What Molecular Genetics Can Do for the Nursery Industry©

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INTRODUCTION

Recent advancements in plant molecular genetics have mainly been applied to field crops, but are also pertinent to ornamentals. This talk will address four areas in which molecular genetics has the greatest chance of impacting the nursery industry: hybrid verification, plant identification, marker-assisted breeding, and development of transgenic plants.

HYBRID VERIFICATION

Interspecific and intergeneric hybridizations are often made in breeding programs for the purpose of combining the best traits from two species; however, it may take several years before progeny develop features that identify them as hybrids. Molecular markers, which are small fragments of DNA, can be used for verifying hybridity even at the seedling stage. This process involves looking for markers that are specific to each parental parent and then examining putative hybrids for the presence of markers from both parents. These markers are frequently visualized as bands on gels.

Parentage of naturally occurring hybrids is often inferred based on morphological features and overlapping geographical areas of potential parents. Knowing the exact parentage of these hybrids can be valuable, especially if there is a desire to re-create the hybrid using superior forms of the parental species. Identification of parental species of naturally occurring hybrids is carried out in much the same way as hybrid verification. Possible parents are screened for molecular markers that differ between species, and hybrids are examined for presence of markers from more than one species.

PLANT IDENTIFICATION

If a series of molecular markers that are specific to a genus, species, or cultivar can be identified, they can be used for plant identification. The closer the relationship is between two individuals or groups of plants, the more markers that are needed to distinguish between them. For example, while only 13 molecular markers were required for producing a molecular identification key to 16 species of *Hydrangea* and related genera (Rinehart et al., 2006), 39 molecular markers were needed to distinguish among 100 *H. macrophylla* cultivars or small groups of closely related cultivars (Reed and Rinehart, 2007). Cultivars within some of these small groups of related cultivars could be distinguished by using additional molecular markers.

The use of plant patents for woody ornamental plants is becoming more and more common. In theory, molecular markers provide a method for helping to enforce plant patent rights. However, because molecular marker libraries can be expensive to develop, they are currently available for only a few nursery crop species. Also, demonstrating that two plants are different (i.e., that no patent infringement has occurred) is much easier than proving two plants are the same. This is because molecular markers represent a sample of the DNA from an organism, rather than its entire genetic composition. For example, it could be difficult to find markers that differentiate a sport from the original cultivar since sports may only differ from the original cultivar in one or a few genes.

MARKER-ASSISTED BREEDING

Ornamental breeding programs often have the objective of improving disease and insect resistance, which are dependent on environmental conditions and pest populations. Other important traits cannot be determined until the plant reaches reproductive maturity, which may take several years in some crops. Molecular markers offer an opportunity to determine which plants in a breeding population have the desired traits without having to conduct intensive screening tests or wait for these traits to be expressed. Molecular-marker-assisted breeding involves looking for molecular markers that are closely linked to, and therefore frequently inherited with, genes for the traits of interest. If these markers can be found, then plants can be selected, even at the seedling stage, based on the presence of these markers. Marker-assisted breeding is effective for traits that are controlled by one or a few genes and those that involve many genes, each of which has a small effect.

Marker-assisted breeding programs are underway in many of the major food crops, but are lacking in ornamentals. To be effective, marker-assisted breeding requires the identification of a large number of molecular markers that span all of an organism's chromosomes. It appears that the only ornamental in which a saturated genetic linkage map has been constructed is rose (Yan et al., 2005); however, development of molecular linkage maps in *H. macrophylla* (T.A. Rinehart, pers. commun.) and *Cornus florida* (R.N. Trigiano, pers. commun.) are currently underway. The explosion of research in genomics and bioinformatics may also result in marker technologies that are applicable to nursery crops. It is likely that linkage maps and marker-assisted breeding will become a reality in some major ornamental species in the near future.

TRANSGENIC PLANTS

A transgenic plant contains a gene or genes that have been artificially inserted into the plant instead of the plant acquiring them through sexual reproduction. The process by which transgenic plants are developed is called transformation. Transgenic plants are also referred to as genetically modified or GM plants. Transformation allows a plant to acquire traits not present within the species and which could not be transferred through traditional plant breeding.

The main transgenic plants grown in the U.S. are corn, soybeans, and cotton. Genetically modified cultivars of canola, squash, and papaya are also commercially grown in this country. Most commercialized transgenic crops have been modified to have resistance to herbicides, insecticides, and viruses. Transformation also has the potential for developing crops with improved nutritional value, such as the "golden rice" with increased levels of beta-carotene.

The only transgenic ornamental crop currently marketed in the U.S. is carnation. The "Moon" series of carnation resulted from the transfer of a gene for blue flower color from petunia; this series includes mauve-, violet-, and purple-flowered cultivars (Florigene, 2007a). Florigene and the Japanese company Suntory have also produced "blue" roses (actually more of a mauve color) by insertion of a gene from pansy, but this product is not yet commercially available (Florigene, 2007b). Transformation systems for over 30 species of ornamentals have been reported (Deroles et al., 2002), but have not been commercialized. Transformation usually requires a tissue culture system that allows whole plants to be regenerated either from a single cell or very small groups of cells; however, efficient regeneration protocols have not yet been developed for most nursery crop species.

In addition to the direct research costs associated with developing transgenic plants, most transformation systems require the use of patented technology. If a transgenic plant is to be commercialized, then licensing fees related to patented technology used to develop the plant must be considered. While some of these fees have been waived by companies in support of humanitarian efforts (e.g. "golden rice"), it seems unlikely that transgenic nursery crops would receive the same treatment. Obtaining government approval for releasing transgenic plants can be a lengthy and costly process. Three Federal agencies — the Food and Drug Administration (FDA), the Animal and Plant Health Inspection Service (APHIS), and the Environmental Protection Agency (EPA) — have oversight for the approval of transgenic plants. Depending on the crop and transgene, approval from one or more of these agencies is required before a transgenic plant can be commercialized. One concern that is addressed during the regulatory process is the potential for the transgene to be transferred into native populations or wild relatives of the transgenic crop. More information on the regulatory process for transgenic organisms can be found (http://usbiotechreg.nbii.gov). The costs related to technology development, licensing fees, and regulatory approval must be balanced by potential increased sales and revenue in order for transgenic crops to be practical.

Another obstacle to the commercialization of transgenic nursery crops is consumer acceptance. There has been considerable opposition by some individuals, organizations, and nations to transgenic crops. Benefits of transgenic nursery crops must be weighed against possible negative publicity and avoidance of transgenic products by those opposed to this technology.

SUMMARY

Molecular genetic techniques offer tremendous opportunities for the development of superior crop plants. While some of these techniques still are too costly to be routinely applied to all but the most major food and feed crops, others are currently being or soon will be used in nursery crop improvement efforts. Lack of available technology, costs, and consumer acceptance concerns may delay the application of genetic transformation to nursery crops but, at some point in the future, transgenic nursery crops likely will become a reality.

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