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BORON DEFICIENCY IN ADOBE-DERIVED SOILS OF EASTERN CAVITE

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ABSTRACT

The abnormal characteristics of various plant species in the areas were described and/or illustrated. Preliminary chemical analysis of the soil was undertaken. Conclusions based on the data were subjected to deductions in attempts to confirm the former.

This case report has limited application to some parts of Cavite, but it may serve as a pattern for similar studies in other parts of the country.

Introduction

The traditionally cultivated crops and the volunteer vegetation in many parts of eastern Cavite appear normal. In the flat lands the main crop is rice; its yield approximates the national average. In the rolling fields, mangoes, chicos, tamarind, banana, papaya and a few others, look healthy and productive. Volunteer plants like camachile, ipil-ipil, cacawate and bamboo do not show signs of abnormality. Hence, farmers have heretofore tacitly presumed that the area has good soil for agriculture.

With the increasing population and the diminishing area of farm lands, the fields must be made to produce more rice and various other consumer products to meet the diversified needs of the present inhabitants. In recent years, farmers have tried to grow vegetables such as sitao, eggplant, green pepper, ampalaya, squash and watermelon as a second crop to rice. The leadership in the province envisions that with the irrigation water coming from Laguna de Bay, Cavite will be the vegetable bowl of Metropolitan Manila.

There are, however, indications of some problems which can loom large when the land is put into intensive cultivation. For example, some vegetable crops like sitao show abnormal symptoms when grown during the dry season. Also, papaya does not respond too well to sustained fertilizer application. The new leaves become frizzled and the terminal bud may die.

The problem has undoubtedly has been with the land ever since, but the farmers must have missed to attach some significance to their experience and observation. Usually, a less-curious farmer accounts a crop failure to bad luck or blames the weather. If a particular crop fails successively, the farmer simply refrains from planting it. It seldom occurs to him, to look into the cause of the failure. It takes a suspecting mind, which (Sherlock Holmes-like) see a problem in every straw in the wind, to appreciate the implication of the failure.

The attention of the present writer got attracted to the problem and prompted this study. This was conducted in Imus, Cavite; the National Institute of Science and Technology, Manila; and the University of the Philippines at Los Baños, Laguna. Experiments were made in 1984 and 1985.

Materials and Methods

The soil. The soil is a heavy, dark-colored clay, which is very sticky when wet; it is hard, with a blocky structure, when dry. The Bureau of Soils classified it as Guadalupe clay. It forms an overburden of about one foot thick on an adobe parent rock. When it is watered during the dry season, the water (on evaporating) leaves on the soil surface an incrustation of tiny white crystals.

Analysis for boron. The colorimetric procedure of Yoshida *et al.*, (1972) for available boron was adopted. A 20-gram soil sample was refluxed with 40 ml of double distilled water for 5 minutes. To a 1-ml aliquot of the extract, 2.5 ml of curcumin oxalic acid solution was added and evaporated on a water-bath at 55°C. The colored residue was dissolved in 5 ml of 20% alcohol solution of glycerine. Absorbance at 580 mu was taken simultaneously with the standard boron solutions similarly treated.

Analysis for zinc. The AOAC gravimetric method for zinc in fertilizers was followed. The soil was digested over a flame in a mixture of nitric acid and sulphuric acid; then, extracted with water; the extract was treated with hydrogen sulphide to precipitate the copper-arsenic group; the filtrate was treated with citric acid and adjusted to pH 3; hydrogen sulphide was again passed to precipitate the zinc sulphide; filtered, the precipitate was ignited at 950-1000°C to obtain zinc oxide.

Observations and Experiments

Survey of Abnormality

The writer became conscious of the soil problem in March 1984, when he noted that his sitao seedlings (*Vigna sesquipedalis*) had chlorotic leaves. The pair of leaves (produced after the cotyledons) had yellow bases (Figs. 1, 2, 3) and subsequently, the young plants died off. The few surviving plants produced many stubby shoots, reminescent of the "witches broom' disease.

In the adjacent plot, okra (*Abelmoschus esculentus*) and eggplant (*Solanum melongena*) were noted to have rugose young leaves. The undulation was apparently the result of the early cessation of growth in the veins and margin of the leaf blade, while, the vein-islets continued to expand. The cupped-up blades are shown in Figures 4, 5 and 6. On further growth, the eggplant was noticed to produce numerous active lateral buds. Apparently apical dominance was lost. Whether or not the chlorosis in the sitao and the cupping up in okra and eggplant were due to the same causative factor could not be ascertained.

Figure 1. Sitao seedlings showing chlorosis and drying of the pair of leaves produced after the cotyledons.

Figure 2. Young sitao at an older stage. Note the yellowing at the base of leaflets.

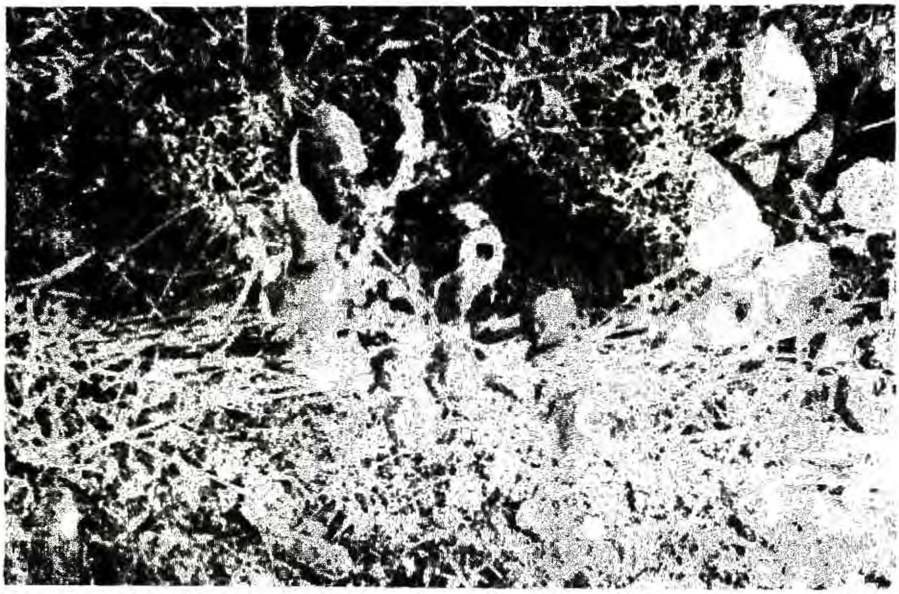

Figure 3. Much older sitao plants. Note the rough surface of leaflets and the cupping up.

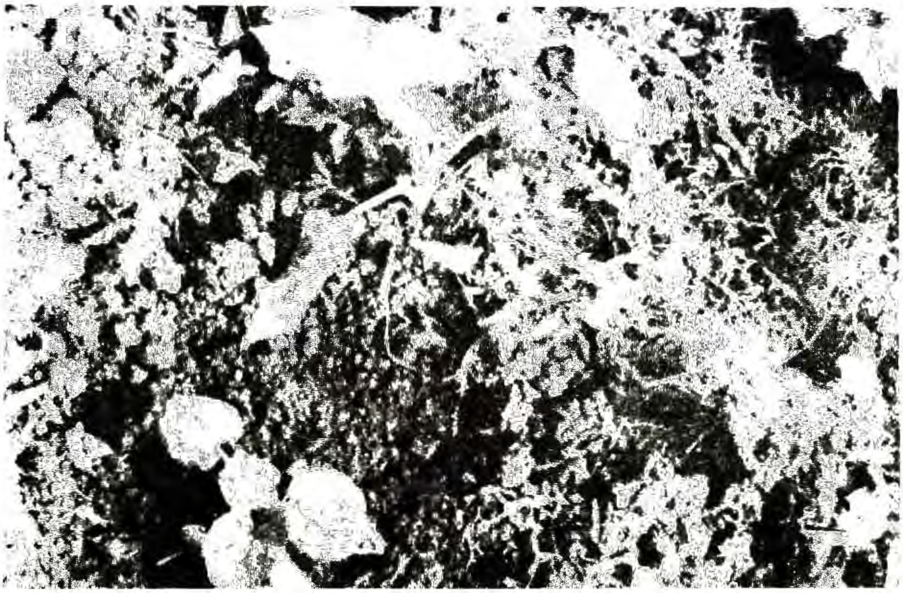

Figure 4. Young plants of okra. Note the chlorotic and distorted youngest leaf and the cupped older leaves.

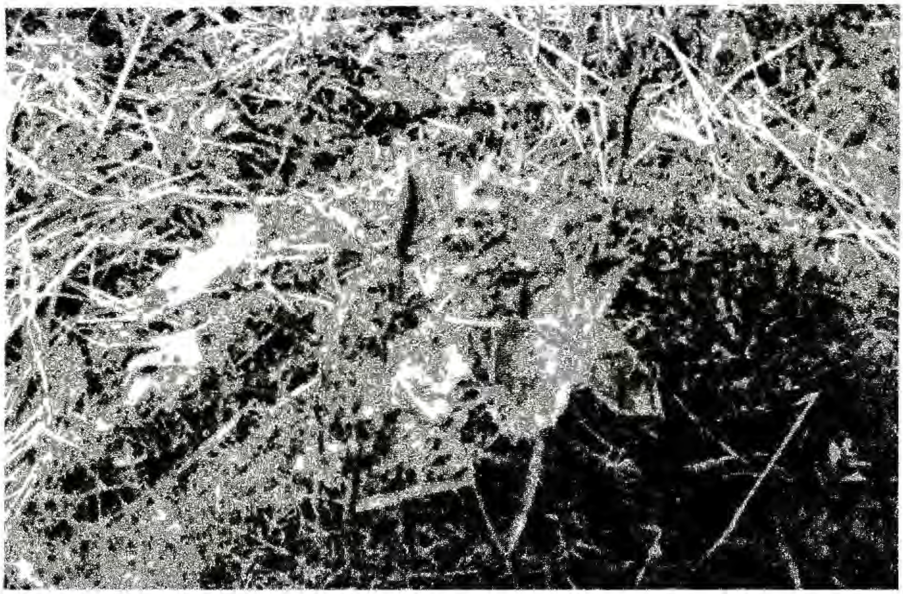

Figure 5. Older plant of okra. Note the cupped up leaf with dried margin.

Figure 6. Young eggplant. Note the rough cupped leaves. Lateral buds are starting to shoot out at this stage.

Figure 7. Tomato at flowering. Note chlorosis at the base of young leaflets.

Figure 8. Squash at first flowering. Note the distorted and stunted shoot.

Figure 9. A much older squash. Note the small rough leaves and premature drying.

Figure 10. Old cucumber vine with dried and drying leaves. Chlorosis and cupping up are noticeable.

On the other hand, tomato (*Lycopersicon lycopersicon*) did not show any sign of abnormality in the seedling and early growth stages. Abnormality started to show up at the approximate time of flower development. The base of the leaflets were yellow and rough for an unduly long time. These leaflets remained small and leather-like (Fig. 7). Squash (*Cucurbita maxima*) and cucumber (*Cucumis melo*), likewise showed delayed symptoms of abnormality (Figs. 8, 9, and 10).

Although gabi (*Colocasia sp.*), cassava (*Manihot utilissima*), bermuda grass (*Cynodon dactylon*) and a few other weeds were apparently normal, or even luxuriant, the similarity were the appearance of "witches broom", chlorosis and malformation of young leaves and the loss of apical dominance, including death of the terminal bud was apparent.

Attempts to Correct the Abnormality

Since sitao seemed to be most sensitive to the defective soil factor, it was used as test plant in the subsequent exploratory experiments.

In April, 1984, small plots were treated with borax as follows: 1) borax at the rate of 10 grams per square meter was mixed in the surface soil before the sitao seeds were planted, 2) borax, at the same rate, was applied about one week after the seedlings emerged; and 3) borax was applied as in (2) and repeated thereafter as deemed necessary.

The general impression gathered in this trial was that the soil-applied borax did not have any beneficial effect. Regardless of the timing of the application, the seedlings were not able to recover from the chlorosis, and they subsequently died off. In fact, some plants in treatment (3) died much earlier than in the other treatments. Apparently, boron reached a toxic level in some spots of this treatment.

One incidental observation, which led the writer to suspect that the severity of the abnormality was somehow related to the season of the year, was that the stray sitao seeds (which germinated after the heavy rains in June 1984) grew into very healthy plants, producing long, well-filled pods. Two things could have alternatively or jointly happened: the reduced light intensity (occasioned by cloudiness) could have alleviated the effects of boron deficiency; or, the rains must have leached out some detrimental soil constituent.

To pursue the hypothesis that the soil was deficient in boron, a plot was planted to sitao in January 1985, for subsequent boron treatment. Instead of applying borax to the soil, a dilute solution of borax (*ca.* 10 ppm B) was sprinkled on the leaves every two or three days. The mildly chlorotic leaves turned green and the cured plants produced long, well-filled pods.

Encouraged, the writer ran a follow-up trial in early March, 1985. The results were disappointing right from the start because the seedlings which emerged were severely chlorotic, just like the March planting of the previous year. The generally yellow, etiolated-looking leaves were sprinkled with the borax solution, almost every day. Although a few spots turned green – presumably the areas where the droplets of borax solution landed and seeped in – the plants were stunted and unproductive. Ultimately the "witches broom" condition appeared. Their stems broke when some plants were pulled up, indicating that they were brittle.

Although it is not a part of this experimentation, the experience of a nearby farmer may be worth recounting. In order to forestall his unhappy results of the previous years, he applied to his patch of sitao a heavy dose of ammophos fertilizer, (20-20-0) and he flood-irrigated the soil. As a result of these treatments, his plants became vigorous and dark green. However, the plants were short and stocky with many lateral branches. they took a long time to develop twining vines. They were shy fruiting and the pods were empty at the distal end.

This last unsought observation re-kindled the suspicion that the soil might have a constituent which could get concentrated to a deleterious level during the dry season. It was likely that in the instant case much of this constituent was leached out when the field was flood-irrigated, and whatever remained was tied down by the fertilizer as insoluble phosphate. While the twin treatments corrected in some way the deleterious excess, they did not correct the deficiency in boron; hence, the observed loss of apical dominance.

The fact that the sitao seedlings became chlorotic quite early (at the two-leaf stage) seemed not to reconcile with the knowledge that boron-deficiency symptoms generally come after the seedling stage. (There is enough boron reserve in the seed for use of the seedling during early growth.) The discrepancy could suggest that some deleterious factor inhibited chlorophyll formation.

Soil Analysis

The results of analysis for water-extractable boron are presented in Table 1. The concentration of boron in Imus soil is less than one-half of that in College soil. Incidentally, plants in College do not exhibit symptoms of boron deficiency.

To analyze the soil for the putatively toxic constituent, the writer obtained a water extract and fractionated it into various groups according to the scheme of qualitative analysis. It was hoped that enough of the substance (the apparently water-soluble fine crystals) could be accumulated in the water extract. Another reason for using the water extract was that iron in it would be minimal. Iron was avoided because it could form bulky precipitates which might occlude other elements.

The indications by qualitative analysis for the presence of zinc were equivocal; just the same, an attempt was made to analyze for it quantitatively. The data are presented in Table 2. It will be noted that the concentration in College soil was more than ten times that in Imus soil. Moreover, the color of the residue in the latter was not typical of zinc oxide. It may be deduced that if detrimental effects due to excessive zinc should occur at all, they should be expected in College soil.

Discussions

The observations so far gathered, which point to a deficiency of boron in the

Table 1. The water-extractable boron content of three soil samples

SAMPLE	*Replication*			*AVERAGE*
	1	*2*	*3*	
I. Parts per million in the extract:				
Imus, topsoil[1]	0.27	0.20	0.23	0.23
Imus, subsoil	0.23	0.17	0.17	0.19
College, topsoil	0.51	0.45	0.40	0.45
II. Computed parts per million in the soil:				
Imus, topsoil				0.117
Imus, subsoil				0.095
College, topsoil				0.230

[1] The residues after ignition of extracts from Imus samples were brick-red; that from College sample was white, typical of zinc oxide.

adobe-derived soil consisted of the following: (a) the deficiency symptoms, such as the "witches broom" condition, loss of apical dominance, chlorosis and roughness of young leaves, and general brittleness of the stem and leaves; (b) the malformations were quite severe during the dry season; (c) the recovery of plants from the abnormality upon treatment with boron; and (d) the relatively low level of boron as revealed by chemical analysis.

While these indications may be considered strong, they are not yet conclusive. More experiments and observations may have to be conducted in order to make certain that the impressions would graduate into knowledge.

While mind-meandering is a luxury which only the idle rich and the idle poor can afford, it may be amusing if we – the so-called busy, disciplined people – could sometimes indulge in the luxury. For example, it may be refreshing to speculate on how many problems we have missed to identify because our minds were not ready to recognize them. One principal cause of our failure is our having adopted, consciously or subconsciously, the attitude that the world is divided into opposites; thus, if you are not with me, you are against me; negative or positive; thesis or antithesis. We have not allowed space in our thought for dual existence or for borderline cases. In our instant case, we failed to appreciate the state of incipient deficiency.

It is disturbing to note that in a field with a borderline content of an element

Table 2. Weight of zinc oxide from 10-grams of three soil samples

SAMPLE	Replication			AVERAGE
	1	2	3	
I. Weight of zinc oxide, g:				
Imus, topsoil[1]	0.0220	0.0217	0.0187	0.0208
Imus, subsoil	0.0354	0.0350	0.0333	0.0346
College, topsoil	0.2326	0.4984	0.4418	0.3909
II. Computed parts per million in the soil:				
Imus, topsoil				408.9
Imus, subsoil				680.2
College, topsoil				7,685.0

[1]The residues after ignition of extracts from Imus samples were brick-red; that from College sample was white, typical of zinc oxide.

-- i.e., incipient deficiency or incipient excess -- most species would appear normal. If some of them were unthrifty, they would pass notice because they would not show abnormal symptoms. In such a field we very rarely meet with species with abnormality, because the very sensitive species would have died out as a result of competition, or they would no longer be in the field since the farmer (based on experience) would have eliminated them from his cropping system. And yet, the sensitive species are important indicators of impending danger. It may be worthwhile for us to seek them out and use them for reconnoisance. Foreknowledge of danger can forestall losses. To wait for abnormal symptoms to appear in our crop plants (which are less sensitive to the deficiency) before remedial measures are taken may not be expedient because usually at this stage of deterioration, remedial measures are no longer effective.

It is further disturbing that fertilizers have a complexing effect on the abnormality of the soil. When the element is incipiently deficient, application of nitrogenous fertilizers might initially mask it because the vigorous plant could extract exhaustively the limited supply. Then subsequent fertilizer application would elicit severe abnormal symptoms and irreparable damage. On the other hand, in a state of excess, the fertilizer could mask its detrimental effects through one of many physico-chemical or biological mechanism. For instance, in our case where something was probably in excess, the ammophos could have tied down the excess as insoluble phosphate, so symptoms of excess did not show.

It is perhaps imperative that we should study the various aspects and effects of elements, at borderline levels of deficiency or excess, in order to rationally and economically manage the soil and the farm.

Acknowledgement

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Selected References

Lepper, H. A. Chairman Editorial Board. 1945. Methods of Analysis, Association of Official Agricultural Chemists. Washington D.C.

Miller, E. C. 1938. Plant Physiology. N. Y. McGraw-Hill Book Co., Inc.

Yoshida, Shonichi, D. A. Forno; J. H. Cook, and K. A. Gomez. 1972. Laboratory Manual for Physiological Studies of Rice. International Rice Research Institute Miscellaneous Publications.

Modesto R. Recel, Discussant

I would like to thank the President and members of the National Academy of Science and Technology for giving the opportunity to benefit and share scientific experiences with you, on the occasion of your 7th Annual Scientific Meeting.

I am very pleased, indeed, to be one of the discussants for Dr. Jose R. Velasco's paper on "Boron Deficiency in Adobe-derived Soils of Eastern Cavite."

The work of Dr. Velasco is an eyeopener for other researchers to follow suit in resolving one of the long time dilemma of farmers tilling adobe-derived soils.

The paper, to me, is very interesting, but very intriguing to researchers in the sense that boron deficiencies are evident despite of the relatively high boron content of the soil ranging from 340 to 540 ppm as compared to figures in literature saying 200 ppm B to be toxic to plants, 25 to 100 ppm as normal and 15 to 25 ppm as critical levels in the soil by hot water analysis.

Apparently, there could have been an over-estimation of boron in the soil and this may be attributed to the analytical procedures and the equipment used. This suggests, therefore, the need to correlate the soil test values with crop response to the nutrient in question. This, I believe is one of the significant impact of the study of Dr. Velasco.

Plant tissue analysis may be used to monitor the concentration of a nutrient in question. The test value may be used to confirm possible deficiency or toxicity of certain nutrients.

In some instances, applying a deficient nutrient may not solve the deficiency problem. Here, we may examine the ratios and proportions of nutrients in the soil as well as in the plant. The pH of the soil should also be carefully examined because this property is very much associated with the availability of the macro- and more so with the micronutrients.

There is also the suspicion of Dr. Velasco on the deleterious effects of excessive concentration of certain substances resulting to the inhibition of chlorophyll formation as manifested by the chlorotic appearance of the plant.

There being no more time available, I wish to thank you again for giving me this opportunity to share views with you and to benefit from the fruits of your research efforts at NSTA.