SHORTENING THE JUVENILE PHASE IN CRABAPPLE SEEDLINGS

RICHARD H. ZIMMERMAN

Agricultural Research Service
U.S. Department of Agriculture
Beltsville, Maryland

Seedlings of pears and apples, in common with those of many other tree species, have a juvenile phase lasting 4-5 years or more. This long period before the seedlings flower is a major hindrance to rapid progress in tree breeding programs, which require several seedling generations for success. This is especially true for the U.S. Department of Agriculture program to develop high quality pears resistant to fire blight. In order to develop methods for shortening the juvenile phase in pears, it became clear that we needed to understand better the nature of juvenility and its relationship to flower initiation. From a review of the literature, it also seemed clear that such research must be done with seedling trees since vegetatively propagated trees do not always respond to treatments in the same way as seedlings.

Pear seedlings are difficult to use in juvenility studies because of their genetic variability and because they are rather difficult to keep in active growth in the greenhouse for extended periods of time. However, some species of flowering crabapples were suited for this research because they are fairly closely related to pears and because they form seedlings by apomixis. This is a process by which seeds develop without fertilization so that the resulting seedlings are genetically identical. Five species of apomictic crabapples were tested for suitability and one, the tea crabapple (*Malus hupehensis* (Pamp.) Rehd.), was selected for the experimental work. The research went through several phases. At the beginning, growing conditions for relatively rapid flower initiation in tea crabapples were defined. Then methods were developed to bring them into flower and finally the growing conditions were continuously improved to shorten the time to flowering

For defining the basic conditions for tea crabapples to flower, three treatments were used (2). Seedlings transplanted to the nursery from the greenhouse 10 weeks after germination were about 1 m tall after two growing seasons. Seedlings grown in the greenhouse for 8 months, then hardened off and given cold treatment for 5 months before being returned to the greenhouse for another 6 months were nearly 2 m tall after two growing seasons. Seedlings grown continuously in the greenhouse for the same length of time (19 months) were nearly 4 m tall. Plants grown in the field had many long lateral branches. Those grown in the greenhouse for two seasons had a few long lateral branches which developed during the second season in the greenhouse. Those grown continuously in the greenhouse had only one or two short spurs. All the plants were transplanted to a permanent field location after the second growing season.

All the seedlings grown continuously in the greenhouse flowered after the second growing season and continued to flower every year thereafter. One-third of the seedlings grown for two seasons in the greenhouse flowered after the second growing season but it took four growing seasons before all flowered. None of the nursery-grown seedlings flowered after the second growing season, 20 percent flowered after the third season, and all flowered after the fourth season. From this experiment, it was clear that the juvenile phase could be shortened by growing the seedlings to get tall plants as quickly as possible.

The next step was to have the crabapples flower in the greenhouse. Seedlings were grown in the greenhouse for 10 months by which time they were more than 3 m tall. They were then hardened off, defoliated and given cold treatment for up to 10 weeks. The plants were returned to the greenhouse and were in bloom within 1 month, only 13 to 14 months after seed germination.

To eliminate having to move the plants to cold storage, I then tried using growth regulators on greenhouse-grown seedlings to induce buds to grow without chilling. Cytokinins, gibberellins, and mixtures of the two, were applied to buds with or without removing the leaves from the seedlings. After numerous trials, I found that a mixture of the cytokinin PBA (6-benzylamino-9-(tetrahydropyran-2-yl)-9H-purine) and gibberellins 4+7 applied in a lanolin fraction was most effective. Currently I am using 2000 ppm of PBA plus 250 ppm of GA_{4+7}. Using this technique, crabapple seedlings have had flowers open 9½ months after seed germination.

How are the crabapples grown to get this rapid flowering? In the greenhouse, seedlings are started in 2¼ inch peat pots and then are transplanted to 4", 6", and finally 8" plastic pots as necessary to prevent checking of growth by transplanting. During rapid growth, the plants are fertilized twice a week with a 20-20-20 water-soluble fertilizer (1.7 g / 1) but this is reduced to once a week when the plants are nearly full-grown. Supplemental lighting is used so that the plants are always under long-day conditions. Seedlings grown in this way will be 1 m tall in 20-21 weeks. They grow at the rate of 2 cm per day from the time they are 60-80 cm tall and maintain this growth rate for up to 20 weeks. Seedlings have been as tall as 3.5 m in 11 months.

Even more rapid growth can be achieved if the plants are started in growth chambers and moved to the greenhouse later. Standard growing conditions are a 16-hour photoperiod with a light intensity of 2000-2500 foot-candles, temperatures of 25° / 18° C. (77° / 64° F.) light / dark, and 65 percent relative humidity. The plants are fertilized with a dilute solution of 20-20-20 water-soluble fertilizer (0.1 to 0.25 g / l) up to 5 times per day. Seedlings grown in these conditions will be 1 m tall in 13-14 weeks and will be 3 m tall in 7½ months.

Earlier experiments (1, 3) showed that even more rapid growth can be attained when additional CO_2 is introduced into the growth chambers. About 2000 ppm CO_2 seems to be adequate but the temperature must be increased to 30° / 24° C. (86° / 75° F.) light / dark and additional fertilizer and water are necessary. Preliminary results indicate that seedlings should be able to attain a height of 1 m in 10-11 weeks.

On the original seedlings grown in the greenhouse, the transition from the juvenile to the mature phase took place at a height of 1.8-2.0 m above the cotyledonary node. As the growing conditions have gradually been modified and improved so that the plants grow more rapidly, this transition has taken place somewhat lower at a height of 1.5-1.6 m. If the plants are started in the growth chamber for up to 20 weeks, this height is reduced to 1.3 m. However, the first flower is formed at around node 75 whether the seedling is grown in the greenhouse, started and grown in the growth chamber before going to the greenhouse, or started in the greenhouse and later transferred to the growth chamber for varying periods of time. It now seems that the node number is a better estimate of the site of the transition from the juvenile to the mature state than plant height.

We now have a test plant which can be used as a tool to study the delicate process of transition from the juvenile to the mature state within a reasonably short period of time. It also provides us with readily identifiable leaf and flower buds in which we can study the chemical changes associated with the transition and hopefully discover those responsible for flower initiation. At the same time, nurserymen can adapt these growing techniques for production of seedling trees.

LITERATURE CITED

1. Krizek, D. T., R. H. Zimmerman, H. H. Klueter, and W. A. Bailey. 1971. Growth of crabapple seedlings in controlled environments: effect of CO_2 level, and time and duration of CO_2 treatment. *J. Amer. Soc. Hort. Sci.* 96:285-288.

2. Zimmerman, R. H. 1971. Flowering in crabapple seedlings: methods of shortening the juvenile phase. *J. Amer. Soc. Hort. Sci.* 96:404-411.

3. ——————, D. T. Krizek, W. A. Bailey, and H. H. Klueter. 1970. Growth of crabapple seedlings in controlled environments: influence of seedling age and CO_2 content of the atmosphere. *J. Amer. Soc. Hort. Sci.* 95:323-325.

BILL FLEMER: Would the maturity of a crabapple seedling be hastened by taking the leader and training it over into a horizontal position?

DICK ZIMMERMAN: No, we find that the best thing to do to hasten the flowering of seedlings is to get it to grow as rapidly as you can, as long as you can. Any procedure which checks the growth of the seedling will, in turn, delay the flowering of the seedling.

MODERATOR PINNEY: U.S.D.A. has certainly been a big help to us in our birch program and if any of you ever get to Beltsville, Maryland, you should certainly make it a point to stop in and see some of the interesting things they have going there.

Our next paper is a substitute for the paper listed on your program since the gentleman who was to present that paper has hurt his leg and will not be with us. The paper which will be given is by W. G. Ronald and W. A. Cumming. The work to be reported was done while Mr. Ronald was at the research station in Morden, Manitoba though, more recently, he has been spending some time at the University of Minnesota. The paper will be read by Mr. Herman Temmerman. under whose technical direction the experiments were carried out.

COMPATIBILITY AND GROWTH OF COLUMNAR EUROPEAN ASPEN ON POPLAR ROOTSTOCKS[1]

W. G. RONALD[2] AND W. A. CUMMING

Canada Department of Agriculture
Research Station, Morden, Manitoba

Hardwood or softwood cuttings of most poplars root easily with the exception of white poplars and aspens which belong to one section of the genus *Populus*. White poplars generally propagate easily by softwood cuttings and with more difficulty by hardwood cuttings; both softwood and hardwood aspen cuttings generally root poorly. Under natural conditions the aspens regenerate quickly from root suckers and seed.

Columnar European aspen (*Populus tremula* L. 'Erecta') is a valuable columnar clone that has proven difficult to propagate. Many attempts, by the authors, to root softwood cuttings have resulted in

---

[1]Contribution No. 104 of the Canada Department of Agriculture, Research Station, Morden, Manitoba

[2]Present Address: Department of Horticultural Science, University of Minnesota, St. Paul, Minn 55101, U.S.A