Rose Breeding of the Future

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The fossil record dating back 35 million years, indicates that roses were widespread across the Northern Hemisphere. Roses have been a part of various cultures throughout the ages. The first systematic application of the science of breeding and selection to roses was begun in England in 1865. The U.S. Plant Patent Act of 1930 made it possible for breeders to receive revenues for their intellectual property, which in turn enabled them to expand their breeding of roses. The rose is probably the most intensively bred woody ornamental plant in the world. Still, rose breeders have been unable to develop resistance to black spot (*Diplocarpon rosae*), a primary objective. Breeders are looking at genetic engineering as a tool to advance germplasm to the point where breeders can utilize the immunity to black spot found in nature. Biogenetic firms and university researchers are currently exploring the techniques of transformation and regeneration(T-R) and the use of antisense technology, for the expression of new colors, disease resistance, fragrance, and improved shelf-life (cut flowers).

EARLY HISTORY

Roses have been around for a long, long time. The fossil record from the Oligocene, dating back 35 million years, indicates roses were widespread across the Northern Hemisphere. Fossils have been found showing roses at least this old in North America, Europe, and Asia.

Over thousands of years, spanning different cultural periods, we have little information on any breeding or selection in roses. We know roses were selected for desired traits and propagated, because we have written records of directions for propagation, pruning, and even forcing roses from Roman times forward.

EARLY BREEDING

The first written records in Western Europe on seed collection, ripening, sowing, and variety selection come from 17th Century France. Open-pollinated seeds of roses were collected, sown, and desirable seedlings selected and propagated. Large nurseries dedicated to rose propagation and sale developed in France. In the 18th Century, roses became very popular in Europe. Large collections of roses like that of Empress Josephine at Malmaison became popular.

Still, breeding of roses into the nineteenth Century was considered an art and not a directed act with specific goals. Controlled pollinations were not practiced, there was little record keeping and the selection depended on luck, as much as the breeder's skills. Even so, quite famous rose-breeding firms grew up in the early 1800s and by the mid 1850s firms specializing in breeding roses had developed.

The first systematic attempt at applying the science of breeding and selection to roses began in England in 1865. In that year, Henry Bennett wrote that, using the principles of breeding developed by agriculture and applying them to roses, would bring a revolution to this plant. Unlike the French, who used open-pollinated seed, Bennett chose to select parents whose traits were desired and carefully hand pollinated them with stated objectives for the progeny in mind. He used greenhouses to produce and ripen seed, carefully sowed seed in glasshouses, and ruthlessly selected for desired traits. Success from this approach to rose breeding spread quickly to France, Germany, and the U.S.

MODERN ROSE BREEDING

From 1870 to 1920 all of today's surviving major rose-breeding firms were founded. The great Northern Ireland firms of Dickson and McGredy, the German firms of Tantau and Kordes, the French firm of Meilland, the Danish company Poulsen, and the U.S. firm of Jackson & Perkins all got their start in this period. All of these companies developed large, sophisticated breeding programs based on careful selection of the best parents, controlled crosses, and careful seedling selection, followed by rapid build-up and introduction to the market place. Because of the lack of intellectual property protection, it became necessary to flood the market with new product for 2 or 3 years to capture enough money to pay for research.

All of this began to change with the U.S. Plant Patent Act of 1930 and the first patents issued in 1931. Breeders now had the opportunity to protect their invention and gain an income over time to invest in future research. This increase in revenue helped to rapidly expand breeding of roses in the U.S. It would have the same effect in Europe 30 years later when Plant Breeders Rights were finally accepted and became law.

The result of all this long accumulation of breeding and protection for intellectual property has meant that the rose is probably the most intensively bred woody perennial ornamental plant in the world. Worldwide, hybridizing programs of the major breeders produce over 3 million seed per year and cost an estimated $10 million dollars. With all of this research, breeders of roses are still left with several fundamental breeding goals that remain to be attained.

FUTURE

Breeders of roses, with a tremendous base of advanced germplasm derived from many wild species, still have not accomplished perhaps their most important goal: resistance to black spot fungus (*Diplocarpon rosae*). Even using the diploid species *Rosa multiflora* and *R. rugosa*, immunity to black spot is still on the distant horizon. With rapid mutation by the pathogen and the dilution of resistance by conventional breeding, breeders are looking at genetic engineering as a tool to advance the germplasm base to the point where breeders can take full advantage of the immunity to black spot found in nature. However, fundamental and expensive roadblocks are in place preventing this from happening.

Breeders know almost nothing about roses at the gene level. We do not have gene maps of roses at the diploid or tetraploid level. We do not have linkage maps or marker genes and our knowledge of genetic engineering techniques is at best primitive. Even with this lack of fundamental basic knowledge, genetic engineering in roses is taking place. Perhaps the most famous example of this is the blue rose project by Florigene (formerly Calgene Pacific) of Australia. Florigene began studies into modification of flower color in roses over 10 years ago. They have two approaches to color modification. The first involves isolation of new genes that can be transferred and expressed in roses. The other approach is to alter color by use of "anti-sense" orientation.

In the first approach, Florigene, by using advanced and elegant genetic engineering techniques has isolated the so-called blue gene in Petunia. Florigene has successfully isolated the 3', 5' - hydroxylase gene and its promoters and successfully transferred them to a rose. They have been able to regenerate the transformed rose cell into a whole plant and have got expression of the gene. However, differences in vacuolar pH and the presence of copigment also affect the blueness in flowers. In the case of this transgenic rose, the vacuolar pH is too low to allow the blue color to be expressed in the petals. Florigene now has to either adjust pH in the vacuole or find a rose with a suitable pH. Both approaches have been examined over the last 2 years. As yet, the blue rose has not emerged.

The second approach, the use of "anti-sense" technology has proved successful in rose, petunia, carnation, and chrysanthemum. The expression of sense and anti-sense constructs in transgenic plants for the enzyme chalone synthase (CHS) is now becoming routine. Commercial testing in chrysanthemum with this technology have been accomplished and cultivars released.

Further research at Florigene on improvement of shelf-life in roses suggests that the use of anti-sense constructs of ACC synthase (necessary for ethylene production) can control ethylene production. The same technology, using ACC oxidase, is also possible. These are the same genes that are used to produce long-life tomatoes.

Other genetic engineering companies are working in this field. DNAP has patented a transformation-regeneration (T-R) system for roses. Moet, in France, has also developed a successful T-R system and has been reported to be working on fragrance expression in roses. Other firms are reported to be interested in using roses in their genetic engineering programs.

It seems that over the short term (10 years), genetic engineering of roses will continue to be done. Until more is learned about the rose itself (mapping, linkage), most genetic engineering will use off-the-shelf patented genes and these will be inserted into the rose and tested. Examples include the ethylene blockers, herbicide-resistance genes, insect-resistance genes and color-modification genes.

In the longer term, as the basic science of the rose is learned and we come to know where individual genes are located, gene transfer between roses will become common place. For example, instead of using diploid species for resistance breeding, individual resistance genes or gene complexes will be transferred to specific tetraploid clones.

Traditional plant breeding will be enhanced with these techniques. The breeder's role will become more directed - the rifle or pinpoint approach to breeding will replace the shotgun approach. Our dream of true resistance to diseases like black spot may finally be realized. Of course, because we are dealing with natural systems, the pathogen may have something to say about this.