POTASH DEFICIENCY IN TEA CULTIVATION

(REVIEW)

T. E. T. BOND

A recent publication* by I. de Haan and A. F. Schoorel, from the Proefstation West Java, Buitenzorg, draws attention to the discovery of a disease in tea caused by a deficiency of potash in the soil.

This might seem surprising in view of the fact that potash fertilisers have only rarely been found to give increased yields of tea and have often actually depressed the yield. As the authors point out, however, experiments in the past have largely been carried out, in Java at least, on relatively young volcanic soils with a high reserve of potash and other minerals, whereas the deficiency disease has been detected so far only on a group of soils of different age and origin, in which, owing to prolonged weathering, the mineral reserves are relatively low.

The disease first became apparent about three years ago, when various firms in West Java reported a serious local deterioration in the plantations over a wide area. Chemical analysis of soil and leaves indicated the nature of the problem, since marked differences in potash content occurred between samples from healthy and affected localities. Symptoms agreeing with those observed in the field were reproduced in pot cultures under conditions of known potash deficiency, artificially induced. The complex relationship between the appearance of deficiency symptoms and the potash content of the leaf and amount of available potash in the soil has been fully worked out, while manuring with potash fertilisers has been shown to eliminate the disease in the field and to effect a great improvement in the general condition of affected plantations.

The symptoms of the disorder in tea bear a close resemblance to those which are known to occur under similar conditions in other plants, as for instance, in the "leaf scorch" disease of apple and other fruit trees. Affected tea bushes appear backward and poorly developed, due to the premature defoliation of the lower leaves, particularly towards the base of the plant. Branches which have lost their leaves in this way continue to form new ones at the top

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but as might be expected, the flush growth is considerably less vigorous than in a healthy bush. The lateral buds also fail to develop, so that the stems tend to remain unbranched. The leaves are usually dull green in colour and less glossy than the normal. When they are fully grown, the colour becomes darker still and may be replaced by a bronzed appearance, particularly along the margins and at the tips. These parts of the leaf eventually dry out completely and by their grey or brown colour give rise to the characteristic "scorched" effect. Often the drying out of the leaf margin is followed immediately by fungal attack and in fact it appears that typical grey blight (*Pestalozzia*) symptoms may sometimes be developed as a response to potash deficiency. In severe cases of the disease, the leaves tend to be crumpled or curled downwards along the midrib in addition to showing the other symptoms. The roots of badly affected bushes are also abnormal, being long and weak, with relatively few lateral branches. Probably, in the tea bush, as in other plants, the symptoms of potash deficiency will be found to vary according to the available supply of nitrogen, and will thus be aggravated by heavy nitrogenous manuring.

Potash, in the form of its soluble salts, is one of the essential elements for plant growth. It occurs chiefly in the young growing parts of the plant, and to keep these supplied a certain amount is normally withdrawn from the older wood and from the fully grown leaves, as they reach maturity. It is for this reason that a deficiency of potash is felt first by the older leaves, the effect is one of premature ageing due to the increased withdrawal of potash to the growing parts. Potash salts appear to exert an influence especially on the water relationships of the plant and the "scorching" of the foliage from the margins and tips inwards is believed to result from an inadequate uptake of water under conditions of potash deficiency. The relation between potash supply and the nitrogen economy of plants is very striking: a shortage of potash causes an accumulation of soluble nitrogenous compounds in the leaf. Growth and assimilation, *i.e.*, the manufacture of organic food materials, are quickly retarded by a deficiency of potash, but are also soon retarded by an excess over the optimum requirement, and this is probably the explanation of the decrease in yield sometimes resulting from the application of potash fertilisers.

SAND CULTURE EXPERIMENTS

Tea seeds were germinated in washed quartz sand and the seedlings transferred to glazed earthenware pots containing the same material to which were supplied nutrient solutions of known composition. During the first growth period, from transplanting the seedlings at the end of 1937 until they were pruned in May 1939, there

was little difference between the plants receiving no potash and those receiving the complete nutrient solution. (It must be remembered that a limited supply of all elements necessary for growth is provided in the stored food materials of the seed). After pruning, however, the "potash-free" plants developed typical deficiency symptoms, and their growth was considerably reduced.

FIELD OBSERVATIONS

In the early stages of potash deficiency, the plantations appear more or less normal and the yield is not affected. A certain amount of blight (*Pestalozzia*) is usually to be found and the woody growth is rather poor. However, a deterioration soon sets in and the bushes develop a thin appearance due to the loss of their lower leaves, as already mentioned. This commonly happens first towards the end of the pruning cycle. Wood formation is progressively worse and the leaves develop the characteristic symptoms in abundance. Eventually, the bushes die out after pruning. Whole patches may be affected, or isolated diseased bushes may survive.

The soil types on which potash deficiency symptoms occur in West Java can be described briefly as much weathered, lateritic soils derived mostly from andesitic material, *i.e.*, from sub-basic volcanic rocks containing from 50-60 per cent of silica. They are reddish to yellowish brown in colour and are freely pervious. Potash deficiency is found on these soils at all altitudes from 500 to 3,500 feet above sea level. It has not so far been observed on the younger sandy soils of volcanic origin, occurring on the higher mountains, nor on the typical marls. On the west coast of Sumatra, however, sandy or loamy mountain soils appear to be affected, but relatively little work has been done in this region.

In West Java, observations and experiments were carried out in four different areas. These are briefly described below.

(a). *West of Tybadak.*—In this district, the contrast between highly productive and badly affected, almost useless estates was most striking. All stages in deterioration could be seen in a short journey. A preliminary experiment showed conclusively that recovery could be effected, (*i.e.*, provided an excessive number of deaths had not already occurred) by a sufficiently heavy application of a complete fertiliser mixture. The quantity of mixture stated to give satisfactory results was 300 grams per plant, which can be taken to represent some 130 lbs. nitrogen, 200 lbs. phosphate and 200 lbs. potash per acre. A less generous application, of 75 grams per plant, produced little or no improvement. A further experiment was planned to investigate the effect of applying potash fertilisers only, but this was spoilt by a severe attack of *Helopeltis*.

(b) *The Plateau of Soekanegara and Njalindoeng.*—Here the results of a manurial experiment running for the past ten years were available and the following difference in potash status could be distinguished among different plots: (1) Definite symptoms of potash deficiency seen, (2) No visible deficiency symptoms, but considerable response to potash manuring, in yield, (3) Slight response to potash manuring only, (4) Adequately supplied with potash with no further response to additional amounts.

(c). *Western Outliers of the Boerang Range.*—An experiment on nursery plants was undertaken on an estate showing severe symptoms of potash deficiency. Growth as measured by the average height of the plants and the weight of prunings at the end of the experiment was best on those plots receiving the complete mixtures of 100 grams (about 3½ ounces) sulphate of ammonia, 50 grams superphosphate (or 90 grams rock phosphate) and 50 grams muriate of potash per square metre of about 25 plants, *i.e.*, about ¾ lb. of potash per square yard. Although none of the nursery plants showed definite symptoms of potash deficiency, those receiving potash were noticeably more free from "blight" and of a brighter green colour than any of the others.

(d). *North of Buitenzorg.*—An experiment was set up on a severely affected estate at less than 200m. elevation.

Four manurial treatments were given, as follows:—

(1). No Manure — O.

(2). Complete manure — NPK (75g sulphate of ammonia, 50g. superphosphate, 50g. muriate of potash, per plant) (*i.e.*, about 330 lb. potash per acre).

(3). No Potash — NP (do. muriate of potash omitted).

(4). No Phosphate — NK (do. superphosphate omitted).

The plants were pruned at the beginning of the experiment and manured immediately and again after three months. The effect of potash was clearly visible in the condition of the plants as they came back from pruning, while a record of the first ten plucking rounds gave the following total yields expressed as percentage of the yield from the unmanured plants:—

N.P.K. 145% N.P. 119% N.K. 161%

Symptoms of potash deficiency in the plants receiving no potash were aggravated by plucking, owing to the removal of that element in the flush.

(e). *Observations in West Sumatra.*—As mentioned above, symptoms of potash deficiency have been observed here also. While the situation is not yet fully worked out, it appears that striking increases in yield have resulted from the application of potash fertilisers.

The following results are typical of an experiment in this region:—

	PRODUCTION OF FRESH LEAF		WEIGHT OF PRUNINGS	
	Jan. '36—May '38.	May '38—Sept. '39.	May 1938.	Sept. 1939
No Manure	100%	100%	100%	100%
N only	114.5	114.2	110.2	114.2
N.P.	120.0	119.5	121.1	119.5
N.P.K.	146.0	153.4	216.3	210.6

It is noteworthy that addition of potash to the fertiliser has had considerably greater effect, in each growth period, on wood formation than on leaf production.

DEFICIENCY SYMPTOMS IN RELATION TO THE POTASH CONTENT OF THE LEAF AND OF THE SOIL

From all the experiments in the different areas described above, soil and leaf samples were taken for chemical analysis, with a view to establishing the relation, if any, between their potash content and the presence or absence of deficiency symptoms or manurial response to potash in the crop. While for the soil samples, the methods of sampling and analysis follow a more or less well established technique, the leaf analyses present certain peculiar difficulties. The biggest of these will at once be apparent from a consideration of the changing potash content of the leaves at various ages. As already mentioned, this is highest in the young, actively growing stage and decreases with increasing maturity. Various earlier attempts to predict manurial deficiencies from the ash analysis of the leaf — the so-called "foliar diagnosis" method — have probably failed owing to lack of appreciation of this fact.

The present authors have used only fully grown, mature (but not moribund) leaves for their analyses, and although the precautions adopted in sampling these are not stated in detail, their results indicate that the difficulties were satisfactorily overcome.

Taking all the results together, the conclusion emerges that provided the physiological age of the leaf is taken into account, in the manner indicated, the potash content of the leaf can be used as a reliable indication of the potash status of the plant. The following figures show the ranges of potash content observed in the ash from samples of leaves of various external appearance:—

Severely affected (Marked deficiency symptoms) ...	4.4%- 9.6% K_2O
Slightly affected (slight do.)	9.0%-19.0% ,,
Healthy	17.0%-44.0% ,,

Thus with less than 10 per cent of potash (K_2O) in the ash, or non-combustible residue of the leaf, the leaf is definitely diseased; with more than 20 per cent, it is healthy. However, the content of other elements, especially nitrogen, is of importance in certain instances. In tea, the authors state that by heavy application of nitrogenous and phosphatic fertilisers potash deficiency symptoms could be induced which were not accompanied by any abnormally low content of potash in the ash. Generally speaking, potash deficient plants have a relatively high nitrogen content, which, however, they are not able to make use of until the deficiency of potash is made good. Their phosphate content is usually only slightly lower than that of the normal leaf, while the total amount of ash present remains about the same, the balance being made up by increased quantities of magnesium (MgO) and, presumably, sodium (Na_2O.).

The potash content of the soil samples is conveniently expressed as the percentage of potash by weight of air-dry soil, extracted by means of 25 per cent hydrochloric acid. Here again, although a wide range of variation exists, the potash content of the soil is a reliable indication of its potash status in relation to the growth of the tea bush. In this case, the soils are grouped according to the occurrence of deficiency symptoms or the existence of a crop response

to potash manuring. The following percentages were obtained:—

Both potash deficiency symptoms and a response to potash manuring: .003% to .007% K_2O

No deficiency symptoms, but response to potash manuring: .009% to .017% K_2O

Do. no response to potash manuring: .016% to 0.58% K_2O

Thus, potash deficiency symptoms will occur if the percentage of potash in the soil (estimated as above) is less than about .007 per cent, while a beneficial effect of adding potash fertilisers may be expected on soils containing up to .017 per cent of potash. The authors are careful to state that these percentages will hold good only for the soil types to which their observations are confined. On different soils, quite different limits may be found.

As might be expected from the foregoing results, the potash content of the leaf is susceptible of modification within wide limits by the amount of potash available in the soil. With soils initially low in potash, a marked increase of potash in the leaf will be produced by an added supply to the soil. Thus, in the experiment carried out in the Buitenzorg district, already described, the potash content of the leaf was almost doubled (compared with the value from the unmanured plot) by a complete fertiliser mixture containing muriate of potash. On soils increasingly rich in available potash, this effect is rapidly diminished and it is probably negligible on soils in which the potash content exceeds .030—.040 per cent. This value is considerably higher than the limit (.017 per cent) above which no crop response to potash manuring can be demonstrated, and it suggests that the plant can accumulate potash in amounts appreciably in excess of its maximum requirements for growth and crop production.

Under exceptional conditions a low potash content may be found in the plant while in the soil it is relatively high. This is held to indicate a disturbed uptake of potash from the soil, and the authors suggest an examination of the soil profile for signs of pan formation or other conditions for which a remedy can be sought in improved cultivation.