Citrus Budding in the Tropics: Towards an Explanation of the Favorable Results of Lopping

J. A. Samson and J. P. M. Bink

All great citrus regions of the world are situated in the subtropics. Therefore, it is understandable that practically every citrus book has been written with the subtropics in mind, and that methods and practices evolved in and for the subtropical climate are also applied in the tropics.

BUDDING

Nursery practices may illustrate this point. In the subtropics autumn or *fall* budding is preferred in many areas. This is done at a time when the tissues are still growing actively and a good union can take place. Soon afterwards temperatures drop and the stem enters a dormant stage, although root growth may continue for quite a while. In spring, when stem growth is resumed, the top of the stock is cut back to just above the bud, or a few inches higher. Thus the nurseryman hopes to transfer growth into the inserted bud.

In *spring* budding, something similar may happen but with a time lag of a few weeks. While union is taking place, the inserted bud has to compete with the top and with other buds of the rootstock. Topping then generally yields less favorable results and the inserted bud may miss the first growth cycle altogether. To overcome, this, "lopping," that is, cutting half way through the stem and bending it away from the bud, is introduced. Instead of lopping, bending and breaking over have been tried with similar results. The so-called Surinam bending method was first described in 1915.

It was generally surmised that the leaves of the stock would continue to furnish the roots with nutrients, while the "flow of sap" would force the bud into growth. It should now be possible to replace these rather vague notions with a hypothesis in terms of growth hormones and carbohydrate supply. Before we proceed to do this, however, it is necessary to remark that this hypothesis will contribute but little to the practical knowledge of the subtropical nurseryman, who, led by his experience, has, for decades, actually applied the principles to be set forth. To the tropical propagator, on the other hand, a better understanding of the basic processes involved may suggest practical ways to improve his results.

GROWTH CORRELATIONS

The growth of stems is not independent from the growth of roots in the same plant; it a coordinated process. It has been shown that several hormones, or rather groups of hormones, regulate this process, to wit: the auxins, gibberellins, cytokinins, abscissins and ethylene. All these materials are produced at a certain region in the plant and transported elsewhere, thereby setting up gradients. Thus the ratio between these hormones at any given place may be the deciding factor of the growth process taking place there. It seems that especially the auxin/cytokinin ratio is an important factor (Wareing and Phillips, 1973).

The growing top, or apex of the plant produces *auxin*, which is transported downward. One of the many effects of auxin is the inhibition of axillary buds, a phenomenon called *apical dominance*. *Cytokinin* is synthesized in the roots and

brought up in the wood vessels; it is able to break the apical dominance. *Gibberellin* can do this too. *Abscissin* is formed in older leaves, it retards growth and induces dormancy. As a result of chilling conditions its effect is broken down gradually. In the tropics drought may have a similar effect.

THE HYPOTHESIS

Based on the foregoing, we can see that topping completely destroys the apical dominance. It also takes away a good part of the assimilating apparatus of the plant. Its effect therefore will be a fast stimulation of the bud most favorably placed, but this shoot will find it difficult to maintain growth as it soon will run out of nutrient reserves. Furthermore, the roots will be starved for carbohydrates and will stop producing cytokinin which is necessary for sustained growth of the shoot.

The effect of lopping is that the connection between the top and the inserted bud is broken. This lowers the auxin concentration on that side and the bud is now stimulated. The upper part of the stock continues its production of carbohydrates and of auxin, which is now transported along the inner side of the bend. All buds on that side will be inhibited. The roots, meanwhile receiving carbohydrates, will remain active and produce cytokinin, which is sent upward. That will take care of the sustained growth of the shoot.

If this reasoning is correct, then lopping should be preferred over topping in all circumstances. However, there is some extra work attached to it and the advantage is not at all clear in fall budding. There may be three reasons for this. In the first place, budding in the subtropics is generally done on 2-year old stock; secondly, reserves will be high after a winter when photosynthesis may continue, while respiration (which has a much higher optimum temperature) has been low; and thirdly, the effect of abscissin has been changed as a result of chilling temperatures. In spring budding, however, one has to wait until the tissues are actively growing (the bark must "slip"). Thus, some valuable weeks are lost while the bud union is taking place. Here, lopping would probably show a decided advantage over topping. This would even more be the case in the tropics, where budding is generally done on one-year old stock and where there is no rest period caused by winter conditions.

As for bending, this is not different in principle from lopping, but the technique is more difficult to perform. Breaking over means just a short interruption of apical dominance, while ringing stops not only the transport of auxin, but that of carbohydrates as well. For that reason we shall leave these techniques out of the discussion.

EXPERIMENTAL WORK

The work described here was done in greenhouses of the Department of Tropical Crops, Agricultural University, Wageningen, The Netherlands. The temperature was set at 25 °C in the daytime and 15° C at night. At this latitude, 52° N, the longest day is 16 hours and 44 minutes.

For the first experiment, (Coester, 1975), rough lemon seeds from Florida were sown November 1, 1972 and the plants were budded August 3, 1973 at a height of 20 cm with Shamouti. Due to a heat wave and a mechanical breakdown in the ventilation many buds failed and only 40 out of 160 plants could be included in the experiment. The treatments were: (1) topping; (2) lopping; (3) TIBA-rings (this is a chemical that inactivates auxin transport without hampering carbohydrate transport); (4 to 8) TIBA-rings with (4) Benzyl-adenin, BA, an artificial cytokinin applied by injection; (5) GA, a gibberellin (more specifically GA_3), likewise applied; (6) a mixture of BA and GA. In all these cases TIBA was used three days ahead of the hormone. In (7) BA and in (8) GA were given on the same day as TIBA.

The results of the first experiment supported the assumption that there is a

dynamic balance in the plant between auxin and cytokinin, which decides whether the bud will be inhibited or stimulated. It was shown that the application of TIBA breaks the apical dominance and that BA activates the buds temporarily.

In the second experiment (Oude Ophuis, 1975), rough lemon and Rangpur lime seeds from our own trees were sown on 15 and 31 January, 1974. As this would leave us insufficient time for budding and the experiment, it was decided not to bud, but to carry out the experiment with buds of the rootstock itself. The treatments, given by the end of September to rough lemon were: (1) topping, (2) lopping, (3) defoliating, (4) TIBA, (5) TIBA + BA, (6) TIBA + BA + GA. There were 36 plants in a latin square. For Rangpur lime the following treatments, again in a latin square, were used: (1) topping, (2) lopping, (3) defoliating + lopping, (4) TIBA, (5) TIBA + GA, (6) TIBA + BA, (7) TIBA + BA + GA. The hormones were then applied to the stomata of the subtending leaves by means of a rubber clench, connected to a syringe. Conclusions reached were as follows.

All treatments, with the exception of defoliating, broke the apical dominance. There was a clear effect of GA, but not of BA, presumably because BA was not transported out of the leaf in effective concentrations. Lopping was shown to activate considerably less buds than topping and one may therefore assume that more reserves per bud were available. Although it acted slower, at the end lopping gave longer, stronger and definitely more straight-up growing shoots than topping. Partly defoliating the upper part of the stem, leaving the top and some 6 young leaves intact, in combination with lopping, resulted in a temporary acceleration of growth and in an increase of the number of reacting buds. This may have been caused by the removal of young, auxin producing leaves. The tops of lopped plants did not grow anymore, while the tops of TIBA-treated plants kept on growing.

A third experiment, this time with Cleopatra mandarin and sour orange, again from seed of our own trees, is now in progress.

DISCUSSION

In the humid tropics, citrus budding may continue throughout the year, except for a few weeks (or months) when it is either too wet or too dry. Respiration is high throughout the year, so that the plant has only small reserves of carbohydrates. Therefore, topping will be an unsatisfactory method and lopping is to be preferred. Moreover, lopping is a much more selective way of activating buds, as auxin transport remains intact on one side of the stem, while apical dominace is broken only locally, above the inserted bud.

Probably Mahfudi (1950) was one of the first to formulate a hypothesis concerning the factors involved in different treatments to promote bud growth. The hypothesis presented here is an extension of the one he used. It seems desirable that similar experiments be undertaken with rubber, cacao, mango, grape, apple, rose and other crops that are usually or sometimes propagated by budding.

LITERATURE CITED

COESTER, W. A.
1975. Citrusproef. Enige onderzoekingen naar de mogelijke factoren die een rol spelen bij het doorbreken van de apicale dominantie bij citrus oculaties na het oculeren. Internal report V 75/5, Dept. of Tropical Crops, Wageningen.

MAHFUDI, M.
1950. Enige aantekeningen bij nieuwe wijzen van behandelen van pasgemaakte oculaties voor een aantal vruchtbomen. Landbouw (Bogor) 22:544-64.

OUDE OPHUIS, A. J. M.
1975. Beinvloeding van het uitlopen van ogen bij *Citrus* spp. Internal report V 75/4, Dept. of Tropical Crops, Wageningen.

WAREING, P. F., and I. D. J. PHILLIPS
1973. The control of growth and differentiation in plants. Pergamon Press, Oxford.