

Modern Plant Breeding

Editor's Notes: In my September column, we looked at the techniques associated with traditional plant breeding and found that this ancient art has enabled man to mold plants to his needs and provide increased amounts of needed food. In this month's column, we will examine some of the plant breeding techniques developed since World War II. You will note that some of these procedures have led to controversies associated with the term GMO's.

Modern plant breeding uses techniques of molecular biology to select, or in the case of genetic modification, to insert, desirable traits into plants.

Marker-Assisted Selection

Sometimes many different genes can influence a desirable trait in plant breeding. The use of tools such as molecular markers or DNA fingerprinting can map thousands of genes. This allows plant breeders to screen large populations of plants for those that possess the trait of interest. The screening is based on the presence or absence of a certain gene as determined by laboratory procedures, rather than on the visual identification of the expressed trait in the plant.

Genetic modification

The debate surrounding genetic modification of plants is huge, encompassing the ecological impact of genetically modified plants, the safety of genetically modified food and concepts used for safety evaluation like 'substantial equivalence.'

Genetic modification of plants is achieved by adding a specific gene or genes to a plant, or by knocking out a gene with RNAi, to produce a desirable phenotype. The plants resulting from adding a gene are often referred to as transgenic plants. If for genetic modification genes of the species or of a crossable plant are used under control of their native promoter, then they are called 'Cisgenic' plants. Genetic modification can produce a plant with the desired trait or traits faster than classical breeding because the majority of the plant's genome is not altered.

To genetically modify a plant, a 'genetic construct' must be designed so that the gene to be added or knocked-out will be expressed by the plant. To do this, a promoter to drive transcription and a termination sequence to stop transcription of the new gene, and the gene of genes of interest must be introduced to the plant. A marker for the selection of transformed plants is also included. In the laboratory, antibiotic resistance is a commonly used marker: plants that have been successfully transformed will grow on media containing antibiotics; plants that have not been transformed will die. In some instances markers for selection are removed by backcrossing with the parent plant prior to commercial release.

The construct can be inserted in the plant genome by genetic recombination using the bacteria *Agrobacterium tumefaciens* or

A. rhizogenes, or by direct methods like the gene gun or microinjection. Using plant viruses to insert genetic constructs into plants is also a possibility, but the technique is limited by the host range of the virus. For example, Cauliflower mosaic virus (CaMV) only infects cauliflower and related species. Another limitation of viral vectors is that the virus is not usually passed on to the progeny, so every plant has to be inoculated.

The majority of commercially released transgenic plants, are currently limited to plants that have introduced resistance to insect pests and herbicides. Insect resistance is achieved through incorporation of a gene from *Bacillus thuringiensis* (Bt) that encodes a protein that is toxic to some insects. For example, the cotton bollworm, a common cotton pest, feeds on Bt cotton it will ingest the toxin and die. Herbicides usually work by binding to certain plant enzymes and inhibiting their action. The enzymes that the herbicide inhibits are known as the herbicides target site. Herbicide resistance can be engineered into crops by expressing a version of target site protein that is not inhibited by the herbicide. This is the method used to produce glyphosate resistant crop plants. Genetic modification of plants that can produce pharmaceuticals (and industrial chemicals), sometimes called pharmacrops, is a rather radical new area of plant breeding.

Issues and concerns

Modern plant breeding, whether classical or through genetic engineering, comes with issues of concern, particularly with regard to food crops. The question of whether breeding can have a negative effect on nutritional value is central in this respect. Although relatively little direct research in this area has been done, there are scientific indications that, by favoring certain aspects of a plant's development, other aspects may be retarded. A study published in the Journal of the American College of Nutrition in 2004, entitled Changes in USDA Food Composition Data for 43 Garden Crops, 1950 to 1999, compared nutritional analyses of vegetables done in 1950 and in 1999, and found substantial decreases in six of 13 nutrients measured, including 6% of protein and 38% of riboflavin. Reductions in calcium, phosphorus, iron and ascorbic acid were also found. The study, conducted at the Biochemical Institute, University of Texas at Austin, concluded in summary: "We suggest that any real declines are generally most easily explained by changes in cultivated varieties between 1950 and 1999, in which there may be trade-offs between yield and nutrient content."

Plant breeders' rights is also a major and controversial issue. Today, production of new varieties is dominated by commercial plant breeders, who seek to protect their work and collect royalties through national and international agreements based in intellectual property rights. The range of related issues is complex. In the simplest terms, critics of the increasingly

continued on page 22

continued from page 9

Algunos procesos del azúcar sin refinar y sus unidades de operación son inherentes y difíciles de controlar. Por ejemplo, filtros rotativos al vacío que tienen el propósito de recuperar la mayor cantidad posible de sacarosa; coberturas metálicas en vez de telas dan como resultado una filtración oscura con niveles significativos de sólidos finos flotantes; la única medida razonable podría ser estimular la última filtración ajustando el flujo de agua de lavado usando un sistema de presión diferencial por medio del sistema cercano infra-rojo para la recuperación de sacarosa pero a base altos

costos; esto requeriría poder captar la última filtración de la sección de lavado del filtro; lo que no es nada fácil y quizás se lograría con más facilidad con una sección de compresión?

La meta en general es la misma, convertir materia prima agrícola en productos alimenticios u otros productos. La pregunta es; si los procesos implicados deben ser re-evaluados, combinados y simplificados, usando diferentes parámetros que optimicen el control y por consiguiente los costos y el rendimiento.

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continued from page 10

restrictive regulations argue that, through a combination of technical and economic pressures, commercial breeders are reducing biodiversity and significantly constraining individuals (such as farmers) from developing and trading seed on a regional level. Efforts to strengthen breeders' rights, for example, by lengthening periods of variety protection, are ongoing.



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Statement of Ownership: 1) Sugar Journal. 2) Pub #0039-4734. 3) Date of filing: Oct. 01, 2007. 4) Frequency: Monthly. 5) 12 issues published annually. 6) Annual subscription: \$50.00 & \$85.00. 7) Mailing address: PO Box 1 9084, New Orleans, LA 70179. 9) Publisher and Executive Editor: Romney Kriedt Richard. Executive Publisher: Charley Richard. 10) Owner: Romney Kriedt Richard, 51%; Charley Richard 49%. 11) Bondholders, mortgages and other security holders owning or holding 1% or more of total amount of bonds, mortgages or securities, none. 15) Extent and nature of circulation: Actual number of copies of single issue published nearest to filing date. A) To tal number of copies printed 4000. B) Paid Circ: 1) mail subscriptions: 1385. 3) Sales through dealers, and carriers, street vendors and counter sales and other paid distribution outside USPS: 2520. 4) Paid distribution other classes of mail through the USPS: 20.C) To tal paid circulation: 3925. D) 4). Free or nominal Rate outside county copies: 50. E) Total Free Distribution outside the mail: 50. F) To tal distribution: 3975. G) Copies not distributed: 25. H) To tal: 4000. I) Percent Paid: 98.7%. Average number of copies preceding 12 months: A) 3316. B) (1) 1177. (3) 1897. C) 3094. D) (4) 122. E) 122. F) 3216. G) 100. H) 3316. I) 93.3%. I certify that the statements made by me above are correct and complete. Romney Kriedt Richard, Publisher and Executive Editor.