AN "EXTRA HEREDITY" APPROACH TO ASPEN BREEDING IN THE LAKE STATES*

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Early in 1952 a project was initiated for breeding native aspens for growing in northern and central Wisconsin. The Rhinelander Paper Company and the Marathon Corporation jointly are supporting the project, and Beloit College has made available greenhouse, laboratory, and office facilities. The goal of research is to determine whether adding one, or two, complete sets of the nuclear factors which determine a tree's inherited life potential, to the double set of such factors in the cells of the ordinary wild tree may constitute a profitable means (1) of increasing the per acre production of paper-making fiber, and (2) of improving upon the quality and utility of the fiber by producting a longer one.

Since several terms which are not familiar to all who are interested in the genetic improvement of forest trees are almost indispensable to a description of this project, it may be useful to define them here. Polyploid trees differ from the ordinary diploid trees, upon which we now

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depend, with respect to the number of sets of those microscopic, linear transmission structures -- the chromosomes -- which are present in the nuclei of all of their cells. On these chromosomes, collectively, reside all of the inheritance factors -- or genes -- which are transmitted to offspring in Mendelian fashion.

According to present information, the vegetative cells of ordinary wild aspens, as well as those of nearly all aspen hybrids, are each internally regulated by exactly 38 chromosomes in two similar sets of 19 each. This double set condition is referred to as diploid. A polyploid tree, on the other hand, is any tree which contains more than two of these complete sets of chromosomes in its vegetative nuclei. If there should be three such sets, the condition is described as triploid, and the four-set condition is known as tetraploid.

Since these distinctions cannot be understood very clearly apart from some acquaintance with the actual reproductive processes and with the physical basis of inheritance, there may be some value in coining a term out of common language and calling all polyploids "extra heredity" trees, thereby distinguishing the triploids and tetraploids collectively from most hybrids and the great mass of wild trees of non-hybrid origin. For want of a more precise non-technical term, the "extra heredity" tag will be employed in this report, where appropriate.

The most general effect of increasing the number of sets of chromosomes beyond the diploid condition has been enlargement in cell size. Sometimes individual plants are also larger. In tree species the length of tracheid fiber, which is related to the strength of paper manufactured from it, may be increased, but there may also be a similar effect upon fiber diameter and wall thickness. All of these factors, plus others, affect the quality of paper made from the wood pulp, and only by producing a sufficient variety of extra heredity woods for testing is it possible to determine either the net effect of all factors or the particular effect of any one factor upon the characteristics of the paper.

The design of the present project envisions the possibility of securing native triploid trees of both quaking aspen and largetooth aspen by detection of naturally produced triploids in the forest, by making crosses involving one polyploid parent where a suitable one can be found, and by artificial production of tetraploid trees, using colchicine treatments. In Sweden, all of these types of approach have yielded extra heredity breeding materials, some of which are promising and others too weak to survive, of the widely distributed Populus tremula, an European cousin of our own quaking aspen.

A search for triploid aspens in several localities in the Lake States was initiated last summer, and will continue this season. If triploid aspens occur naturally in North America, Swedish experience with P. tremula and other evidence would incline us to look for individuals and clones characterized by exceptionally rapid growth, unusually large leaves and buds, and large stomata.

Triploid seedlings and perhaps also a few tetraploid seedlings worth trying in Wisconsin might also be secured by applying pollen from triploid individuals of the European P. tremula to female catkins of our native diploid trees of both P. tremuloides and P. grandidentata. Through the courtesy of Dr. C. Heimburger, of the Ontario Department of Lands and Waters, such pollen was made available several weeks ago from Swedish triploid branches which he has propagated by grafting.

A third method for securing extra heredity stock of aspen is by use of colehicine or some other agent capable of interfering in cell division in such a way that many dividing cells in the growing regions of root tip and stem tip are converted from cells having a double set of chromosomes to cells having a quadruple set. This method is by no means always successful, nor does it guarantee a completely tetra-plaid plant. Efforts of this kind in Sweden, however, give some encouragement, and the method is a valuable one because it offers the possibility of combining in an extra heredity tree the divergent genetic contributions of two parents, both of which can be selected with a great degree of latitude and with possible recourse to parent trees which were involved earlier in crosses which have produced at least apparently desirable progeny. Doubling the number of chromo-somes in a hybrid may also enhance the chances of securing a tetra,-ploid which is fertile,

Several thousand hybrid seeds for colchicine treatment and controls were produced during the last seven weeks from about 20 different matings. These crosses are made in the greenhouse by the common method of placing flower-bud-bearing branches from trees of both sexes in water, transferring pollen to female catkins after about a week's development, and then caring for the branches another two or three weeks until the seeds ripen in the catkine.

flower-bud-bearing branches were obtained from a number of trees in Wisconsin, Minnesota, and the Upper Peninsula of Michigan, including several collections sent through the cooperation of the Headwaters

Branch of the Lake States Forest Experiment Station and the Quetico-Superior Wilderness Research Center. Pollen samples were received from, exchanged with, or sent to Dr. Scott Pauley of the Cabot Founds, tion at Harvard University, and poplar breeders in Canada, Sweden, the Netherlands and Italy. In similar activities and in some cases also in other respects, there has been some cooperation with the genetics and pathology tree breeding projects at the University of Wisconsin, and with the Cloquet Experimental Forest of the University of Minnesota, the Diamond Match Company at Cloquet, the Minnesota and Wisconsin Departments of Conservation, U. S. Forest Service rangers; the Lake States Forest Experiment Station and its branch at Rhinelander, Wisconsin, Trees for Tomorrow, Inc., foresters with the two sponsoring companies, and others. A guide has been prepared to assist foresters in the field who are in a position to help locate superior trees bearing flower buds.

As early as possible, chromosome counts will be made from all types of material, and these will need to be continued over a considerable period, probably, in the case of seedlings treated with colchicine.

Colchicine-treated and control untreated seedlings from the same seed sources will be set out this spring in fenced test plantations at the Ripco Experimental Farm, the U. S. Forest Service Argonne Experimental Forest, on land provided by the Beloit Iron Works near Beloit, and possibly also near Rothschild, Wisconsin. Detailed records of many characteristics will be kept for all materials tested.

As early as the end of the second year of growth, wood samples from the larger seedlings may be ready for testing. The procedure will be, first, to make hand sheets, subject them to the usual physical tests for paper, and determine the pulp yield per unit weight of wood, amount of bleaching required, etc. Later, it is planned to make measurements of average fiber length, width and wall thickness, and to relate these results to those secured in the manufacture of hand sheets. Procedure in making these tests has been discussed with wood technologists at the Forest Products Laboratory in Madison and at the Institute of Paper Chemistry.