Status of Boron in the Soil.

Disorders in deciduous fruit trees due to boron deficiency have been recognized for many years in the Granite Belt and corrective treatments are an essential feature of efficient orchard management. For practical purposes, it is assumed that when the boron content of the soil falls below 0·3 p.p.m. additional boron is probably required. Even at these levels tree reaction varies from season to season in pome fruits according to the amount of rain which falls prior to and during the growing period. In the soil used for these trials, the boron level was 0·3 p.p.m. (soluble boron in hot water extract—determined by Agricultural Chemist).

The experimental data presented above suggest that the cropping potential of the tomato crop is substantially reduced by lack of sufficient boron in the soil. Periodic applications of borax therefore seem desirable in areas where vegetables are regularly grown.

(3) Status of Molybdenum in the Soil.

Although molybdenum deficiencies have long been recognized in coastal areas of southern Queensland, where the more susceptible crops such as cauliflower and rockmelon are grown extensively (Morgan and Henderson 1950), the economic significance of possible deficiencies at Stanthorpe were not realised until 1952, when spot applications of an ammonium molybdate spray to beans and some other crops substantially improved leaf colour and plant growth. The shortage of available molybdenum may, in part, have been aggravated by the progressively increasing acidity of the soil following the use of acidic fertilizers at heavy rates during and subsequent to the Second World War.

The problem at Stanthorpe, however, is not so much the correction of the disorder when molybdenum deficiency symptoms develop as the desirability of treatment at an earlier date; production from commercial crops may appear satisfactory and yet be far below the potential of the land when supplies of molybdenum are increased (Hewitt and Jones 1952).

(4) Additive Effects of Boron and Molybdenum.

Deficiencies of boron and molybdenum have distinctive effects on plant metabolism.

Adequate amounts of boron are essential for cell multiplication in the cambial tissues and a deficiency is followed by abnormalities in the associated parts of the plant.

A deficiency of molybdenum, on the other hand, causes an upset in nitrogen utilization, particularly when the crop is grown on highly acidic soils. Typical symptoms are chlorosis, stunting and malformation of the lamina and necrotic lesions along the margin of the leaves.

Where both boron and molybdenum are deficient in the soil and responses are obtained from corrective measures for each, one would expect a greater response when both are applied to the crop. No such additive effect was recorded in the trials. This could have been due to target spot infection which reduced the cropping period and total yields from which significant differences were determined or, alternatively, to deficiencies of other essential nutrients such as nitrogen. The latter seems the more probable in view of the response to a urea spray in the 1953-54 trial.

(5) Treatment Schedules.

Reserves of both boron and molybdenum in many soils are limited and deficiencies are therefore most pronounced in land which has been extensively farmed for long periods. Such conditions exist in the older established horticultural areas, such as the Brisbane district.

In this and similar areas, commercial crops are good indicator plants for boron, and it is standard practice to use a pre-planting dressing of borax on beetroot and cauliflowers. Boron residues from these crops appear adequate for tomatoes, beans, cabbage and other plants in the rotation. At Stanthorpe, where few beetroot and cauliflower are grown, growers have no ready guide to the need or otherwise of boron applications in commercial crops.

The present trials reveal a deficiency of boron both on virgin ground (1954-55) and on land which has been cultivated for some time (1953-54). It seems essential therefore that, in the absence of indicator plants in the rotation, boron should be applied either as a soil dressing of borax or in a foliage spray containing borax every second or third year on land which is continually cropped. This practice may not provide optimum amounts of boron but it should increase yields without any risk of residues accumulating in the soil in toxic quantities.

The molybdenum position is much the same as that for boron, and regular treatments appear to be necessary for optimum yields. However, the risk of toxic residues building up from foliage sprays of ammonium molybdate applied to each crop is negligible. For the time being, therefore, treatment of all crops at an early stage in growth is considered desirable.

V. CONCLUSIONS.

In trials carried out in the Stanthorpe district, increased yields of tomatoes were obtained following application of boron as borax, molybdenum as ammonium molybdate, and boron plus molybdenum. The second of these trials was established on virgin ground and it is therefore postulated that reserves of these elements on most farms are below requirements for maximum production.

Gross abnormalities in plant growth due to deficiencies of boron and molybdenum have not been recorded in the tomato crop at Stanthorpe. Indicator plants for deficiencies of these elements are not widely grown commercially in the district. The practice adopted elsewhere of applying corrective measures to susceptible crops where they occur in the rotation is therefore hardly practicable.

At Stanthorpe, the best procedure may be to apply a soil dressing of borax at least every second year to land which is regularly cropped to vegetables and to apply an ammonium molybdate spray to all crops.

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