THE SCIENCE behind crop improvement and new plant development

How do crops become resistant to insects? Survive herbicide lethal to weeds? How do breeders develop hybrids?

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Improving crops for better yield and quality has been the cornerstone of human civilization.

Traditional crop improvement has relied on identification of plants that perform better than others. Seeds from such plants were saved for future plantings and, following harvest, seed was again saved for the next season.

Eventually, the result was development of heirloom cultivars. Heirloom cultivars are extremely popular with home gardeners for backyard planting and valued for flavor, color, and other quality characteristics.

Such cultivars may also be better adapted to climatic conditions of a particular region and express resistance to certain diseases and pests, having been grown in that region and subjected to artificial selection for several generations.

Heirloom cultivars now widely distributed may be suitable for home gardening and production for local markets, but certain characteristics, such as absence of uniform fruit development, a longer time required for fruit maturity and ripening, low yields, and poor shipping and storage qualities, make them unsuitable for large-scale commercial production.

Growing a Better Plant

Plant breeders exploit heterosis, commonly known as hybrid vigor, in cultivar development. Specific parents genetically distinct from each other used in developing hybrid cultivars have each been developed through repeated self-pollination to make most of the genetic constitution of each parent extremely uniform.

Such parents are then used to make crosses and obtain a progeny commonly known as a F_1 (Filial generation 1) hybrid. Hybrid cultivars attain beneficial traits from both parents and have significantly improved characteristics than either. Hybrid cultivars have higher yields and growth and development uniformity. These characteristics result in easier harvesting and better shipping and storage qualities that make hybrid crops more conducive to transport over longer distances.

Higher yielding crop cultivars are a major goal in crop improvement. Efforts to develop improved cultivars that are sustainable under less-than ideal growing conditions were prompted by a rapid increase in human population complicated by drastically declining natural resources such as arable land and good-quality water for cultivation.

Developing Cultivars Poses Problems

Plant breeders face obstacles during development of improved cultivars. Oftentimes, desirable traits such as insect or disease resistance or drought tolerance that may be present in wild relatives are not easily transferred to cultivated crops using regular breeding techniques. This may occur due to sexual incompatibility derived from artificial speciation, which prevents the formation of viable progeny.

The transfer of beneficial traits between wild and cultivated plant species may be possible, but they come at the cost of disrupting the existing good characteristics in a cultivar. Breeding a cultivated variety with a wild relative can result in the potential reappearance of undesirable traits like seediness and poor taste, which the breeder initially tried to remove when developing a cultivar.

Obstacles to conventional breeding can also be seen in development of perennial cultivars. A number of perennial fruit and tree species have to grow for several to many years before they flower or produce fruit. Thus it takes a very long time to cross pollinate two trees and then evaluate the progeny grown from the seed for traits such as fruit yield. So producing and evaluating crosses in such crop species may consume the lifetime of a plant breeder with no guarantee of any significant improvement.

Overcoming Complications

Genetic engineering can help overcome some of these obstacles. Transferring specific desirable traits in existing commercial cultivars develops Genetically Modified (GM) crops, also known as Genetically Engineered (GE) crops or transgenic crops.

Producing a GM plant involves inserting pieces of DNA (DNA sequences) that code for desirable traits in plant cells or tissues under laboratory settings. The modified cells and tissues are then carefully grown into whole plants that express the inserted desirable traits such as drought tolerance, insect, disease and herbicide resistance, or improved quality characteristics. DNA pieces can be derived from a wide host of donor organisms including plants, animals, bacteria, and viruses. Genetic engineering allows breeders to add specific desirable traits from these organisms while leaving out unwanted traits and the ability to rapidly produce plants that can be evaluated quickly. Additionally, it allows commercial cultivars to be further improved while leaving existing desirable traits intact.

Genetic Engineering Put to Use

Popular examples of genetic engineering for production of GM crops include the transfer of traits for herbicide and insect resistance in alfalfa, corn, cotton, canola, soybean, and sugar beets, the development of disease-resistant papaya and plum cultivars, and potato and apple cultivars with improved quality characteristics.

Herbicide resistant GM crops contain a gene from a bacterium, commonly found in soil, that helps modified plants detoxify the effects of the herbicide while allowing for effective weed control.

Crops modified for insect resistance contain a gene from *Bacillus thuringiensis*, a commonly occurring soil bacterium that produces a compound toxic to certain insects under natural conditions. Commercial formulations containing the same bacteria are also used for controlling insect pests in organic agriculture. A protein produced by the bacteria destroys the insect gut upon feeding by insect. GM plants have been engineered to produce the same protein that causes insect mortality.

Other notable examples of GM crops include papayas that have been modified to resist the papaya ring spot virus disease, rice which has been modified to produce a precursor of vitamin A to combat vitamin A deficiency diseases, and plums that are resistant to plum pox virus.

GM plants are used to produce other products, such as corn starch, corn syrup, corn and canola oil, and soybean oil used in mayonnaise and other products, and sugar from sugar beets for various foods.

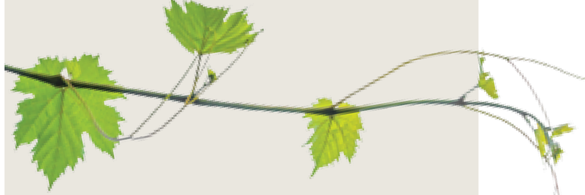
GM crops have often been embroiled in controversies regarding their safety to mankind and environment. Studies assessing the perceived health risks associated with GM crops have concluded GM crops and their products are as safe for consumption as their comparable non-GM counterparts bit.ly/usdagecrops.

Will Precision Breeding Decrease the Controversy?

Precision breeding is a recent improvement in genetic modification technology. Precision breeding uses DNA pieces found solely in sexually compatible species. The technology is a logical refinement of conventional breeding procedures and has been made possible by new discoveries in genetic engineering techniques.

Efforts have been initiated to identify DNA pieces in wild relatives of cultivated species, which can be used for the incorporation of naturally occurring insect and disease resistance, as well as cold and salt tolerance.

Precision breeding is consumer and ecofriendly; the crop genome is disrupted much less than conventional breeding, and precision breeding techniques should raise fewer genetically modified organism-related consumer concerns since the genetic material inserted into a crop is derived from its own relatives and not a foreign body.



BY GROWING A BETTER PLANT

Hybrid vigor is not a new concept – its affects had been observed in ancient times, but it wasn't until the early 1900s that interest intensified in this phenomenon and by the 1930s hybrid corn seed was introduced. Farmers quickly adopted the seed due to the wide variety of benefits, including producing more food per acre of land. In 1935, hybrid corn in Iowa was 10 percent of all corn grown; that grew to 90 percent by 1939.

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