DEFICIENCY DISEASES AND THE SYMPTOMS OF MAGNESIUM DEFICIENCY

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Introduction

The recognition of mineral deficiency and toxicity symptoms in the field is of the utmost importance in crop-culture. A deficiency symptom does not normally develop until the supply of the essential element is well below the amount required for good health. This means that, if the planter sees a deficiency symptom, the needs of the crop have not been met for some years. A deficiency symptom should therefore act as a red light, an emergency signal from the plant, and the grower should react.

Types of Deficiency Symptoms

Deficiencies of some elements affect the whole appearance of the plant. This is well known for nitrogen, phosphorus and sulphur. Other deficiencies affect only a particular part of the plant and the symptoms and their location presumably depend on the physiological function of the deficient element. This kind of localised reaction occurs with potash, calcium and magnesium.

Trace-element deficiencies cause rather localized symptoms as a rule but, when their function is connected with growth, as with zinc and boron, they can also have an over-all effect.

In its severest form any deficiency can suppress growth, though the initial effects may be rather localized.

Some elements are fixed and accumulated in the older leaves, with no possibility of transport to younger parts. A deficiency of such an element tends to cause symptoms in the growing parts. This is the situation, for instance with calcium, iron, and boron. Other elements, such as potassium and magnesium, are readily transported from older parts to new parts of the plant; the result is that the deficiency shows up first in the older parts, which are depleted of the element to supply younger growing parts.

The different functions of the mineral elements result in very varied deficiency symptoms but some classification is possible.

(1) *Chlorosis* of the leaves is a yellowing due to lack of chlorophyl; it always indicates the deficiency of an element which functions in the building or the maintenance of the chlorophyl, namely nitrogen, sulphur, iron, manganese and zinc, which are related to the formation of chlorophyl; their deficiencies show up in the younger leaves. Magnesium is actually a part of the chlorophyl molecule; if it is deficient, chlorophyl is broken down in the older leaves, making them chlorotic, and the magnesium is removed to the actively growing leaves.

(2) *Necrosis* of leaf or stem tissue consists of the death of certain tissues; it can be due to various causes and connected with many functions of elements. Marginal or inter-venal necrosis of leaf tissues is linked with potassium and magnesium deficiencies. Potassium deficiency almost always results in marginal leaf necrosis;

magnesium deficiency results in marginal or inter-venal necrosis only if there is an abundant nitrogen supply. Necrosis of young leaves is characteristic of calcium deficiency; this symptom is probably linked with the function of calcium as a part of calcium pectate in the cell walls.

Vegetation points and bark tissue (phloem) are specially liable to necrosis due to boron deficiency. Boron has an especially important role in growth processes. The same is true for zinc and copper, the deficiencies of which also can cause a serious general collapse of vital growth processes. A fourth deficiency causing necrosis in growing tissues is that of molybdenum.

(3) *Stunting* of plants is just a milder symptom of the above-mentioned deficiencies and is especially seen when there is a deficiency of zinc or boron and less commonly of molybdenum or copper.

Influence of Weather Conditions on Symptom Development

Both sunshine and rainfall have an effect on the development of symptoms (Wallace, 1951).

Nitrogen-deficiency symptoms develop more clearly under conditions of high intensity of light. Some tea clones (*e.g.* the fast-growing TRI 2024) show this clearly.

Symptoms of potash deficiency are more severe under dry-weather conditions.

Deficiency symptoms of magnesium can be pronounced during a wet season, because this element leaches out of the soil; but a high light-intensity has also the effect of increasing magnesium-deficiency symptoms by direct physiological action.

Regarding trace elements, iron and zinc deficiencies are more severe under conditions of high light-intensity. Zinc has a function in the production of growth hormones; if there is a shortage of zinc there is also a shortage of growth hormone; light has the effect of decomposing growth hormones and thereby diminishing the growth. If there is already a shortage of growth hormone due to zinc deficiency, the decomposition of the hormone by sunshine leads to a more severe shortage of hormone and consequently to a stunting of the plant.

Symptoms of boron deficiency are much more pronounced during a dry period due to lower availability of boron in the soil.

Review of Literature on Magnesium Deficiency in Tea

The symptoms of magnesium deficiency in tea were first obtained artificially in sand culture (De Haan, 1941) as follows:—

"In the case of magnesium deficiency, the old mature leaves go a light yellow colour, with the exception of the parts situated immediately along the veins. Sometimes the whole outer half of the leaf has a light yellow to white discolouration. The young leaf is at first normal in colour and development is normal. The old leaf is sometimes slightly folded convexly. Along the margin of the leaf, between the ends of the veins, there occur now and then brown dead patches, but this is not very characteristic" (translated from the Dutch).

In 1954 Tolhurst gave the following description of magnesium deficiency symptoms as found in the field:—

"Apart from poor growth the main points of note were the dullness and brittleness of the old leaves with, in some bushes, a pronounced folding upwards along the midrib. The leaves were not much reduced in size. The colour was pale and without the dark bluish green seen in a healthy leaf. The most characteristic symptom however, was a diffuse yellowish brown to coffee coloured mottling which appeared as a vague mosaic between the main veins and towards the centre of the leaf. Individual bushes vary in details, but the general similarity of the symptom is apparent. The brown areas have never been seen to reach either the midrib or the leaf edge, or to cross one of the main veins."

From these two descriptions, it can be seen that the symptoms may vary widely according to the type of tea, the severity of the deficiency, and the type of leaf observed. The observations by De Haan referred to the lower leaves on plants growing up freely and he emphasized the yellow colour; Tolhurst was concerned mainly with the older leaves in the plucking table and he emphasized the brown areas between the veins.

Chenery (1959) has just described magnesium deficiency in tea in East Africa. He puts special emphasis on the appearance of a "well-defined inverted green V at the base of the chlorotic leaves" and in other cases a "herring bone pattern of main veins on a yellowish-green to brown or yellow background." Both descriptions apply to Ceylon tea. We agree with Chenery that folded leaves are not characteristic.

Since the description given by Tolhurst, the frequency of symptoms of magnesium deficiency has probably increased in tea in Ceylon; in 1958, a vivid yellow discolouration of the lower leaves was the most apparent symptom. At higher elevations a brown discolouration does occur on plucking-table leaves that have shown the chlorosis for a long time.

The Place of Magnesium Deficiency Symptoms on the Tea Bush

The two main factors influencing the occurrence and increasing the severity of magnesium-deficiency symptoms are high intensity of light and high rainfall. Since the leaves of a bush are not all equally illuminated, we may expect the symptoms to occur in their severest form on those leaves that receive the largest amount of light. If all leaves received the same light intensity, then the oldest leaves should show the most severe symptoms, because it is well known that the older leaves are gradually depleted of magnesium for the benefit of deficient growing leaves.

An approximately uniform distribution of symptoms over all the older leaves occurs only on young plants that grow up freely without being pruned and that stand far enough apart not to shade each other. This pattern has been seen on a few plants that grew up freely to a height of about ten feet near an experimental plot at St. Coombs.

Clear symptoms on the lowest leaves can also be expected on clonal plants before they are pruned for the first time, because plenty of light can penetrate to the inner region of the bush. As soon as the bushes start covering the soil, however, and a plucking table has been developed, then the situation changes completely because very little light penetrates below the plucking table. This leads to a peculiar distribution of the symptoms in bushes some years after the first pruning. Depending on the density of the foliage, one finds the symptoms at the level of the plucking table in the first mature leaves and from there downwards in rather rapidly decreasing numbers in older leaves. In this case we do not find any symptoms on the lowest leaves in the bush but we find a severe chlorosis immediately below the growing shoots. On exposed sides of the field along roads we find the same symptoms on lower leaves as well.

Because of the practice of plucking, the distance between chlorotic leaves and young growing healthy leaves is very much reduced, as compared with the situation in freely-growing crops. As a rule one finds on woody shoots, between the chlorotic, magnesium-deficient, leaves and the growing tip, some mature leaves that are not yet affected by the chlorosis. Because we compel the bush repeatedly to produce new shoots from old dormant buds near old leaves, these old leaves become more and more depleted of magnesium and exhibit the chlorosis.

With a less dense plucking table, the chlorosis may develop mainly on leaves lower down in the bush and may easily be overlooked.

The Range of Symptoms

Chlorosis is the most characteristic symptom and direct effect of magnesium deficiency. After the development of chlorosis, a further process of deterioration may take place in the form of browning of the leaf surface due to necrosis of the cells. Acute sun-scorch may also develop in the chlorotic area. Finally, marginal or inter-venal necrosis may occur, but this stage has only rarely been observed in Ceylon*. The chlorosis may develop in many different patterns. On leaves of low-jat clones the chlorosis is, as a rule, more evenly spread over the leaf, with only some green tissue left along the midrib. In the last stages, low-jat leaves are almost completely yellow.

High-jat tea reacts in a different way; the chlorosis starts as patches of inter-venal and marginal yellowing which can resemble manganese deficiency. Later, this yellowing increases and develops into a clear marginal and inter-venal chlorosis, leaving only a narrow strip of green along the midrib.

A common symptom of magnesium deficiency in woody plants is the shedding of the chlorotic and necrotic leaves. This has not been observed on tea. It is quite possible, however, that in magnesium deficiency the life of the maintenance foliage is shorter and the total number of leaves remaining on a bush therefore smaller.

Sensitivity of Plants grown from Seed and Clonal Material

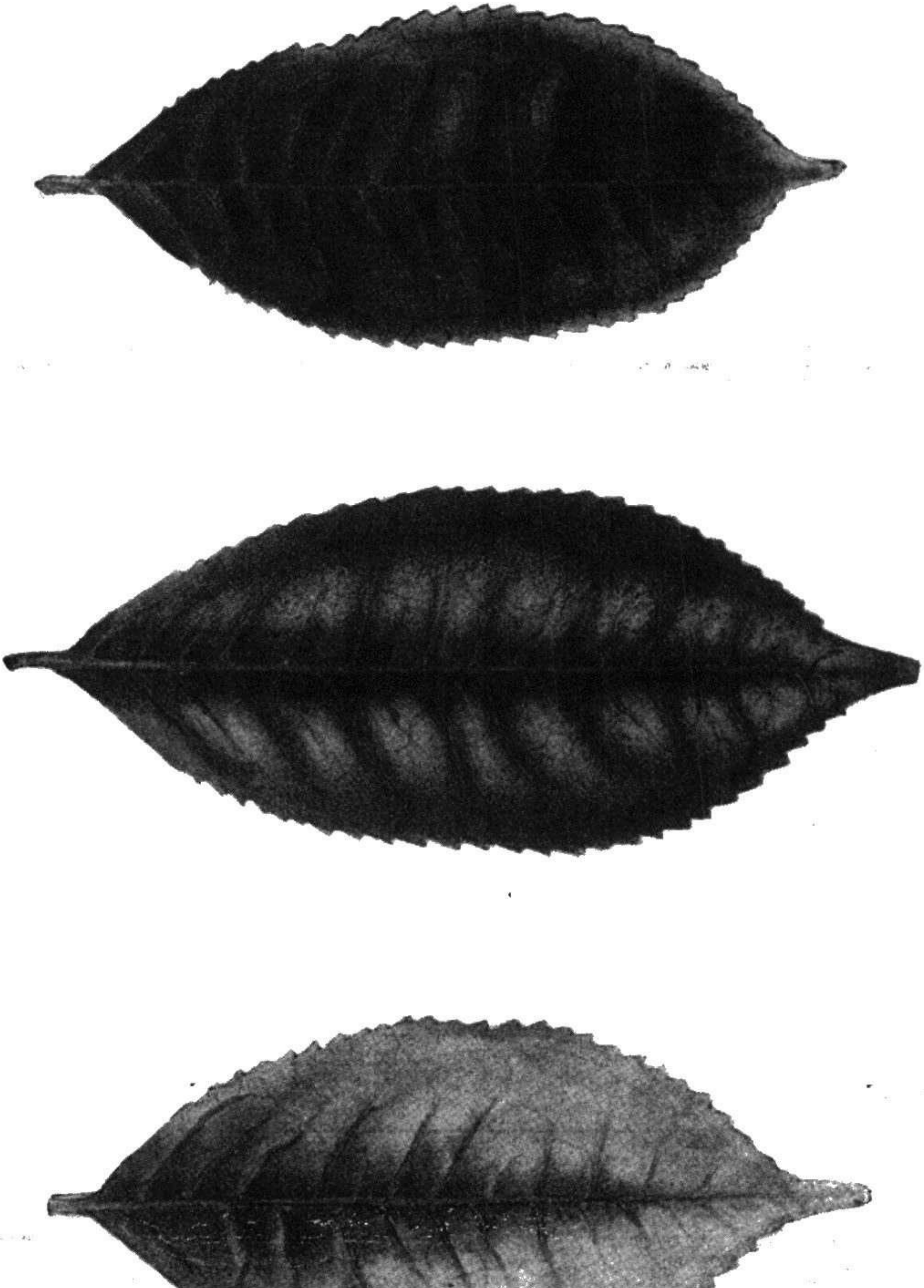
In tea bushes grown from seed, the sensitivity to magnesium deficiency must vary from bush to bush; in clonal material, on the other hand, all the bushes in one clone must have the same inherent sensitivity. Deficiency symptoms are therefore likely to show up more dramatically in some clonal plantings than in old mixed tea; there is, however, no reason to suppose that the clones in use are *on the average* more sensitive than material from seed. There may, however, be an effect: because clones are selected for vigorous growth, they may show deficiency symptoms earlier and more clearly.

There is no doubt that several clones, both high jat and low jat, are very good indicators for magnesium deficiency. Of the high-jat clones, TRI 2024 and TRI 2023 are good examples. TRI 2025 seems to be more resistant. The low-jat Court Lodge clone CL 72 is outstanding in sensitivity to magnesium deficiency, as are also Court Lodge CL 26 and Moray 23. The fact that these clones develop the symptoms so clearly does *not* automatically mean that they also suffer more from this deficiency. Other plants that do not show symptoms so easily might suffer in some other way not visible to us and their growth might be retarded to the same extent. We should therefore be grateful to the clones that do show symptoms, because they indicate the needs of the soil so clearly in this respect.

Coloured Pictures of Deficiency Diseases

A series of coloured plates has been published by De Haan (1941) showing the deficiency symptoms of calcium, magnesium, phosphorus, nitrogen, and sulphur.

* It is a well-known fact that necrosis develops severely only at high nitrogen level. Perhaps we have not reached such a high nitrogen nutrition in Ceylon or perhaps high rainfall prevents the development of such a high nitrogen level.



Marginal and intervenal chlorosis on mature leaves of tea clone T.R.I. 2024 due to magnesium deficiency

Potash-deficiency symptoms were illustrated in colour in the *Tea Quarterly* in 1953 by Portsmouth. Since then, no pictures of this kind have been published and nothing is available for the Ceylon planter. Tolhurst mentioned the need for such plates in 1954 in connection with magnesium-deficiency symptoms. It is hoped that the coloured plate presented here will be the first of a series of pictures of deficiency symptoms and other signs of diseased conditions of the tea bush.

The picture illustrates only a few variants of the symptoms of magnesium deficiency and the planter needs to study his own bushes and find the resemblances between his trouble and the present illustration. We do not claim to cover the full range of symptoms that might be associated with magnesium deficiency.

Separate reprints of this plate are available from the Institute at cost price. The idea is to have a series of plates assembled in a special cover into which the plates can be put one by one as they become available.

Leaf and Stem-Injection Experiments for the Diagnosis of Lower-Leaf Chlorosis

The methods of Roach and Roberts (1945) for identification of mineral deficiencies have been applied to lower-leaf chlorosis of tea but so far without useful result. It is possible that the leaves and stems used were too old for the purpose and could no longer react by producing new chlorophyl. It is planned to repeat these experiments with younger clonal material.

Field trials on magnesium deficiency in tea.—A summary of the two field trials carried out for the diagnosis of the symptoms of lower-leaf chlorosis, suspected of being due to magnesium deficiency, is given below. The symptoms, inter-venal yellowing on the lower leaves, were similar on the material used in both trials.

Method of assessment of the degree of chlorosis.—In the two field trials, the degree of chlorosis was measured by plucking about 25 leaves at random from the lower part of each bush, which is the region where the symptoms of chlorosis are most pronounced. The healthy leaves of the entire lot were separated from those showing symptoms of the typical inter-venal chlorosis, and the percentages of the chlorotic leaves were calculated (Table 1).

TRIAL No. 1

Location:—clonal area, No. 10 Field, St. Coombs Estate.

Material:—each treatment was applied to seven-year-old plants of Moray Clone No. 23 and was replicated twice.

Number of plants in each treatment = 12.

TREATMENTS

(1) Half a gallon of a *2% solution of magnesium sulphate (Epsom salts) was sprayed weekly on 12 plants for 33 weeks (*i.e.* 6–7 fluid ounces per plant per week).

(2) Half a gallon of a 2% solution of magnesium sulphate, into which a sticker had been incorporated, was sprayed weekly on 12 plants for 33 weeks.

(3) One gallon of a 2% solution of magnesium sulphate was injected weekly for 33 weeks into the soil around 12 plants, the points of injection being 9–12 inches away from the collar of each bush.

(4) Twelve plants were kept for 33 weeks as untreated controls.

(5) Half a gallon of a 10% solution of magnesium sulphate was sprayed weekly on 12 plants for 8 weeks.

(6) Half a gallon of a 5% solution of magnesium sulphate was sprayed weekly on 12 plants for 8 weeks.

* That is, 2% $MgSO_4, 7H_2O$; this is about 1% $MgSO_4$.

(7) One gallon of a 5% solution of magnesium sulphate was injected weekly for 8 weeks into the soil around 12 plants, the points of injection being 9–12 inches away from the collar of each bush.

(8) Twelve plants were kept for 8 weeks as untreated controls.

TABLE 1.—*The effect of spraying or injecting magnesium-sulphate solutions on the occurrence of lower-leaf chlorosis*

Treatments	Duration of treatment	No. of applications	% chlorotic leaves
1. 2% $MgSO_4$ spray	19-9-58 to 23-5-58	33	6.1
2. 2% $MgSO_4$ spray with sticker	do.	33	6.7
3. 2% $MgSO_4$ injected into the soil	do.	33	42.8
4. Untreated control	do.	0	68.7
5. 10% $MgSO_4$ spray	29-5-58 to 31-7-58	8	nil
6. 5% $MgSO_4$ spray	do.	8	7.1
7. 5% $MgSO_4$ injected into the soil	do.	8	10.5
8. Untreated control	do.	0	53.8

TRIAL No. 2

Location:—clonal area, No. 4 Field, Court Lodge Estate, Kandapola.

Material:—each treatment was applied to seven-year-old plants of Court Lodge clone CL 72 (= PW 72), and was replicated four times.

Number of plants in each treatment = 10.

TREATMENTS

(1) Half a gallon of a 2% solution of magnesium sulphate was sprayed weekly for 23 weeks on 10 plants.

(2) Ten plants were kept as untreated controls.

Table 2 shows the results obtained in Trial II.

TABLE 2.—*The effect of spraying magnesium-sulphate solution on tea plants showing lower-leaf chlorosis from* 11-3-59 *to* 12-8-59

Treatments		No. of applications	% chlorotic leaves
1. 2% $MgSO_4$ spray	Block 1	23	39.6
2. do.	Block 2	23	14.6
3. do.	Block 3	23	25.5
4. do.	Block 4	23	19.6
5. Untreated controls	Block 1	—	77.3
6. do.	Block 2	—	82.4
7. do.	Block 3	—	81.3
8. do.	Block 4	—	81.0

Discussion

From Table 1 it is evident that spraying of magnesium sulphate has been effective in diminishing the degree of lower-leaf chlorosis considerably. A 10% solution after 8 weekly applications caused the chlorosis to disappear almost completely. Sprayings with 5% and 2% solutions of magnesium sulphate were also effective, though to slightly lesser degrees. Soil injection with 2% magnesium-sulphate solution had no worth-while effect on the chlorosis, but soil injection with a 5% solution appeared to be more effective.

From Table 2 it is clear that spraying with 2% magnesium-sulphate has reduced lower-leaf chlorosis. There is a significant difference between the percentages of chlorotic leaves in treated and control plots.

Pot experiment on the influence of eelworm attack on magnesium deficiency in tea.—A preliminary pot experiment was devised to investigate the effect of foliar spraying and soil injection of magnesium-sulphate solution on plants growing in soil infested with meadow eelworm (*Pratylenchus coffeae* Sher & Allen, 1953).

MATERIAL.—6-8 plants showing severe symptoms of lower-leaf chlorosis of each of the following six clones were used:—

(1) TRI 2024	(4) Drayton 95
(2) TRI 2025	(5) Delmar 10/2
(3) TRI 2135	(6) Diyanilakele 13

The plants were about five years old. The date of inoculation of the pots with meadow eelworms was 24th March, 1959.

The volume of soil in each pot was about 18 litres (two-thirds of a cubic foot).

The method of assessment of lower-leaf chlorosis was similar to that given above for the two field trials.

The following treatments were applied:—

(1) foliar spraying of 2% magnesium-sulphate solution, on plants growing in meadow eelworm-infested soils, at the rate of 1 gallon of solution per 25 plants weekly.

(2) foliar spraying of 2% magnesium-sulphate solution, on plants growing in soils free from meadow eelworm, at the rate of 1 gallon of solution per 25 plants weekly.

(3) 2% magnesium-sulphate solution was poured into the pots containing soils infested with meadow eelworm at the rate of 175 ml. per pot weekly. The total quantity thus applied was 87.5 grams $MgSO_4$ per pot for the 25 treatments.

(4) 2% magnesium-sulphate solution was poured into the pots containing soils free from meadow eelworm at the rate of 175 ml. per pot weekly.

(5) untreated controls in soils infested with meadow eelworm.

(6) untreated controls in soils free from eelworm.

Table 3 shows the effects of the sprays and of the soil injections on the degree of lower-leaf chlorosis in soils infested with meadow eelworm and in fumigated soils free from meadow eelworm.

TABLE 3.—*The effect of 2% magnesium-sulphate spray and soil injection, on the diminution of lower-leaf chlorosis on meadow-eelworm infested soils and on fumigated soils free from meadow eelworm (treatment from 23-2-59 to 12-8-59)*

Treatments	Eelworm present + absent —	No. of applications	% chlorotic leaves
1. Foliar spray ...	+	25	8.9
2. Foliar spray ...	—	25	3.8
3. Soil injection ...	+	25	5.9
4. Soil injection ...	—	25	6.4
5. Untreated control ...	+	0	66.9
6. Untreated control ...	—	0	63.8

Discussion

From Table 3 the following conclusions can be drawn:—

(1) The results obtained in the field trials are confirmed in the pot experiment, where the foliar spraying and soil injection of magnesium-sulphate solution considerably diminished the degree of lower-leaf chlorosis.

(2) The effectiveness of foliar spraying and soil injection of magnesium-sulphate solution in diminishing lower-leaf chlorosis is not much influenced by the presence of a heavy infestation of meadow eelworm in the soil; there is a very significant difference in the percentage of chlorotic leaves in the treated and control plants, irrespective of the meadow-eelworm infestation.

Summary

1. A general account is given of types of deficiency symptoms and of the influence of weather conditions on the appearance of these symptoms.

2. The literature on magnesium deficiency in tea is reviewed, in the light of symptoms of magnesium deficiency as now commonly found in Ceylon. Emphasis is laid on the occurrence of marginal and inter-venal chlorosis in mature leaves in the plucking table and in older mature leaves as far as they are exposed to full daylight, as the main characteristic symptoms of magnesium deficiency.

3. The effect of light on the development of magnesium-deficiency symptoms in connection with their occurrence on the tea bush is discussed.

4. A list of sensitive and more resistant clones is given.

5. The value of coloured pictures of deficiency diseases is discussed in connection with the addition of a colour plate of magnesium deficiency to this article.

6. Results are given of spraying on to the leaves of the plant and injection into the soil of magnesium-sulphate solutions of different strengths for diagnostic purposes.

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References

CHENERY, E. M. & SCHOENMAEKERS, J. (1959). Magnesium deficiency in East African tea. *E. Afr. agric. J.* **25:** 25–27.

DE HAAN, T. (1941). Deficiency symptoms on tea, caused by an insufficient supply with the most important nutrient elements except potassium. *Arch. Theecult. Ned.-Ind.* **15:** no. 1, 1–32.

PORTSMOUTH, G. B. (1953). Potash deficiency in tea. *Tea Quart.* **24:** 79–81.

ROACH, W. A. & ROBERTS, W. O. (1945). Further work on plant injection for diagnostic and curative purposes. *Tech. Commun. Bur. Hort.* E. Malling, no. 16: 12 pp.

ROE, D. (1958). Some observations on the use of magnesium sulphate for a chlorosis of tea. *Tea Quart.* **29:** 132.

TOLHURST, J. A. H. (1954). Magnesium and manganese deficiencies in the nutrition of the tea bush. *Tea Quart.* **25:** 84–86.

WALLACE, T. (1951). The diagnosis of mineral deficiencies in plants by visual symptoms. (*London, H.M. Stationery Office.* 107 pp. + 312 col. plates.)