SATURDAY MORNING SESSION

October 20, 1962

The final session convened at 8:30 A.M. with Dr. Vernon T. Stoutemyer, Chairman, Dept. of Floriculture and Ornamental Horticulture, University of California at Los Angeles, presiding. The program started with an introductory presentation by Dr. Stoutemyer..

THE CONTROL OF GROWTH PHASES AND ITS RELATION TO PLANT PROPAGATION

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Much modern plant research is directed toward the control of plant growth either by regulation of the environment, or by the application of chemicals. The progress already made along this line has been encouraging and, in some cases, spectacular. Our florist shops now offer chrysanthemums every day in the year. Powerful new selective herbicides, often spread by plane or helicopter, kill certain plants in a field, pasture or forest while leaving others. The use of chemicals to aid rooting of cuttings is another example. In some of the eastern states, sprayers dispensing maleic hydrazide are used along highways in place of mechanical mowers. Such instances can be multiplied. We shall discuss an aspect of this problem which is little understood and that is the question of control of juvenility and of readiness to flower and fruit in woody plants.

If we could overcome juvenile characteristics in woody plants as quickly as possible, the breeders of tree fruits would be very happy. On the other hand, vegetative propagation would often be greatly simplified if we could cause reversions to juvenile growth at will. In a limited way, these objectives are now possible.

Both woody and herbaceous plants commonly progress through a series of changes in morphology as they go from the seedling to the mature fruiting stage. Sometimes the differences are so slight and gradual that they are not apparent to the casual observer. In other cases they are striking. Some Australian acacias have pinnate leaves in the seedling stage, but after a few months or years lose them and produce only phyllodes in place of the leaves. On the other hand, in some conifers, the change to mature foliage may require many years, even a substantial part of a century in some New Zealand species. In some plants a whole series of transitional leaf types appear. Sometimes two different binomials were given to the same species by taxonomists who were deceived by the varied expressions of growth.

In general, a plant showing juvenile leaf characters will reproduce much more easily vegetatively, and will not produce flowers and

fruit, but there are exceptions. Some conifers, olives, and eucalyptus have ben observed to fruit on shoots showing juvenile characters. Citrus seedlings sometimes flower exceedingly early in life and then do not flower again for a number of years.

There are some horticulturists who largely ignore the subject, since they interpret the leaf dimorphism to be an expression of different types of growth due to some incidental environmental conditions. However, most horticultural experimenters at the present time recognize the phenomenon and are giving it increasing attention. There are today research centers in England, Holland, Germany, Austria, Russia, and Italy which are studying juvenility in plants.

The speaker has devoted attention to methods of prolonging or reestablishing the juvenile form of growth, because of a long interest in plant propagation. Probably the most progress has been made on this part of the problem. Since breeders of fruit or forest trees are interested in eliminating juvenile expressions of growth as quickly as possible, we shall first mention in outline the treatments which have been reported sometimes to promote this objective.

The late N. P. Krenke, an able and productive Russian worker, put forward a theory of cycle ageing and rejuvenation which he derived from an interpretation of his experiments by means of the Marxian dialectical materialism. Some recent Soviet horticulturists have not accepted his theories. Krenke derived some of his ideas from Michurin, whose theory of mentor grafting is widely held and practiced by Soviet fruit breeders. According to this view, a young seedling in the juvenile stage is very plastic and if deprived of all of its leaves for a period and grown entirely by the photosynthesis of the mature stem as a mentor or trainer scion, it will take on permanently some of the desirable characters of the mentor scion. Many breeding projects in Soviet Experiment Stations still apparently use this technique, probably because of the strong political support of the Lysenko group of geneticists. The idea is found also in pomological literature from the various Iron Curtain countries, but we do not know of any reputable Western scientists who have supported this view. Personally, we regret that a carefully controlled experiment to examine the whole theory has not been conducted in Western countries. In Western Europe there are now two very distinct viewpoints regarding juvenility in woody plants among pomologists. One group expresses the traditional viewpoints perhaps first clearly expressed by the German botanist, Goebel, in which the two stages are regarded as quite distinct and to some extent permanent in the lower portion of the tree. On the other hand, others minimize the differences between the two stages and regard their manisfestations as dependent on changes in the nutritional and hormonal balances wihin the tree. To support this viewpoint, they cite observations that the base of a tree may not remain permanently juvenile but may bear flowers and fruit. On the other hand, the so-called juvenile shoots may appear high in mature trees.

Over a dozen different treatments have been claimed to accelerate flowering and fruiting in seedlings of woody plants, but the evi-

dence for many of these treatments is very confusing and contradictory. The present evidence seems to indicate that the efficacy of the treatments apparently depends on the species. There are effective means of speeding the flowering of woody plants of mature, established clones. Caution should be used in interpreting the results of many experiments since in some cases the seedling had often made considerable progress toward the production of flowers before the treatments were applied.

The following are the most important treatments for which favorable claims have been made.

1. *Use of extra or prolonged growth periods.*
   The use of extra growth cycles made possible by artificial environmental control has given contradictory results. However, by the use of artificial lights to provide continuous illumination, Lammerts produced flowering of camellia seedlings at the end of the first year. Similar success has also been reported with birch and rhododendron.
2. *Transplanting and root pruning.*
   This is a standard treatment with wistaria and some success has been claimed with fruit tree seedlings.
3. *Fertilizer applications.*
   Although heavy application of nitrogen may cause heavy vegetative growth which will delay flowering, sometimes with conifers this hastens the appearance of cones, especially when applied in combination with root pruning.
4. *Geotropic responses.*
   Bending stems to a horizontal or descending position sometimes accelerates flowering.
5. *Mound layering.*
   This treatment has been claimed to accelerate the fruiting of grape seedlings from the fifth to eighth year to the third or fourth year.
6. *Bark inversion, ringing and notching, or tying.*
   Possibly these have had some value, but often have temporary effects. A variant has been to tie young seedling plants into knots.
7. *Grafting or budding in crowns of mature trees.*
   This technique has been successful with *Hevea* rubber seedlings and with pines, but has been of uncertain value with many species of fruits.
8. *Grafting on related species.*
   A few striking illustrations of success are known and the technique has been useful with a herbaceous plant, the sweet potato.
9. *Grafting on dwarfing stocks.*
   This technique is useful on old established clones, but it has a problematical value on young seedlings of fruit trees.

10. *Growth regulators.*
Growth retardants have been used to produce bud setting on azaleas.

11. *Grafting mature scions into seedlings.*
The Russian "Burbank," Michurin, claimed to be able to hasten the first flowering of fruit tree seedlings by grafting scions of mature clones in the tops.

12. *Climatic factors.*
Seedling fruit trees have been observed to bear earlier in localities having the most favorable climate. High summer temperatures have been observed to promote cone formation on certain conifers.

The reverse situation, the production of juvenile types of growth at will, is probably of more general interest to plant propagators. Some progress has been made along this line, although there are some controversies relating to the interpretation of certain observed phenomena. The following are treatments which have been observed either to produce reversions or at least to favor the prolongation of juvenility.

1. *Growth from root sprouts or sphaeroblasts.*
Most experimenters agree that juvenile tendencies are prolonged in the roots and crown of the tree. Root sprouts often thus show juvenile characters and root easily. Sphaeroblasts are concretations of wood and meristem which arise on some tree trunks and branches. Adventitious buds are formed on some of them and shoots from them may show juvenile characters.

2. *Severe pruning or heading back.*
This treatment sometimes causes reversions, especially if done near the base of the tree. Reversions are less common in the top of trees with most species.

3. *Reproduction by seed.*
Normal seedlings show juvenile characters and this is true also of nucellar seedlings of citrus which reproduce the variety but in a rejuvenated form. These seedlings are often prized in citrus as they are ordinarily free of viruses and are often exceptionally vigorous.

4. *X-ray treatments.*
This has been reported by one group for English ivy.

5. *Cold treatments.*
This has been reported by one group for English ivy. This and the previous treatment have not yet been substantiated by other experimenters.

6. *Reduced light.*
This is generally considered to prolong the juvenile stage of growth or to promote juvenility.

8. *Grafting on juvenile stocks.*
Grafting of adult ivies on juvenile understocks will promote

reversions, but only if the temperatures are above a certain minimum.

9. *Treatments with gibberellin.*
Spraying mature shoots of ivy with gibberellin produces reversions, if the temperature is above a certain minimum. The range of applicability of this treatment is not known.

At the present time some theories have been advanced regarding the nature of juvenile and adult growth phases in plants, but there is yet little in the way of well-documented, fresh information.

In our laboratory we have attempted to analyze the nature of the phenomenon by means of tissue cultures taken from juvenile reversion shots on adult flowering plants of English ivy. These often occur spontaneously at the bases of mature plants. They can be produced at will by certain treatments, but only the naturally-occurring reversion shoots were used in these experiments.

Both the English and the Algerian ivies in the juvenile stage are true vines having flattened stems, dorsi-ventral leaf arrangement with palmate leaves and frequently produce aerial roots and red pigments. The adult fruiting shoots appear after a period of years and are shrubby and have entire leaves. Root formation is rare on the stems. Transitional forms are common.

The sterile cultures of English ivy were started by pulling off the epidermis and taking pieces from the subepidermal layers about 2 mm square with a scalpel.

These were grown or placed on White's medium (1943) modified as follows:

KNO_3, reduced to 47.0 mg/l (from 80 mg/l)
NH_4 Cl added, 60.0 mg/l
Coconut milk, 100 ml/l
Casein hydrolysate (enzymatic), 200 mg/l
Inositol, 100 mg/l
Napthaleneacetic acid, 1 mg/l
Difco Bacto Agar, 6 gms/l

The medium was prepared with glass distilled water and the pH of the media was adjusted using 0.1 N NaOH to 5.8 before autoclaving at 18 lbs. for 30 minutes.

Small flint glass vials with plastic caps were convenient and saved space. This medium permitted the successful subculturing of callus tissues of English ivy and was found after a prolonged study of methods by my laboratory technician, Mr. O. K. Britt.

The significant finding of these studies is that the tissue cultures from the juvenile tissues have a considerably higher growth rate than those from the mature tissues. Also, the juvenile cultures form roots much more freely. These differences have persisted through seven subcultures. We believe that this shows that the differences between juvenile and adult growth are profound and are apparently on a cellular basis.