'BITTEN-OFF' DISEASE OF TEA SEEDLINGS.

C. H. GADD, D.Sc.

Petch [6] described under the name 'Bitten off' root disease, a disease of tea seedlings which is characterised by the disappearance of the finer rootlets of pulled plants as though they had been bitten off by insects, though insects suspected of causing the injury are not usually found. He pointed out that if the plants are carefully dug out, the roots are found to be decaying, the decay beginning at the ends of the finer rootlets.

'Bitten off' is one of the most destructive diseases of certain tea nurseries in Ceylon. The first indication that anything is wrong is the unthrifty appearance of the plants; the leaves are crowded together and the older leaves fall prematurely. Eventually growth ceases entirely; the leaves fall and the plants die. It is usually the unsatisfactory growth of the seedlings which draws attention to the disease. By that time, not only have the finer roots disappeared but the greater part of the tap root also (Fig. 1). Frequently, no trace of the decayed roots can be found, but the remains of the tap root and the stumps of the laterals show signs of decay.

Petch also suggested that a species of Rhizoctonia was the cause of the disease. The isolation from the roots of diseased specimens of a large number of fungi, including a species of Rhizoctonia, and their later transference to roots of healthy seedlings failed, in every instance, to cause the disease. As the extensive search for a possible parasite failed to disclose one which would attack seedling roots when growing under normal healthy conditions, attention was given to possible environmental causes.

Bernard in the Dutch East Indies has described a somewhat similar disease of tea seedlings in which the primary root turned brown and rotted off from the tip upwards soon after it had emerged from the seed. The cause of this disease was attributed to excessive dampness in the seed bed at the time of germination, which weakened the young plants and favoured the development of a parasite.

It is to be expected that excess of water alone, without the intervention of a parasite, will lead to the death of tea seedlings, if such conditions are maintained, but the symptoms preceding such deaths have not been described. To ascertain what these might be the following experiment was devised.

Fig. 1. Seedlings showing 'Bitten off' symptoms.

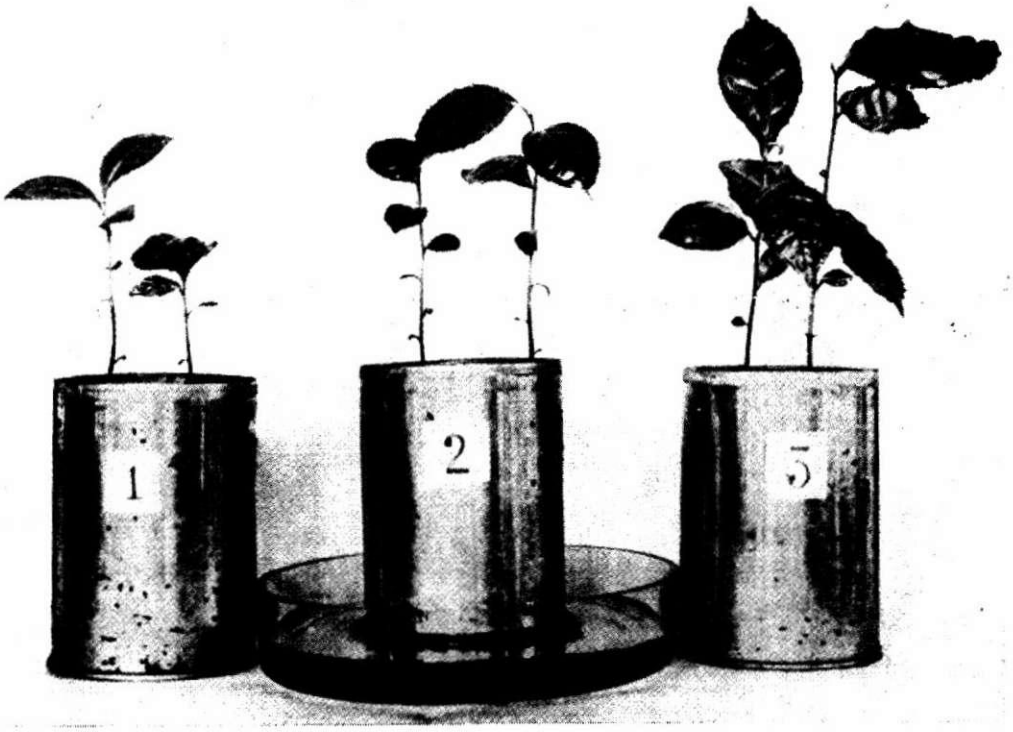

Fig. 2. Seedlings grown under different soil moisture conditions.

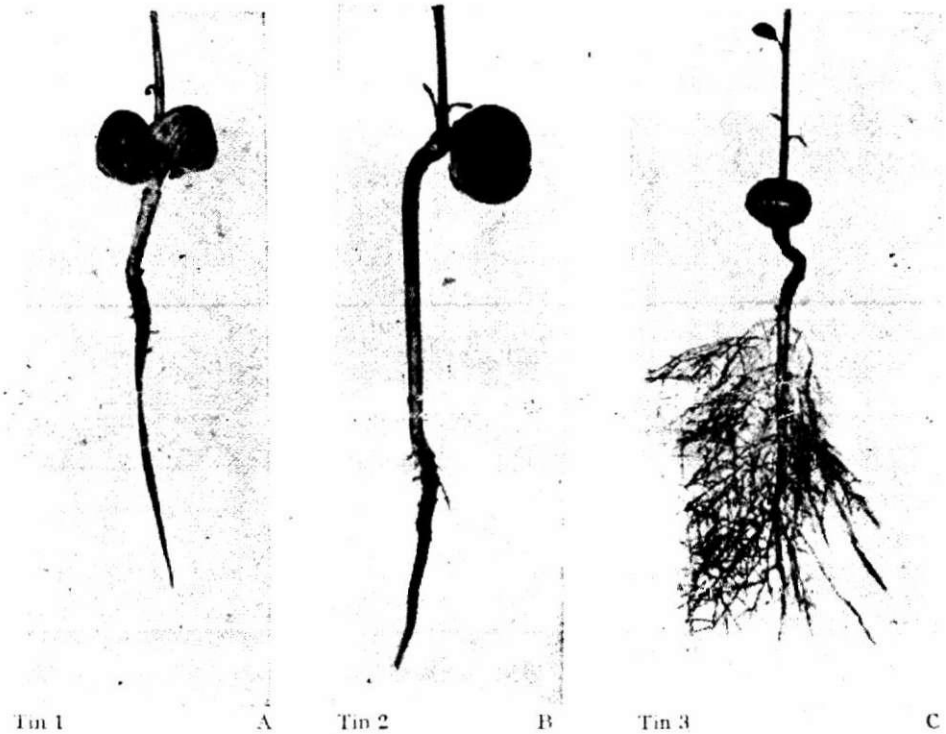

Fig. 3. Roots from tins 1, 2 and 3 are shown as A, B and C respectively.

A black Nuwara Eliya soil was first tested for its water-holding capacity. Known weights of the dry soil were placed in tins with perforated bottoms and then saturated with water. The excess of water was allowed to drain away and when drip had ceased from the bottom of the tin the soil was reweighed. The condition of the soil then was such that it carried the maximum amount of water without being actually water-logged. The mean of 3 tests gave a value for the water content as 49 per cent of the weight of the dry soil. From this result it was decided to add 44 per cent of water to that soil (*i.e.*, 5 per cent less than the maximum) to represent a very wet but not water-logged soil.

Young tea seedlings, selected for uniformity of size, were planted in similar soil in cylindrical tins 8.5 cms. in diameter and 12 cms. deep, the bottoms of which were perforated to allow of drainage. Water was allowed to drip continuously from a fine tube on to tin No. 1 and to drain away from the bottom of the tin. The rate of drip was at first equivalent to a rainfall of 4 inches per day but later it was reduced to an equivalent of $1\frac{1}{3}$ inches per day. These conditions represented continuous, though abnormal, rainfall with fairly good drainage.

The second tin, No. 2, was placed in a shallow basin containing water sufficient to cover the bottom of the tin to a depth of 1 cm. No water was applied to the surface of the soil. This represented a water-logged soil with a water table about 11 cms. or 4 inches below the soil level.

To the third tin, water was added until the water content amounted to 44 per cent of the dry weight of the soil. Periodically, water was added to restore the water content. This represented a wet but not water-logged soil.

After 3 months the experiment was stopped. The condition of the plants at the end of the experiment is shown in Figure 2. The plants in tin No. 3 had made fair growth, while those in tins 1 and 2 had become unthrifty but showed no signs of organic disease. When however, the plants were carefully removed from the soil their roots presented another picture (Fig. 3). The roots of the plants in tin No. 3 were well developed with no signs of decay, but the roots of the plants from tins 1 and 2 were in poor condition. There were no lateral roots and the main root had decayed for some distance from the tip towards the base. In short, these plants exhibited the symptoms of 'Bitten off.'

There was nothing to choose between the root systems in tins Nos. 1 and 2. There were no fine roots in the upper and supposedly drier layers of tin No. 2 and it was evident that an excess of running

water was as detrimental as an excess of stagnant water brought about by an artificial water table.

Here then was a possible cause of the 'Bitten off' disease of tea seedlings, but field examinations soon demonstrated that an excess of water was not the sole cause. A few cases of the disease have been investigated where it was possible to demonstrate that an excess of water was the cause, but for every such case many were encountered for which such an explanation was very unsatisfactory.

Petch was the first to point out that 'Bitten off' occurred most frequently in nurseries made on the sites of old buildings and labourers' gardens. Enquiries regarding the previous history of affected gardens fully confirmed Petch's observation. Excess of water as a cause does not account satisfactorily for these observations, so other possible causes had to be sought for.

In order to ascertain the effect of acidity on the development of the tea plant, seedlings were grown in water culture solutions of various pH values.[4] These experiments indicated that pathological symptoms, as shown by the death of roots and yellowing and dwarfing of leaves, can be induced with solutions approximately neutral in reaction, and corrected when the acidity of the solution is increased. Confirmation was obtained from pot experiments [5] which also demonstrated that the optimum pH value of soil for tea lies between 5.3 and 6.5 and that higher values lead to the development of pathological symptoms. In short, tea will not tolerate a neutral or alkaline soil and such conditions give rise to the disease known as 'Bitten off.'

These conclusions have been amply confirmed by numerous analyses made by the Agricultural Chemist, a few of which have been published.[1] They also offer a satisfactory explanation of why 'Bitten off' so frequently occurs in nurseries formed on old building sites. The alkalinity on such sites results from the incorporation into the soil of mortar and lime rubble. The reason why line gardens prove so unsatisfactory is perhaps not so apparent until the fact is taken into consideration that labourers use as manure wood ashes which are highly alkaline.

Alkalinity of soil can be brought about by means other than liming. The excessive use in gardens of wood ashes from domestic fires, and in tea adjoining factories of ashes from the driers, is a common cause of detriment to soils used for tea culture.

The effect of wood ashes was clearly demonstrated in a nursery visited recently. The site adjoined the factory and was separated from it by a broad path. The tea plants in the nursery were healthy except for those growing along a strip parallel with the path.

Enquiries elicited the information that at one time there had been a long flower bed alongside the path, and at intervals a liberal supply of wood ashes had been applied to it with beneficial results to the flowers. When the land was used as a tea nursery the exact position of the bed could be recognised by the presence of seedlings affected by 'Bitten off' disease in that area, whereas the plants in the remainder of the nursery were healthy.

Eden has also called attention to the detrimental effect of compost when applied in undue amounts in supply holes, nurseries and supply baskets.[3] Well made compost is usually alkaline and unless suitably diluted with acid soil the resulting mixture is insufficiently acid for healthy growth of tea.

Judging from the number of plants affected by 'Bitten off' sent to the laboratories each year, it is evident that the cause of the trouble is still not generally recognised. Tea will not tolerate anything but acid soil, and land which has a neutral or alkaline reaction, though excellent for most other plants, is quite unsuited for tea. There are two ways of determining whether a particular soil is suitable for tea culture. One is by attempting to grow tea on it and the other is by having its reaction tested. The latter method is quicker and far cheaper. Many soil reaction tests are made after trouble has occurred, and, though these have supplied a mass of evidence regarding cause and effect, it would be more satisfactory to all concerned if the tests were made before risking failure. Much loss could then be avoided.

Although 'Bitten off' is best known as a disease of seedlings, it will be realised from the nature of its cause that it is not restricted to seedlings. Adult tea will exhibit comparable symptoms if the reaction of the soil is changed owing to cultural treatment. One such way of changing the soil reaction has already been mentioned, viz. the excessive use of wood ashes from factory driers. The condition of the tea immediately surrounding a factory will often indicate what use has been made of factory wood ashes.

Liming is a well-known agricultural practice but for obvious reasons it cannot be recommended for tea.

Ceylon soils in the tea areas are usually acid. Small areas may have had the reaction altered by means already mentioned, but Eden has also called attention to large-scale occurrence of soil alkalinity,[2] and instances a whole estate found to be suffering from pronounced soil alkalinity. Such areas are likely to occur in the vicinity of limestone. Attempts to establish well-grown seedlings or tea stumps in such areas are likely to fail.

SUMMARY

1. An acid soil is essential for successful tea culture. If the soil is not sufficiently acid, the plants develop symptoms characteristic of the disease termed 'Bitten off.'

2. Old building sites and line gardens are usually unsuitable for nursery sites owing to the soil being alkaline due to lime rubble or wood ashes.

3. Injudicious use of compost will have the same effect.

4. Soils in the vicinity of limestone outcrops are likely to be unsuitable for tea culture owing to their unfavourable reaction.

5. If there is any doubt concerning the suitability of sites for tea nurseries the soil reaction should be tested, preferably before the seed is sown, and not after the disease symptoms have occurred.

6. Another but less common cause of the disease is excessive water.

REFERENCES

1. Eden, T.—Annual Report for 1928, Tea Research Institute Bulletin 3, pp. 19-20, (1939).

2. — Annual Report for 1931. Tea Research Institute Bulletin 8, p. 36 (1932).

3. — Annual Report for 1938, Tea Research Institute Bulletin 19, pp. 59-60 (1939).

4. Gadd, C. H.—Tea and Soil Acidity. I—Water Culture Experiments, *Tea Quarterly*, I, pp. 2-6 (1928).

5. — Tea and Soil Acidity. III—Pot Culture Experiments, *Tea Quarterly*, II, pp. 1-6 (1929).

6. Petch, T.—The Diseases of the Tea Bush. London, 1923.