Plant scientists short-cut cross-pollination

BELTSVILLE — To improve a crop plant, breeders traditionally have had to rely on the rather slow method of cross-pollinating mature, flowering plants. Breeders now have a short cut, says plant physiologist Gideon W. Schaeffer at a USDA-sponsored symposium on plant reproduction.

Plant scientists are selecting desired traits from small clumps of tissue that have been grown in the laboratory from pollen. The technique is called anther culture.

Although it is a fledgling technique, Schaeffer and his colleagues at the Agricultural Research Center in Beltsville, Md., have used it to locate wheat and rice plants that produce more of the essential amino acid, lysine, in their seed.

Finding this hereditary trait by anther culture takes only about one-third the time of current methods. And the work can be confined to one laboratory instead of several acres of land, Schaeffer told members of the press

Anthers, which are the pollen-producing organs of plants, are placed in a sterile growth medium and subjected to chemicals that inhibit the growth of all pollen cells that do not have the desired hereditary trait. Those that survive presumably contain the genes for the desired trait, and they are then generated into new plantlets.

The technique works by virtue of the fact that the anthers' pollen grains are the male sex of the plant world and, thus, contain half the normal number of the plant cell's chromosomes. Genes on these chromosomes do not have any competition from genes on a partner chromosome which might repress a desirable hereditary trait, as for example, genes for tallness and shortness found in the same pea plant over a century ago by Gregor Mendel. With anther culture, says Schaeffer, "What you see is what you've got."

Another advantage of anther culture is its ability to produce plants with uniform chromosomes, which produce uniform seed when self-pollinated. When clumps of pollen tissue are induced to double their chromosomes, the new plantlets contain pairs of chromosomes that are identical. To achieve this uniformity by current breeding methods, breeders have to backcross the plant containing the desired trait several times with parent generations.

Schaeffer, who coordinated a session entitled "Transfer of Information and Genetic Interplay" during the 3-day Beltsville symposium, highlighted several speakers' presentations. The session dealt with the role of various processes in evolution.

University of Illinois geneticist Jack R. Harlan reported that small pieces of DNA control the heredity of plants not by behaving as genes themselves but by regulating the expression of genes. These DNA units can move from a site on a particular chromosome to any number of sites on other chromosomes, switching nearby genes on or off, Schaeffer explained.

The gene regulators may be as important in affecting the heredity of plants as the recombination of chromosomes during cross-fertilization, especially in crosses between two distant species of plants. They are probably more important than mutation followed by natural selection in speeding up the evolutionary process, Harlan asserted.

Schaeffer said that this theory could account for some unexpected traits that have appeared in his own work with anther culture. Looking down the road, Schaeffer foresees the day when gene regulators may be inserted into chromosomes at the desired site by recombinant technology.

Professor H.F. Linskens from The Netherlands' University of Nijmegen, Department of Botany, and professor Robert Ornduff with the Department of Botany, University of California at Berkeley, pointed out several factors that seem to limit the ability of plant species to adapt to the pressures of evolution, Schaeffer said.

For example, plant species that are able to outcross—exchange genes with other species—theoretically would have a greater chance for survival because they have a larger gene pool to draw from. Hollies, for instance, which have male and female reproductive organs on different plants, have the greatest chance for variability in their genes. But hollies and other dioecious plants are the exception rather than the rule in the plant world. Many species have evolved with rather narrow reproductive habits. Some can only reproduce vegetatively.

Linskens described certain plant species that exclude potential gene donors by the structure of their flowers or by a chemical incompatibility, similar to the immune reaction in animals.

In speculating on why certain species limit their ability to adapt, Ornduff said that the reproductive systems of plants more likely evolved because of an advantage conferred on the species in the past, rather than for any future advantages they may offer, Schaeffer reported.