1984

Asexual vs. sexual propagation of quaking aspen

Robert B. Campbell Jr.

ASEXUAL VS. SEXUAL PROPAGATION OF QUAKING ASPEN

Robert B. Campbell, Jr.

ABSTRACT: Quaking aspen (*Populus tremuloides* Michx.) regenerates almost exclusively by root suckers in the western United States, even though female clones produce abundant viable seed. During the past decade, interest in propagating aspen for use as an ornamental and for revegetation of forest land has increased. To satisfy these diverse needs for aspen planting stock, nurserymen have a choice between sexual and asexual propagation. Criteria for clone selection, suggestions for root and seed collection and storage, propagation techniques, and the advantages of both sexual and asexual propagation are discussed.

INTRODUCTION

Quaking aspen (*Populus tremuloides* Michx.) has the widest distribution of any native tree species in North America (Fowells 1965). This significant fact suggests that quaking aspen can grow under a vast range of environmental conditions. Thus, if aspen could be successfully propagated, it could be used widely as an ornamental and for reforestation and land reclamation. In the western United States, this important species relies almost entirely upon vegetative regeneration from root suckers. Female clones, however, produce many viable seeds.

Interest in propagating quaking aspen for use as an ornamental and for reforestation surged during the past decade. Vegetative propagation techniques have been developed (Schier 1978b) and have specific advantages. However, seed propagation is less labor intensive and is used by some nurseries to produce large quantities of planting stock.

I will present various factors that nurserymen should consider before selecting between sexual and asexual methods of propagating aspen.

ASEXUAL PROPAGATION

Quaking aspen clones have numerous long, lateral roots in the top 6 inches of the soil profile. Suckers may arise along these roots and become a younger generation of ramets that are genetically identical to the trees of the parent clone.

Robert B. Campbell, Jr. is a botanist with the Intermountain Forest and Range Experiment Station, USDA Forest Service, located at the Forestry Sciences Laboratory, Logan, Utah.

Many amateur and professional landscapers transplant these natural suckers, or wildlings, for ornamental purposes. When the wildlings are dug up, the soil usually falls away exposing the root system. Typically, the transplant's root system consists of only a 12- to 18 inch segment of lateral root from the parent clone. Once transplanted, the wildlings usually grow slowly at first and develop small leaves. Generally they have few, if any, branch roots at the time they are removed from the parent clone, and the existing root system is inadequate; consequently many wildlings do not survive after transplanting (Schier 1982).

A few commercial landscapers report good survival and growth of transplanted aspen when the suckers have well-developed, independent root systems. They are careful to keep the root ball tightly bound, which protects the fragile new roots. Sharp shovels are used to minimize root damage, which can be an infection site for pathogens. It is best to transplant aspen in the dormant stage. Survival can be excellent when aspen 3 to 5 inches diameter at breast height (d.b.h.) and 18 to 20 ft tall are carefully transplanted with a 44-inch tree spade. (Personal communication with Ron McFarland of Landscaper's Service, Steamboat Springs, Colo.)

Another nurseryman substantially improves the survival and vigor of transplanted wildlings as follows: (1) Wildlings are selected from undisturbed clones where the regeneration varies in size and age. (Failure apparently is common when wildlings come from clones with a history of disturbance as characterized by many suckers of the same age.) (2) When trees 3 to 5 inches d.b.h. are transplanted, the trees are first wiggled and only those trees that are firmly rooted in all four directions are selected. (3) After transplanting, the aspen are given three applications of a complete foliar fertilizer and one hydraulic injection of the fertilizer into the root system. (4) The trees are sprayed with Benomyl (a systemic fungicide) to reduce the incidence of fungal pathogens common to aspen. (Personal communication with Jerry Morris of Rocky Mountain Tree Experts, Lakewood, Colo.)

Methods have been developed to artificially propagate aspen vegetatively (Schier 1978b). Though labor intensive, these methods offer a way to produce rooted aspen suckers capable of vigorous growth. I want to dispel the myth that vegetatively propagated aspen inherently have slow growth. Aspen trees propagated vegetatively 14 years ago at Logan, Utah, are now 32 ft tall.

Clone Selection

In 1976, aspen suckers were propagated vegetatively from 10 healthy and 10 deteriorating clones in Logan Canyon. Schier and Campbell (1980) describe the site and suckering characteristics for these 20 clones. The two groups of clones differed appreciably with respect to aspen density, basal area, and mortality.

The rooted sucker cuttings were planted in tubes, 2.5 inches in diameter by 10 inches long, filled with peat moss:vermiculite (1:1) and placed in the greenhouse. The next spring the suckers were transplanted to peat moss:sand (3:2) in 1 gal pots and moved to the lathhouse. Under the direction of Dr. George A. Schier, the young trees were transplanted during spring 1978 to a common garden at the Green Canyon Nursery 3 miles northeast of Utah State University.

A total of 439 aspen were planted randomly in 15 rows of up to 30 individuals per row with a 6.6-ft spacing. Soil amendments and fertilizers were not used at the nursery. Rainbird sprinklers provided regular but moderate irrigation. After 2 years at the nursery, the trees had substantial variation in height growth. In an attempt to standardize subsequent vegetative growth, all stems were cut off at ground level in the spring of 1980. Thus all new suckers started from established root systems. As new suckers arose, a dominant sucker was selected; all other remaining and subsequent suckers were cut off.

The new suckers are now in their fourth growing season, and some trees are over 12 ft tall. Data recorded include: height growth for each year, the number of lateral branches, the length of the longest three laterals, and stem form. Preliminary results indicate that substantial variation in these morphological traits occurs between clones. Also, clonal variation is obvious for the time of leaf flush, leaf size and shape, and the angle of branching between the main stem and lateral branches. This common-garden planting illustrates well the genetic control of these characteristics in aspen.

The survival rate in the common garden is an impressive 99 percent. Of the 439 aspen planted, only three died; two others were stolen. Although a few trees have poor growth, at least 95 percent have acceptable growth.

Many factors should be considered when selecting a clone for asexual propagation. Do the trees in the clone have a desired shape and appearance? Is the soil type desirable for root collection? Are there abundant (or sufficient) lateral roots near the soil surface? Will the roots collected have a high capacity to sucker, and will the sucker cuttings develop roots? (Preliminary trials are suggested to determine the clone's suckering and rooting capabilities.) These questions relate to specific factors that vary greatly among clones in nature.

Tree height may be a misleading guide for acceptance or rejection of a prospective clone. Environmental conditions, particularly those related to available moisture, strongly influence height growth. One would expect trees vegetatively propagated from a clone with tall trees to grow reasonably tall; however, I have seen suckers propagated from clones with short trees on a poor site grow unusually fast and tall in a better environment.

Harniss and Nelson (in press) indicate that aspen clones vary in susceptibility to <u>Marssonina</u>, a fungal leaf blight. They surveyed about 1,000 acres of aspen in northern Utah during a recent epidemic year for <u>Marssonina</u>. Resistant or lightly infected aspen trees occupied only 18 percent of the total area. They suggest that the best control of this leaf blight, particularly for ornamental and revegetation purposes, would be to select for highly resistant clones.

Numerous desirable traits of specific aspen clones can be perpetuated by vegetative propagation. Barnes (1966) suggests that the following characteristics are generally uniform among the ramets of the same clone: leaf size, shape, and color (both spring and fall); phenology; stem form and branching habit (for example, excurrent growth or wide spreading crown and degree of self-pruning); sex; bark color and texture; and tendency for disease and insect attack. These traits may be important to consider when a clone is selected.

Root Collection and Storage

Schier (1978b) explains in detail the root collection process. He mentions specific advantages for using a spade, an anvil-type pruner, and a moist cloth bag for collecting lateral roots that range from 0.4 to 1.0 inch in diameter.

The season of root collection can significantly alter the number of suckers produced. During the spring flush and early shoot growth, the roots of aspen clones have high levels of auxin, which reduces sucker formation (Schier 1973). Schier (1978b) explains that roots collected during the clone's dormant stage (early spring, later summer, or fall) typically yield more suckers than those collected during active growth. He notes that early spring collections are easier to make and result in less root damage because the soil is still moist.

Perala (1978) and Schier (1978a) report that the number of aspen suckers produced is not related to the length of the root cuttings. Because the length is not a critical factor, roots can be cut for the convenience of tray size and available space.

Schier and Campbell (1978) suggest that in some situations it may be useful to hold aspen roots in cold storage before planting the roots to begin the suckering process. For example, nurserymen could have the flexibility to collect roots from clones at different times, hold them in cold storage, and then plant the roots at the same time. In addition, the first growing season for the new suckers could be lengthened if the roots were collected in the fall, stored, and then planted in the greenhouse during late winter. Schier and Campbell (1978) treated root segments with Benomyl, wrapped them in moist paper towels, placed them in plastic bags, and stored them in the dark at 36° F for up to 25 weeks. In most cases the cold storage did not significantly alter the number of suckers produced by the roots. They suggest that roots from most clones can be stored for extended periods of time and still produce suckers suitable for propagation. Even after storing root cuttings from three clones for 12 months in a cold room, I found that some suckers still arose from the roots. When the remaining roots from the same lot were tested next at 18 months, they were rotten and did not sucker.

Propagation Method

Briefly, procedures developed by Schier (1978b) to vegetatively reproduced aspen are: (1) Collect lateral roots from desirable clones. (2) Clean the roots, cut to suitable lengths, treat root segments with Benomyl, and plant them horizontally at a depth of 0.5 inch in trays of vermiculite. (3) Place the trays in a greenhouse, water lightly each day, and allow the root segments to sucker for 6 weeks. (4) Cut the new suckers from the root segments, treat the suckers' bases with indolebutyric acid (IBA), and plant the sucker cuttings in moist vermiculite:perlite (1:1). (5) Put these cuttings on a misting bench for 2 to 3 weeks to root. (6) Transplant the rooted cuttings to containers with peat moss:vermiculite (1:1) and apply a complete fertilizer. Use supplemental light during short days and maintain the temperature between 59° and 77° F. Aspen have winter chilling requirements that are satisfied at 36° to 50° F.

SEXUAL PROPAGATION

Female aspen clones produce highly viable seed in the spring (Fowells 1965; McDonough 1979). Growing aspen from seed is less labor intensive than the asexual methods discussed above. Some nurserymen are growing seedling aspen on a production scale. Native Plants, Inc. presently has in its nursery several hundred thousand aspen seedlings of various sizes, both as bare root stock and in containers (personal communication with Mike Alder, Native Plants, Inc., Salt Lake City, Utah).

I will comment on several items that may be useful to nurserymen who wish to propagate aspen from seed.

Clone Selection

Not all aspen clones bear seeds. Typically, aspen have imperfect flowers arranged in catkins. With few exceptions, all of the catkins produced in a clone will be the same sex. Reports in the literature suggest that the male to female ratio of aspen clones varies in some areas in favor of the male (Fowells 1965, Grant and Mitton 1979). From my general observations, I believe that only 20 to 25 percent of the clones in the West will set seed in any one year. Thus, finding female clones with seed is a major limitation for clone selection.

Before flowering, the winter floral buds usually can be picked apart and carefully observed with a hand lens to determine the sex. The best time to determine the clone's sex is mid- to late spring when the catkins are extended. The male catkins have a cluster of purple anther sacs on each scaly bract. The female catkins have a single, green, top-shaped capsule at each bract. Although catkins disintegrate rapidly after shedding pollen or seed, enough fragments to identify the clone's sex usually will remain on the duff layer throughout most of the summer. Emphasis should be placed on finding female clones with desirable attributes for the proposed use of the new seedlings. Nevertheless, because of genetic recombination the seedlings will not be exactly like the trees in the female clone. The odds for desirable offspring, however, should be better if the female clone has the preferred characteristics.

Seed Collection

Aspen flowering is controlled in part by temperature. Because of this, the same clone may vary up to 3 weeks in date of flowering from year to year. Temperature also affects flowering phenology along elevational gradients, with earliest flowering beginning at the lower elevations. In northern Utah male and female catkins usually begin to emerge in mid- to late April. The male catkins soon elongate and the clusters of purple anther sacs begin to shed pollen. Following pollination, some 4 weeks later as the leaves begin to flush out, the female catkins elongate as the seeds mature and the green capsules swell. One to 2 weeks later the capsules open and shed the seed in a fluff of cottonlike hairs.

Rather than collecting the cottony fluff in the field, use a long pruner to cut branches from trees with female catkins about a week before the seed would ordinarily be shed. The catkins can then be forced in a greenhouse or laboratory.

A method commonly used in Europe for seed harvest from European aspen (*Populus tremula*) will also work for quaking aspen. The cut ends of the catkin-bearing branches are placed in containers filled with water. Water is added as needed and kept at a temperature of 46° to 50° F. High air temperatures (68° to 104° F), low relative humidity, and gentle ventilation quicken the ripening process. The catkins should not be exposed to full sunlight. When the capsules open, a suction device is used to remove the cotton and seed. The seed will separate from the cotton as the air current passes through a series of three cylinders connected by small tubes. The viable seed accumulates in the first two cylinders (FAO 1979).

Aspen seed need not be removed from the cotton for germination, but cleaned seed is easier to handle. The mature seed is tan, plump, and small; Schreiner (1974) indicates there are about 3 million cleaned seeds per pound.

Seed Viability and Storage

McDonough (1979) stresses that aspen in the West produce ample amounts of nondormant, germinable seed. However, inadequate soil moisture during germination and early seedling growth usually prevents establishment under field conditions. He found germination capacities of 90 to 100 percent at temperatures from 36° to 86° F. Germination began within 8 to 12 h when temperatures were 68° to 95° F. Also, seeds air dried for 2 days at 68° F and then stored in vapor-tight bottles at 28° F for 48 weeks retained 90 percent or better germinability.

McDonough (1979) shows that the depth of planting greatly affects seedling emergence, which decreases significantly if the seed is placed deeper than 0.15 inch below the surface. Greenhouse seedbeds and standard potting soils are suitable for germination and seedling establishment when watered gently.

Poplar seed can be stored for several years with only a slight decline in the germination rate if stored in a cool, closed container with low humidity (FAO 1979). Fowells (1965) explains that good seed crops for aspen occur every 4 to 5 years, with only light seed production in the other years. Nurserymen could collect seed during the years of abundant seed and store it for a few years without appreciable declines in germination potential.

We collected seed in May 1979 from one clone in northern Utah, air dried the seed for 2 days, and then stored it in a sealed plastic envelope at 36° F. Initially the germination rate was 94 percent. I tested the seed lot in April 1982 and observed a 92 percent germination capacity. In April 1983, after 4 years of cold storage, the seeds still had 82 percent germinability.

DISCUSSION

The propagation of aspen from seed requires less equipment, labor, time, and space than intensive vegetative methods of propagation. In addition a large outplanting of seedling stock tends to maximize the genetic variation available in the gene pool. Such variation is a benefit to reforestation and land reclamation because it enhances the adaptability and survival of the total outplanting. These uses normally require large numbers of planting stock that are more feasible to grow from seed.

In contrast, vegetative propagation yields new ramets genetically identical to the parent. Nurserymen can select for the superior clonal traits preferred by their clientele. The future for asexual propagation of aspen is promising with many possibilities for new advances. In fact, tissue culture, another form of vegetative propagation, is currently being used by Native Plants, Inc. to grow tens of thousands of aspen plantlets from a single seedling tree that has superior traits (personal communication with Mike Alder, Native Plants, Inc., Salt Lake City, Utah).

I stress two recommendations that apply to both methods. General wisdom indicates that clones selected for either root or seed collection should be in the same general area and elevation as the anticipated outplanting, whenever possible. Also, aspen respond best when the fertilizers applied contain a full complement of macro- and micronutrients.

Aspen can be readily propagated by either sexual or asexual methods, both of which have unique advantages. Nurserymen are challenged to capitalize on these advantages to produce aspen stock tailored for specific uses.

PUBLICATIONS CITED

Barnes, Burton V. The clonal growth habit of American aspens. Ecology. 47(3): 439-447; 1966.

Food and Agriculture Organization of the United Nations. FAO Forestry Series No. 10: Poplars and willows in wood production and land use. Rome: Food and Agriculture Organization of the United Nations; 1979. 328 p.

Fowells, H. A. Quaking aspen (*Populus tremuloides* Michx.). In: Silvics of forest trees of the United States. Agric. Handb. 271. Washington, DC: U.S. Department of Agriculture, Forest Service; 1965: 523-534.

Grant, Michael C.; Mitton, Jeffry B. Elevational gradients in adult sex ratios and sexual differentiation in vegetative growth rates of *Populus tremuloides* Michx. Evolution. 33(3): 914-918; 1979.

Harniss, Roy O.; Nelson, David L. A severe epidemic of *Marssonina* leaf blight on quaking aspen in northern Utah. Res. Pap. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; (In press).

McDonough, Walter T. Quaking aspen--seed germination and early seedling growth. Res. Pap. INT-234. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1979. 13 p.

Perala, Donald A. Aspen sucker production and growth from outplanted root cuttings. Res. Note NC-241. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1978. 4 p.

Schier, George A. Seasonal variation in sucker production from excised roots of Populus tremuloides and the role of endogenous auxin. Can. J. For. Res. 3(3): 459-461; 1973.

Schier, George A. Variation in suckering capacity among and within lateral roots of an aspen clone. Res. Note INT-241. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1978a. 7 p.

Schier, George A. Vegetative propagation of Rocky Mountain aspen. Gen. Tech. Rep. INT-44. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1978b. 13 p.

Schier, George A. Sucker regeneration in some deteriorating Utah aspen stands: development of independent root systems. Can. J. For. Res. 12(4): 1032-1035; 1982.

Schier, George A.; Campbell, Robert B. Effect of cold storage on development of suckers on aspen root cuttings. Res. Note INT-248. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1978. 8 p.

Schier, George A.; Campbell, Robert B. Variation among healthy and deteriorating aspen clones. Res. Pap. INT-264. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1980. 12 p.

Schreiner, Ernst J. Populus L. poplar. In: Schopmeyer, C. S., tech. coord. Seeds of woody plants in the United States. Agric. Handb. 450. Washington, DC: U.S. Department of Agriculture, Forest Service; 1974: 645-655.

In: Murphy, Patrick M., compiler. The challenge of producing native plants for the Intermountain area: proceedings: Intermountain Nurseryman's Association 1983 conference; 1983 August 8-11; Las Vegas, NV. General Technical Report INT-168. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1984. 96 p.