Garry Smith, Ph.D.

Plant Breeding-Classical to Modern

Editor's Note: Over the past two years of this column, we have looked at the developments and controversies surrounding GMO's. The use of the 'modern term' "genetic engineering" has given the impression that this is the first time in history that the plants we use for food have ever been altered by man. Some uninformed may be content to believe this fantasy, however there are those who may be surprised that all of our food crops have been subjected to genetic improvement via plant breeding techniques, some for thousands of years. My next several columns will attempt to summarize how plant breeding achieves the objectives for developing or improving our food and fiber crops.

Plant breeding is the purposeful manipulation of plant species in order to create desired genotypes and phenotypes for specific purposes. This manipulation involves either controlled pollination, genetic engineering, or both, followed by artificial selection of progeny.

Plant breeding has been practiced for thousands of years, since near the beginning of human civilization. It is now practiced worldwide by government institutions and commercial enterprises. Breeding new crops is important for ensuring food security and development of crops suitable for specific environments.

Domestication of plants is an artificial selection process conducted by humans to produce plants that have fewer undesirable traits than wild plants, and which renders them dependent on artificial (usually enhanced) environments for their continued existence. The practice is estimated to date back 9,000-11,000 years. Many crops in present day cultivation are the result of domestication in ancient times, about 5,000 years ago in the Old World and 3,000 years ago in the New World.

A cultivated crop species that has evolved from wild populations due to selective pressures from traditional farmers or natural forces are called a landraces and are ideally suited to a particular region or environment. An example are the landraces of rice, *Oryza sativa* subspecies indica, which was developed in South Asia, and *Oryza sativa* subspecies japonica, which was developed in China.

Classical plant breeding uses deliberate interbreeding (crossing) of closely or distantly related individuals to produce new crop varieties or lines with desirable properties. For example, a mildew-resistant pea may be crossed with a high-yielding but susceptible pea, to introduce mildew resistance without losing the high-yield characteristics. Progeny from the cross would then be crossed with the high-yielding parent to ensure that the progeny were most like the high-yielding parent, (backcrossing). The progeny from that cross would then be tested for yield and mildew resistance and high-yielding resistant plants would be further developed.

Classical breeding relies largely on homologous recombination between chromosomes to generate genetic diversity. The classical plant breeder may also make use of a number of in vitro techniques such as protoplast fusion, embryo rescue or mutagenesis to generate diversity and produce hybrid plants that would not exist in nature.

Traits that breeders have tried to incorporate into crop plants in the last 100 years include:

- Increased quality and yield of the crop
- Increased tolerance of environmental pressures (salinity, extreme temperature, drought)
- Resistance to viruses, fungi and bacteria
- Increased tolerance to insect pests
- Increased tolerance of herbicides

Before World War II

Intraspecific hybridization within a plant species was demonstrated by Charles Darwin and Gregor Mendel, and was further developed by geneticists and plant breeders. In the early 20th century, plant breeders realized that Mendel's findings on the non-random nature of inheritance could be applied to seedling populations produced through deliberate pollinations to predict the frequencies of different types.

In 1908, George Harrison Shull described heterosis, also known as hybrid vigor. Heterosis describes the tendency of the progeny of a specific cross to outperform both parents. The detection of the usefulness of heterosis for plant breeding has led to the development of inbred lines that reveal a heterotic yield advantage when they are crossed. Maize was the first species where heterosis was widely used to produce hybrids and has been extensively used to produce sugar beet hybrids.

By the 1920s, statistical methods were developed to analyze gene action and distinguish heritable variation from variation caused by environment. In 1933, another important trait was discovered in maize. Cytoplasmic male sterility (CMS), was described by Marcus Morton Rhoades. CMS is a maternally inherited trait that makes the plant produce sterile pollen. This enables the production of hybrids without the need for labor intensive detasseling. The production of modern sugar beet hybrids depends almost entirely on CMS.

These early breeding techniques resulted in large yield increase in the United States in the early 20th century. Similar yield increases were not produced elsewhere until after World War II, the Green Revolution increased crop production in the developing world in the 1960s.

After World War II

Following World War II a number of techniques were

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tonelada de azúcar por dia por dia, este volumen de azúcar supera por mucho el costo de prevenir y evitar todas esta fugas y derrames, especialmente si estas reparaciones son hechas antes de comenzar la temporada de zafra.

Recuerdo cuando estaba joven en el note de inglaterra decían que; “en donde hay muck (tierra orgánica) hay bronce”, o en donde hay suciedad hay dinero. Hay dos posibles interpretaciones a esto. Primero; en la opinión de la clase trabajadora, dicen que para ganar sus salarios hay que ensuciarse, a excepción de aquellos que están en la gerencia. Segundo y lo mejor; el desperdicio cuesta dinero, ambos en términos de perdidas de materiales y del esfuerzo que toma para limpiar.

Muchos de nosotros recordamos a peter skinner, un dia me relato que de una de sus primeras experiencias en un ingenio, estando el de responsable de una parte de la casa de cocimientos una de las bombas de meladura estaba fugando un poco. El gerente de planta le pregunto que estaba pasando, la respuesta de peter fue que no era mas que una pequeña fuga, y dio esta misma respuesta las veces que fue preguntado por esto, finalmente el gerente de planta le respondió que no era una pequeña fuga, y con esto el bono anual de peter se fue al drenaje. **SJ**

Translated by: Luis E. Rivas. Consultant for the sugar industry, Baton Rouge, LA. Lrivase@aol.com

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developed that allowed plant breeders to hybridize distantly related species, and artificially induce genetic diversity.

Interspecific and intergeneric hybrids are produced from a cross of related species or genera that do not normally sexually reproduce with each other. These crosses are referred to as Wide crosses. For example, the cereal triticale is a wheat and rye hybrid. The cells in the plants derived from the first generation created from the cross contained an uneven number of chromosomes and as result was sterile. The cell division inhibitor colchicine was used to double the number of chromosomes in the cell and thus allow the production of a fertile line.

If fertilization is possible between two species or genera, the hybrid embryo may abort before maturation. If this does occur the embryo resulting from an interspecific or intergeneric cross can sometimes be rescued and cultured to produce a whole plant. Such a method is referred to as Embryo Rescue. This technique has been used to produce new rice for Africa, an interspecific cross of Asian rice (*Oryza sativa*) and African rice (*Oryza glaberrima*).

Hybrids or other cultivars also may be produced by other techniques, such as, protoplast fusion, induced polyploidy, radiation, and chemical mutagens. **SJ**