NORTH CENTRAL FOREST EXPERIMENT STATION
Research Note NC-294
1992 FOLWELL AVE. ST. PAUL, MN 55108 FOREST SERVICE-U.S.D.A.
1983

A BUDGET TREE IMPROVEMENT PROGRAM

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ABSTRACT.—In an Upper Peninsula Michigan test of simple design, white spruce of a Beachburg, Ontario provenance grew 17.5 percent taller than white spruce from the Ottawa N.F. The paper describes how to convert such tests to low-cost, low-risk, highly flexible improvement programs. The approach is applicable to other species of low priority.

KEY WORDS: White spruce, Lake States region, genetic gains, seed production areas, multigeneration breeding.

We will describe a low-cost alternative to tree improvement in a defined area such as a seed collection zone or a breeding zone. We will use a simple white spruce test as an example.

White spruce from SE Ontario performs well over a large region in north-central and north-eastern United States and adjacent Canada. Five Ontario sources of seed have been particularly mentioned: Douglas (King and Rudolf 1969), Peterborough (Teich 1970), Beachburg (Nienstaedt 1969, Genys and Nienstaedt 1979, Wright *et al.* 1977), Maple Leaf (Stellrecht *et al.* 1974), and Cobourg (Fowler and Coles 1977).

In most seed-source tests in the Lake States, the SE Ontario seedlings have been among the best performers and have been superior to seedlings of the local seed source. In a Minnesota test (Stellrecht *et al.* 1974), the Maple Leaf seedlings grew 17.5 percent higher 15 years after plantation establishment than the best of three control populations; this translated into a 41.5 percent advantage in tree volume. The Ontario-source trees were 76 and 169 percent taller than those in the other two control populations.[1]

Fowler and Coles (1977) have described a program to develop a source of Ottawa River Valley seeds in the Maritimes. Their plan is based on progeny testing with early roguing in the nursery and field test. We suggest a simple and cheaper approach; we believe the method can and should be used for other species as well.

MATERIALS AND METHODS

Beachburg, Ontario seedlings were raised with Ottawa N.F. stock at the Watersmeet, Michigan nursery. Standard nursery procedures were used and 2-2 stock was planted in May 1968 in an open field near Trout Lake, Michigan, approximately 24 miles NNW of St. Ignace. At the time of planting the sod cover was heavy so a sod scalper was used to prepare the ground. Trees from the two populations were planted in alternate rows at an approximate 6 x 8 foot (1.8 x 2.4 m) spacing. There was a total of 94 NS rows with about 140 trees per row. In September 1970 the survival was 97 percent.

[1]*The controls involve standard nursery stock—two populations from State nurseries and one from an industrial nursery. The sources of seed are unknown but are presumably from Minnesota.*

In October 1981, when the trees were 18 years old, total heights were measured. The sampling was as follows: Pairs of trees—one tree from Beachburg and one from Ottawa in adjacent rows—were measured. We began with the first 4 pairs in row #2 (Beachburg) and #3 (Ottawa) in the SE corner of the planting. Pairs 5-8 were in rows #4 and #5, pairs 9-12 in rows #6 and #7 and so forth on a diagonal from the SE corner of the planting towards the north. When the north edge of the planting was reached, we moved across the rows to the east and again began one row in from the edge of the planting and then proceeded diagonally across the planting towards the southwest. The sampling involved the eastern third of the planting. A total of 232 pairs of trees was measured.

RESULTS

The Beachburg, Ontario trees were the best with a mean height of 3.52 m (11.5 feet) ± 1.02 m (3.3 feet) (st. dev.); the Ottawa N.F. trees averaged 2.99 m (9.8 feet) ± 0.96 m (3.1 feet) (st. dev.). Statistically, the difference is highly significant ($t=5.705$). The degree of superiority is almost identical to the 17.5 percent difference found by Stellrecht, Mohn, and Cromell (1974). As in their study, this superiority in height growth will translate into large differences in volume per tree.

DISCUSSION

To many tree breeders tree improvement is synonymous with seed orchard establishment either as grafted orchards of phenotypically selected trees or as progeny-test seedling seed orchards. Both are costly and both involve compromises between the amount of genetic gain and efficient seed production. In the grafted orchard, the effectiveness of phenotypic selection will determine the amount of gain. It is most effective on uniform sites in species that occur in pure, even-aged stands. For many species, phenotypic selection in natural stands in not very effective. In addition, roguing genetically inferior clones will reduce seed productivity in grafted orchards.

For maximum improvement, the progeny-test seedling seed orchard will require heavy roguing with resulting inefficient utilization of the site for seed production.

In intensive multigeneration breeding programs of economically valuable species, the key is to keep separate breeding populations and production populations (Kang 1980). Modified seed orchard designs are also available but they are costly, and they are probably not justifiable with low priority species.

Plantings such as the one we have described may be developed into an effective improvement alternative at low cost. For high priority species, such as the white spruce in our example, such plantings can be an interim source of improved seed. With several such plantings providing parent material, more intensive breeding could be started at some point in the future.

The plantation in our example can be converted to a seed-production area by removing all the trees of the Ottawa N.F. seed source first and then thinning the remaining Beachburg, Ontario trees selectively, leaving approximately 1/4 of the trees. Doing the initial thinning in two separate steps will increase the cost somewhat, but it will facilitate the selective thinning of the trees of the superior seed source. The remaining trees would be at an approximate spacing of 14 x 14 feet (4.2 x 4.2 m), a good spacing for seed production in early years. One later selective thinning, removing 2/3 of the remaining trees, would leave about 70 trees per acre (172/ha) at an average spacing of 24.5 x 24.5 feet (7.5 x 7.5 m). In the selective thinning, the first consideration should be vigor, quality, and absence of pests; the second, spacing of the remaining trees.

In order to assure even spacing of selected trees and to minimize the influence of microsite variation of the selection, a grid could be superimposed on the area, and a predetermined number of individuals selected within each cell of the grid—site quality within a grid cell would tend to be more uniform and selection therefore more effective.

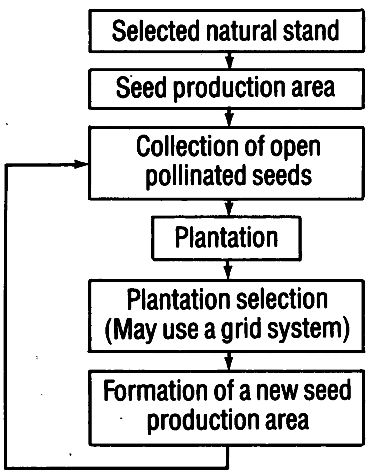
The approach can be used in a multigeneration breeding program. All that will be required is to establish a sequence of plantations always using seed from the previous selectively thinned plantation for each new planting. The approach is low in cost and risk.

Special care should be taken in the nursery in raising the seedlings. Some minor increases in the nursery costs would result. Plantation establishment and maintenance costs would also be higher than usual because special care would be needed in selecting the plantation site and because the best maintenance procedures should be used during establishment. Uniformity of site and maintenance would assure more effective selection. To the degree possible, a site should be selected where the source of outside pollen would be at a minimum to reduce contamination with pollen of low genetical quality.

Negative inbreeding effects with advancing generations could negate the gains achieved early in the program. Large seed collections representing many (100-150) original parent trees would essentially circumvent the problem. If such an original collection were established in a few somewhat different environments and advanced independently from generation to generation, the risk of undesirable inbreeding effects would be further reduced. This is because much of the original genetic diversity could be re-established by mixing the population at some later generation.

Other risks would be small. There will be no major financial loss if the program is abandoned before the selective thinning starts, or at some other stage in its development. The plantings would simply revert to standard uses.

The planting we have described was established with a known superior, broadly adapted source of seed. This is of course an advantage, but it is not essential. Another approach would be to select a high-quality natural stand, develop it into a SPA, and then use the SPA seed for the establishment of the first plantation. This strategy diagrams as follows:



With a network of such plantations over a region, conversion to more intensive breeding programs is possible at any stage. It should be stressed that such a program—and the low-cost program we have described—is environmentally limited to sites similar to sites on which the SPA is established. Future SPA seed established on divergent sites will risk failure. The more the sites diverge from the SPA site, the greater the risk. This, of course, makes the selection of the SPA site particularly important; it must be uniform and representative of the potential planting sites.

The Ottawa trees in the white spruce planting we have described are equivalent to a control. The control permits comparison with currently used planting stock.[2] It is not essential for the breeding, but including such a standard indicates the progress being made.

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[2] *In this particular test a more local Michigan provenance would have been a better standard.*

U.S. GOVERNMENT PRINTING OFFICE:1983-664-000/2 85