PHYSIOLOGY OF ROOT INITIATION

B. T. BULLOCH
Biological Sciences, University of Waikato
Waikato

A botanist's approach to plant propagation is fundamentally one of rueful diffidence. An eminent plant physiologist confessed that, despite his erudition on the mechanics of plant function, he found it impossible to persuade plants to function in his backyard vegetable garden. It's no mystery really for in large part botany consists of taking something the plant does without any trouble and making it seem difficult — in fact, to make it seem impossible is a major break-through. Perhaps it's the difference between science and technology, or if you like, the difference between science and reality.

Biological science today has two prime backdrops: the interaction of organisms with their environment, including other organisms — that is the broad field of ecology; and how organisms function — that is the broad field of physiology.

In the course of their practical work at this University, botany students investigate common hormone-mediated plant responses. For example, a property of GIBBERELLINS is to induce dwarf cultivars of peas, beans and maize to grow to full size. Gibberellins (GA) promote a proportionally much smaller extension of full-sized cultivars, but at increasing concentrations, rapidly become inhibitory and eventually fatal. With a modified mung bean test we demonstrated AUXIN's promotion of adventitious root initiation on French bean cuttings. Using ivy cuttings we showed the enhancement of root initiation and development by the presence of juvenile leaves.

In this latter case one may postulate that the leaves are a source of photosynthate, or phenols which protect auxin from being enzymatically oxidised, or a site of protein synthesis. A mixture of sugar and amino acids only partially substitutes for juvenile leaves, leading some workers to search (unsuccessfully) for a specific rooting hormone, although a synergistic interaction of known growth regulators is more likely.

When this lecture was first mooted I suggested (carelessly) that plant propagation consisted of promoting what was going to happen anyhow.. Let's look at what happens. Notice that the roots induced on the French bean cutting by immersion in auxin solution are in lateral rows directly referable to the anatomy of the stem vasculature. Roots are initiated in the primary rays just outside the vascular cambium. The meristematic activity of the vascular cambium, cutting off derivatives that become phloem towards the outside and xylem towards the inside, produces the secondary thickening of dicotyledonous stems.

Consider willow, a so-called easy rooting subject, which has latent root primordia at its nodes. These latent root primordia are released from suppression by wounding or high humidity to grow out as adventitious roots. Initially the primordia are just undifferentiated groups of cells, but by nine years they may have a well-organised root cap and vascular system. Rapid vascular differentiation is a feature of the release of latent adventitious roots. How do we study the environmental influences *on the cell* that cause cells in such close juxtaposition to differentiate as phloem, xylem, and cambium?

Wetmore & Rier (1) found that if a bud was grafted on to the top of a block of *Syringa* callus in sterile culture, nodules of vascular tissue differentiated in the callus at a precise distance back from the bud, suggesting a critical point in a gradient. Moreover, physiological concentrations of sucrose and IAA (indole-acetic acid) could be substituted for the bud, and when ratios were varied, high IAA favoured xylem differentiation and high sucrose favoured phloem.

Vascular differentiation can also be studied in wounded *Coleus* stems, where physiological concentrations of both exogenous auxin (2) and CYTOKININ enhance the differentiation of WVM's (wound-vessel members), a kind of xylem element. Cambial activity may be studied in segments of *Coleus* stems on sterile media, here auxin favouring xylem production (3) and gibberellin favouring phloem.

Let's consider an experiment with brittle willow, *Salix fragilis,* consisting of applying a ring of TIBA (tri-iodobenzoic acid) between the second and third nodes (numbering from the stem apex) (4). TIBA blocks the transport of IAA, in this case reducing the levels of extractable auxin below the ring by 50 %. Cambial activity was reduced by 25 %, the number of root primordia initiated during the experiment by 50 %, and their cell numbers per primordium by 75 %. The reduction in primordia well-developed at the beginning of the experiment was much less though their cell numbers were also reduced by 50 %. The effects of surgical removal of expanding leaves and buds are similar to a TIBA blockage.

Presumably the reduction in intra-primordial cell divisions and the reduction in cambial activity reflect the same response to auxin depletion, but has the reduction in primordia actually initiated a direct auxin effect or an indirect effect through the depression of cambial activity? This was investigated using exogenous gibberellin to stimulate cambial activity (4). At rates of GA that increased cambial activity by more than 75 %, well-developed primordia were reduced over 95 % in number, whilst primordia initiated during the course of the experiment were less sensitive, being reduced by only 60 % in number.

Hence it may be concluded that auxin does have a direct effect on root initiation in brittle willow, but only if the concentrations of auxin are sufficient to sustain a given level of cambial activity. Further, GA depresses rooting by affecting an auxin-mediated process after the actual initiation.

The varying levels during the year of hormones such as GA and auxin, and the other growth regulators with which they interact, could account for the seasonal variation in the rooting ability of cuttings of many species, as well as the differences among the species themselves.

LITERATURE CITED

1. Wetmore, R.H. & J.P. Rier. 1963. Experimental induction of vascular tissues in callus of angiosperms. Amer. Jour. Bot. 50: 418-30.
2. Thompson, N.P. & W.P. Jacobs. 1966. Polarity of IAA effect on xylem and sieve tube regeneration in *Coleus* and tomato stems. *Plant Phys. 41*: 673-82.
3. Robards, A.W., *et al.* 1969. Short-term effects of some chemicals on cambial activity. *Jour. of Exp. Bot. 20*: 912-20.
4. Haissig, B.E. 1972. Meristematic activity during adventitious root primordium development. *Plant Phys. 49*: 886 - 92.

CHEMICALS AND THE REGULATION OF PLANT GROWTH

A. S. EDMONDS

Biological Sciences, University of Waikato
Waikato

Many chemical substances are now used in horticulture and agriculture to affect the growth and development of flowering plants. Some of these substances are very familiar, for example:

2,4-D	2,4-dichlorophenoxyacetic acid
2,4,5-T	2,4,5-trichlorophenoxyacetic acid

These chemical substances intervene and exert recognisable effects on plant growth and development but in a characteristic, non-nutrient way. Small amounts are effective, and these quantities are not incorporated into the substance of the plant.

Among the many regulatory substances in common use are the two above-named selective herbicides which kill plants of broadleaved species but not of grasses. As well there are total-kill