Chairman Scanlon: This afternoon we have a paper that should generate considerably thought and discussion. I am pleased to present our good friend Steve O'Rourke of Michigan State College.

The Effect of Juvenility on Plant Propagation

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Practical plant propagators have long known that cuttings taken from young seedling plants root much more readily than cuttings from mature plants of the same species. Goebel (11), in 1900 mentioned this relative ease of propagation in younger individuals and established the term "juvenility" to describe the physiological condition involved. Juvenility may or may not be accompanied by morphologcial differences from the mature individual, such as different leaf shapes, thorniness, or other growth characteristics. In many species, however, the superficial appearance of the seedling plant is somewhat different from the mature individual. Ashby (1) reports that Krenke used the leaf shape of the sugar beet leaf to determine the amount of sugar to be found in the roots at that time. Certain characters of the leaf changed gradually over a period of time as the plant progressed from a young seedling toward maturity. Krenke as well as many others (8, 17, 19, 20) indicated that the juvenile characteristics were associated with the *physiological* age of the individual plant rather than the *chronological* or *time* age, as various plant individuals progress at different rates toward maturity, depending upon both their genetic constitution and their varied response to environmental influences. Whyte (20) quotes Lysenko as distinguishing between growth and development in plants. Growth may proceed with little or no development toward the mature or reproductive stage, and under certain conditions the reverse may be true. In like manner the external appearance of the plant may indicate certain internal conditions, but will vary with the species and the environment.

Seedling Age And The Rooting of Cuttings

Gardner (9) in 1929 reported the chance discovery of the ease on rooting of cuttings taken from apple trees in their first season of growth, and further comparisons made with older trees of apple and many other woody plant species. With most fruit tree species, cuttings from one-year seedlings rooted well, from two-year old plants only fair, and practically not at all during the third year or thereafter. Evergreens and shade trees retained the rooting ability of their cuttings for a longer period but in all cases there was a sharp drop in the third year of seedling growth. This investigator also noted that not only were a greater number of cuttings rooted from younger plants but that the time required for root production was much shorter. He tested cuttings taken from one-year budlings of apple with negative results. He then tried treating cuttings from older trees with seed extracts, but without success as far as rooting was concerned. Gardner then cut one-year apple seedlings back to the ground and noted that the sprouts arising the second year furnished cuttings which could be rooted "and in some cases even more readily than that of the first year."

Stoutemyer (17) reported in 1937 that cuttings taken from watersprouts of apple failed to root. Seven-year old seedlings and one-year old seedlings of crabapple were cut back to the ground. Cuttings taken from the resulting sprouts the next season rooted well. Stoutemyer considered these shoots intermediate between the juvenile and mature growth phase.

Stoutemyer observed that shoots arose from scion roots of 17 years

old clonal Virginia Crab trees left in the orchard after the trees had been dug out. Cuttings taken from these shoots rooted well and showed the characteristic thin and smooth leaf form of the juvenile phase of growth. These shoots arose from adventitious buds which formed in the secondary cortex of the roots.

Gardner (10) reported a reversion to the juvenile type of leaf form in *Juniperus horizontalis* and noted that such branches "struck root more freely where they came into contact with the soil than had branches of the normal form with adult foliage."

Thimann and DeLisle (19) tested cuttings from one-, two-and three-year and older seedlings of pine, spruce, maple, ash, and oak. The per cent of successful rooting was in descending order with increased age of the tree.

Deuber (4) compared cuttings taken from Norway spruce 5, 26, and 40 years of age. The greater degree of rooting was generally in favor of the younger trees but fair success was obtained in all age classes. He also tested cuttings from white pine ranging from 2 to 60 years old. Rooting was good in the earlier years but dropped sharply between the fifth and seventh seedling years. Hemlock cuttings rooted well from 4 year old trees but only poorly from trees 20 years of age.

The Seat of Juvenility

It has been reported (9, 17) that when young seedling trees are cut to the ground cuttings from the resulting shoots root as well or better than cuttings from one-year seedlings. It has also been indicated (17) that the leaves on shoots arising from adventitious buds in the roots of apple show pronounced juvenile characters and that cuttings from such shoots root well.

Stewart (16) has shown that when a root of *Acanthus* is cut into pieces the appearance of the leaves arising from the root apex show the juvenile growth form, while those from portions of root farther back have a more mature appearance. The same juvenile characters in the leaves are shown from the growth of axillary buds on internodal stem cuttings taken near the base of the plant, while terminal cuttings continue to exhibit the adult foliage conditions.

Several investigators have found that cuttings taken from the lower portion of a tree root better than those taken from the upper part. Grace (12) took cuttings from the upper third and the lower third of an 18 year old Norway spruce tree. Ten weeks after setting in the greenhouse bench, 43 per cent of the upper and 73 per cent of the lower cuttings were rooted. After nineteen weeks in the bench, 48 per cent of the upper and 86 per cent of the lower cuttings were rooted. The cuttings from the lower portion of the tree also had longer roots and greater root masses.

Doran, Holdsworth, and Rhodes (5) compared cuttings taken from the upper third and the lower third of white pine trees. In one instance 70 per cent rooting was obtained with cuttings from the lower third while those from the upper third did not root at all. Another tree showed 20 per cent rooting from the upper and 10 per cent from the lower portion.

Edgerton (6) used cuttings taken from the upper half and lower half of 10 to 20 feet high red maple trees. The same number of cuttings were used for each individual clone. Those from the lower branches of male trees averaged 49 per cent successful rooting and those from the upper branches 27 per-cent. Cuttings from temale trees averaged 30 per cent rooting for lower branches and 21 per cent for upper branches.

Thimann and DeLisle (19) reported a greater degree of rooting

from cuttings taken from lateral branches than from terminal shoots of white pine and Norway spruce, and a much higher per cent from cuttings near the basal parts of red oak and Norway maple than from either terminal or lateral branches of the same trees.

Stoutemyer, O'Rourke, and Steiner (18) compared softward cuttings taken from stump sprouts of honey locust as against comparable material on lateral and terminal branches and found that the former rooted well and the latter very poorly or not at all.

Juvenility and Thorniness

Frost (7, 8) reported that citrus seedlings, prdouced either by gametic or apogamic means, are thorny in their earlier life but as they mature, the shoots upward and outward from the trunk gradually lose the thorny condition. He also reported that the thorny or thornless condition could be transmitted by budding, depending upon the portion of the shoot from which the bud is taken. This same phenomenon was reported by Chase (2) with honey locust. Desirable clones of honey locust with thorny trunks were propagated to thornless individuals by selecting buds and scions from the thornless portions of upward and outward growing shoots. These clones have remained thornless ever after and also their progeny during successive and repeated buddings.

Stoutemyer, O'Rourke, and Steiner (18) showed that unselected thorny clones of honey locust could be propagated to a practical degree by the use of either dormant stem or root cuttings. O'Rourke (14), however indicated that the thornless clones Millwood and Calhoun could only be propagated by hardwood stem cuttings with the greatest difficulty and that all attempts to propagate these clones by root cuttings resulted in absolute failures. He assumed that the thorny condition of honey locust was associated with the juvenile growth phase with the related ease of propagation while the thornless condition denoted the mature state and the inability to regenerate roots and/or shoots from cuttings.

Rejuvenation by Nucellar Embryony

In *Citrus*, and to a slight degree in *Malus* and some other plant species, seedlings may be produced from embryos which arise entirely from the maternal nucellar tissue surrounding the embryo sac, and subsequently develop within the embryo in the normal way to produce viable seed. The resulting seedlings will therefore be of exactly the same genetic constitution as the seed parent and may be considered clonal since they have been produced by asexual means. Frost (8) and Hodgson and Cameron (13) have reported that such "young clones" produced by apogamy are more juvenile in appearance and characteristics than the "old clones" from which they arose. Buds taken from seedling "new clones" produce more vigorous trees which come into fruiting later than those grown from buds taken from "old clones" of the same variety. The time of fruiting of any clone is apparently associated with the mature growth phase, and as Spinks (15) has pointed out, it cannot be hastened to any degree by treatments and environmental influences. The ease of production of vegetative individuals of uniform genetic constitution and of high vigor has been hailed by Cook (3) as an opportunity for a new field of research in plant science.

Discussion

The evidence is quite clear that plants in their younger stages may express different morphological appearances in certain characters and usually root from cuttings more easily than plants in a mature or senescent

condition. The progress of aging is quite closely associated with development but not necessarily with growth. The changes which take place are internal ones although there may be associated external expressions. The process is purely physiological and should not be viewed from a chronological or time age standpoint.

The implications in the field of plant propagation are more reaching than with the use of cuttings alone. Most experienced nurserymen know that it is necessary to use the roots of rather young seedlings in order to secure a good percentage of graft unions with many plant species. The same principle applies to the use of rootstocks to be used for budding purposes. It is quite common to see roots emerging from soil-touching branches of many young shrubs, while those from older plants do not layer so easily and abundantly except where the branch may arise at or below ground level.

The seat of juvenility or that portion of the plant where the juvenile influence remains longest and exerts its greatest influence is at or just below ground level and probably extends well into the lateral roots. The so-called "reversion to juvenility" is evidenced by leaf characters and rooting ability of shoots of adventitious origin from these lateral roots. Coppice sprouts from the main trunk, especially if of below-ground origin, also show excellent rooting ability.

There is no evidence to show that tests on the subsequent behavior of the clone have ever been made between plants propagated from these "juvenile areas" and the more mature sections of the same clone. It would be interesting to note any rejuvenation effects such as reported by Cook (3), Frost (7), and Hodgson and Cameron (13) with citrus produced from nucellar embryos. If, as indicated by the above workers with citrus, clones do become senescent, the value of rejuvenation is apparent and plant propagators may well think of juvenility not only in regard to ease of propagation but also as a method holding forth promise for improvement of many plant clones. Shoots from roots may be preferred cutting material if such results can be achieved.

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Friday Morning November 9th

Chairman Scanlon: The meeting will please come to order. It looks like we have a busy morning ahead of us. In the event you had not heard of the activities of our Organizational Committee, let me first commend them for the hard work they put in last night. They labored until after one o'clock to have a constitution ready for presentation this morning. Also I wish to thank very kindly Mrs. Richard Fenicchia of Rochester, N. Y. who graciously consented to take notes at the meeting and then transcribed them before retiring. This was a very fine contribution to the Society by Mrs. Fenicchia.

The Constitution prepared by the Committee was then read to the body and thoroughly discussed. It was finally voted to carry the Committee over for a year; to hold a second meeting in Cleveland in December of 1952 (12th and 13th), and to make up copies of the revised constitution for each committee member. The committee then agreed to hold a summer meeting in conjunction with the annual convention of the American Association of Nurserymen at Detroit in July.

The afternoon session started with a paper by Dr. L. C. Chadwick of Ohio State University.