CALLUS.

By

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When woody plants are wounded down to the wood, either by cutting across a stem or by shaving off the bark (cortex), growth takes place from the cambium which has been exposed at the margin of the wound (between the wood and the bark), and this results in the formation of a ring of tissue, often somewhat swollen, surrounding the wound. This tissue gradually extends over the exposed wood of the wound, and in favourable circumstances the growth from the sides may meet in the centre and coalesce, thus forming a completely closed covering over the wood.

This tissue is known as callus. It is the natural means of healing wounds on woody stems. All woody plants should be capable of callus growth, though the rate of growth is slower on old trees and stems than on young ones.

While the callus is growing over the exposed surface, it forms an outer protective layer of cork and an internal cambium which is continuous with the original cambium of the stem. When the ingrowing edges meet and close together over the wound, their cambiums unite and form a continuous cambium, continuous with the original cambium of the stem, so that new wood and bark is formed over the wound, just as on other parts of the stem.

The wood which was exposed by the wound does not unite with the new wood formed over it. The old exposed surface is simply buried, and remains permanently within the stem as evidence of the wounding.

The initiation of callus growth is not necessarily confined to the margins of wounds. On large wounds on rubber trees, islands of callus may appear in the middle of the wound, arising from the ends of medullary rays which have developed an independent cambium.

Tea, being a woody plant, should, and does, form callus, though, even on unpruned bushes, callus growth is slow, when compared with, say, callus growth on a rubber tree.

In general, the growth of callus is more rapid on young trees than on old ones. In temperate climates, the rate of callus growth varies with the time of year at which the wound is made. If made in the growing season, the rate of growth is most rapid when the callus first begins to grow and it slows down later. Thus, in the first year, a broad cushion of callus may be formed round a wound, but in subsequent years the growth becomes less, and it may cease altogether long before the wound is covered.

Naturally, vigorous plants are in a better condition to form callus than weak plants, and anything which will increase the vigour of the plant may be expected to promote the formation of callus. Thus, manured tea bushes would be expected to show a better callus formation than unmanured bushes, though other considerations must be taken into account. But no experiments have ever been carried out which would justify the omission of any of the chief manurial ingredients, nitrogen, phosphoric acid and potash, from a manure mixture for the purpose of favouring the growth of callus.

That callus growth slows down as the wound becomes older is well known. The most vigorous callus growth occurs soon after pruning, unless the pruning has been done at a time when growth is at a standstill, e.g., in the winter, in temperate climates. Consequently, when tea has been manured at pruning time specially to promote the growth of callus, and no marked callus growth is evident during the next six months or so, one must count that manuring a failure from the point of view of callus formation. It is urged that that is a wrong view, and one must wait some years before expecting any response. But, when the tea receives, say, 1,800 pounds of manure per acre during the pruning cycle, it is surely illogical to attribute all subsequent callus growth to an incomplete mixture applied at pruning time. Any cumulative effect must be an effect of the whole system of manuring, plucking, and pruning.

An ideal callus should begin to develop soon after pruning, should grow evenly all round the wound, and should cover the exposed wood before it has begun to decay. Development is best over a flat surface. If the wound is a cavity, the developing callus, as a rule, does not grow down the sides of the cavity, but curves inwards at the top and forms a rolled-up edge. Thus the cavity is never closed, unless it is so small that the rolled-up margin completely blocks it.

On very oblique pruning cuts, the callus often develops only from the lower edge, forming a flap extending over the exposed wood. As previously stated, the callus does not unite with the wood, but simply grows over it. In a proper callus development, growth occurs from the margin all round the wound, and it is the pressure of the developing edges of the callus which causes them to unite, when they meet, and seal the wound. A flap which extends from the margin of the wound on one side only, may grow right over the wound, and even over the stem beyond, and yet afford no protection if there is no growing callus on the other side of the wound, with which it can unite. It will not unite with the bark of the stem, nor with a narrow fringe of callus which has ceased to grow.

An example of such ineffective callus growth is illustrated in *The Diseases of the Tea Bush*, page 126. That example is one of

several which were collected on one estate about ten years ago. In some cases the plates of callus were three inches across, and extended widely over the surface of the stem. They were not fused with the stem, and as a protection they were useless,—a waste of energy on the part of the bush.

In pruning off a lateral branch, the cut should be made close to, and parallel to the main stem. In many cases, the cooly, beginning on the underside of the lateral close to the main stem, cuts outwards, so that a wedge-shaped snag is left (Plate VII., fig. 1.). Usually, a good callus develops from the lower edge, but none, or very little from the upper projecting edge of the cut, with the result that the snag remains as a permanent source of decay.

Callus does not easily grow over a projection. If a jagged piece of wood projects from a saw cut, the callus will grow over the cut surface until it meets the projection, which remains uncovered and affords a point of entry for wood-rotting fungi.

Similarly, when a pruning cut is very oblique, callus growth at the upper thin edge of the wound is poor or absent. Nearly all the growth arises from the lower edge, and this may not cover the wound, or may not unite with the callus at the upper edge. From the point of view of callus development, pruning cuts should not be too oblique, but it is difficult to avoid this when pruning thin branches.

An exception to the foregoing occurs when a bud starts just below the upper edge of the cut. In such cases there is usually a good development of callus all round the cut, probably because the new shoot maintains the supply of water and food right up to the cut. But pruning to an "eye" is impossible on old wood.

That moisture favours the development of callus, at least in the early stages, has been known for many years. There is a well known experiment, often included in elementary text books of botany, which consists of ringing a willow twig and suspending it in a damp atmosphere. The experiment concerns the translocation of food, but, incidentally, it shows a remarkable development of callus under the humid conditions.

However, further facts have to be taken into account. Experiments have recently been carried out on callus formation on hard wood cuttings, some of which were planted in a wet substratum while others were planted in a drier medium. The experiment was begun in late September. At the end of October, those in the wetter substratum were better callused than those in the drier, but, subsequently, the latter gained steadily on the others, and by the end of January they were considerably the more forward. Thus the favourable action of moisture was confined to the early stages.

It follows from the data presented here, that in collar pruning, where large cuts are inevitable, the cuts should be made nearly flat, to obtain a growth of callus all round, and should be as low as possible, to secure humid conditions.

It may be noted here that the problem of callus growth in Ceylon is the development of callus over cuts, two to three inches in diameter, and exhibitions of callus growth on branches less than half-an-inch in diameter, i.e., on young wood, evade the main point.

As already pointed out, callus grows best over a flat or even surface. It is always superficial, i.e., it cannot grow through dead wood. Where callus appears to have grown through wood, there must have been a split in the wood first. Callus cannot push out unsound wood, unless the latter is in loose fragments, or a powder, or reduced to mud.

A callus developing at the edge of a "branch canker" sometimes dies back. This may occur, even if the canker has been cleaned out and a preservative applied, but it is more common where the wound has not been cleaned out.

Callus, even if it completely seals a wound, does not necessarily stop the decay of the wood, if the latter has been infected by wood-destroying fungi before the callus was complete. Figure 2 on Plate VII. shows a branch with two perfect heals. On cutting this branch longitudinally, it was found to be decayed internally, the decay having started from each of the wounds (Plate VII., fig. 3). The level growth of callus indicates that the exposed wood presented a level surface, i.e., there was no cavity, when the callus was growing. It is clear that it was then infected, and the callus did not stop the decay. This example indicates the necessity of protecting the wood by some preservative, even though callus development is good.

Surprise has been expressed that the Institute recommends the use of preservatives, which will tend to keep the wood dry, in spite of the fact that moist conditions favour the growth of callus. There might be some excuse for that surprise if the development of callus over a wound, two to three inches in diameter, were a matter of a few weeks. In actual fact it is a matter of years. Even on tea which has been specially manured, there may be no sign of healing of branch cankers and large pruning cuts at the end of four years, and we have yet to see complete healing over a three-inch cut. Meanwhile the exposed wood continues to decay.

The promotion of callus formation is an excellent object, and it is to be regretted that its advocacy has been coupled, quite irrelevantly, with the condemnation of methods of treating wood rot. Without some treatment of the wounds, decay cannot be arrested. Moreover, the conditions are more favourable for callus growth if the cankers are cleaned out and treated, than if the callus has to grow over

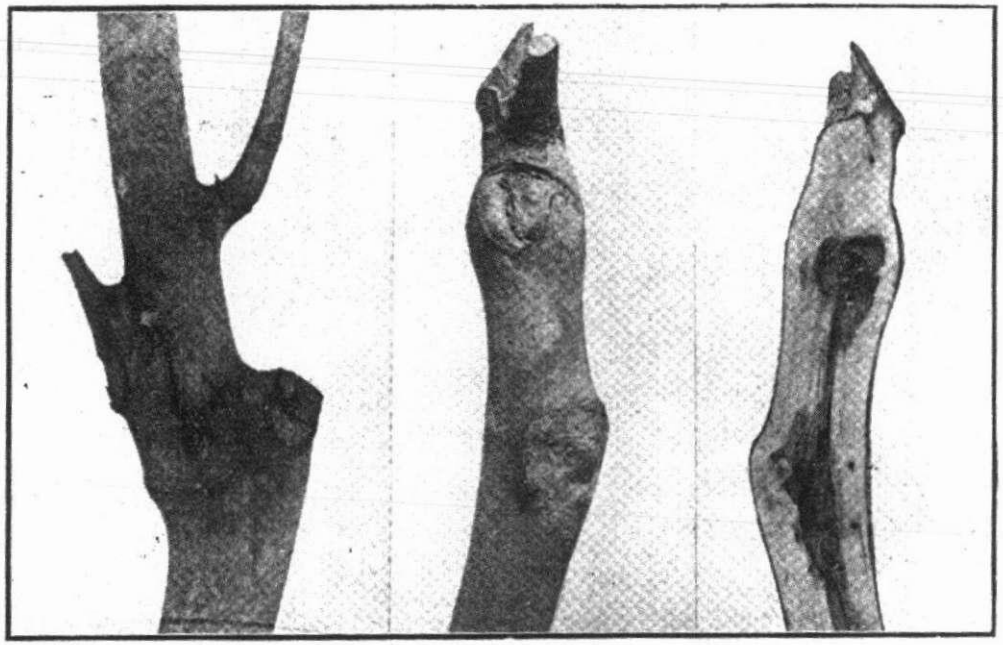

Fig. 1, Snag (on left) after pruning, natural size.
Fig. 2, Branch showing two perfect heals. x 3/5.
Fig. 3, Longitudinal section of same specimen, showing internal rot.

irregular unsound wood. In the present state of Ceylon tea, callus development is supplementary to treatment of wood rot; it cannot replace the latter. It is folly to allow wood rot to proceed without treatment, in the hope of obtaining a covering of callus in, say, ten years time.

The view that the decay within a "branch canker" will be arrested by the formation of a wound gum barrier lacks foundation. It is merely an unwarranted deduction from investigations carried on in temperate climates. No one has yet found such a wound gum barrier in Ceylon tea.

Further, as was stated in the *Tea Quarterly*, Part 2, pp. 29, 30, the scientists who have carried out these modern investigations recommend the use of preservatives for covering wounds. In this country, the results of these investigations are being misunderstood and misapplied.

Any method which will tend to improve the vigour of the tea bush is to be welcomed. But it should not be supported by mistaken arguments which decry other treatments, to the detriment of the tea industry. If the present scale of manuring is justified by the increased yield, well and good. But Directors must not imagine that they are thereby carrying out an efficient treatment of wood rot.

I am indebted to Dr. C. H. Gadd for the photographs on Plate VII.