Developing New Crops

The development of new crops offers a second way to use Arizona's productive soils and sunshine while reducing water use.

The opportunities to improve water efficiency for established Arizona crops are still substantial, as described in the two preceding articles. Development of new crops, however, will allow the fullest use of land where water is most limited. A listing of crop acreages in the state two or three decades from now may include substantial amounts for crops not showing up at all in Table 4, page 7. The key feature of such crops must be that they produce some useful product economically while using minimum amounts of water.

Rapid development of such crops challenges today's plant scientists. Virtually every one of our major crops has been developed over thousands of years. Only within the last century have scientists started to improve technically what had already been improved by informal selection since the dawn of history. Fortunately, plant scientists have a vast storehouse of knowledge about how plants can be improved through the domestication process. University of Arizona researchers have worked on developing new crops for arid lands for several decades, though efforts have intensified in the past five years. New crops developed in recent decades, through work here and elsewhere, include safflower, soy, guar and plantago.

The process is complex, expensive, highly technical and drawn-out. First, one must settle upon the species to be domesticated. This requires preliminary studies about the utility of products, the probability of success, technical barriers and other factors.

Once launched for a given species, the domestication effort demands a long-term commitment: Seed samples of the wild plant from throughout its natural range must be collected and stored to take advantage of its full genetic diversity. Basic studies about the biology of the plant, such as its patterns of reproduction and growth, lay the groundwork for improvements. Selective breeding focuses desirable traits into one or a few selected lines. A method for propagation, be it by seed or by vegetative means, is necessary for planting stands of the selected lines. Production practices, including pest-control procedures, must be worked out. So must processing and marketing techniques for the product. Development of ways to mechanize production and to use by-products improves the plant's chances for success. The economics and environmental implications of production require thorough analysis.

Proper Timing

The success of domestication depends not only on the fundamental suitability of the species selected, but also on good judgment in placing the right emphasis at the right time on these various steps in the domestication process. One pitfall is to attempt an economic analysis at an early stage without allowing for improvement in the target species through breeding and other research. Almost certainly, any wild plant would be declared economically unattractive if yields from the wild state were used in the economic feasibility study. But given adequate time and resources, selective breeding can dramatically change almost any plant species. Most plant species show wide variability in many characteristics when examined throughout their natural range. Where additional variability is needed, it can be generated through irradiation or chemical mutagens. Chromosome doubling and hybridization are powerful tools for genetic manipulation. Plant breeding, however, must also be part of a coordinated strategy for domestication. Preliminary studies of disease or insect susceptibility and climatic restrictions may dictate the direction for research.

The University of Arizona is a world-leading center for the domestication of new arid land plants. The UA College of Agriculture is making excellent progress on four potential new crops: buffalo gourd, jojoba, guayule and gopher plant. With just a foot or two of irrigation, each of these plants yields a product useful as either food or an industrial raw material.

Buffalo Gourd

This wild perennial gourd, native to the arid regions of western North America, may be the key to additional food and feed crops adapted to low-water-use agriculture. Buffalo gourd (pictured on page 22) probably grew in our western deserts long before the advent of man. It has been associated with American Indians for at least 9,000 years. They have used it for food, washing and medicine.

The buffalo gourd plant spreads efficiently even without seed. It sends out long vines along the ground. When the vines contact moist soil or sand, principally during summer rains, they sprout roots. This way, one plant may grow into a large, uniform colony.

Though rooting from runners is its primary method of spreading, buffalo gourd is also a great producer of fruit and seed. A single plant may have several hundred fruit, each about the size of a baseball and containing about 300 seeds with a total seed weight of two-fifths ounce. The dried seeds contain about 40 percent vegetable oil and about 35 percent protein. The oil is about 65 percent linoleic acid, a polyunsaturated fatty acid that is essential in the diets of humans and animals.

In addition to the oil and protein of the seed, the vine may be used as fodder for animals after frost kills it. The perennial root develops into a large, fleshy storage root containing about 18 percent starch, wet weight. A single root several seasons old may weigh 45 to 65 pounds.

The UA buffalo gourd domestication project began in 1976. The research group now includes a breeder-geneticist, a biochemist, a nutritionist, an agronomist, and their assistants and students. During the first three years, seeds were collected from 145 wild plants in an area from Nebraska to Mexico and California to Missouri. Plants from these seeds were evaluated in germplasm nurseries at the UA Agricultural Experiment Station in Tucson. Researchers made selections and crosses to quickly develop a relatively uniform seed source to use in test plots under various cropping conditions. Since buffalo gourd is a perennial, field plot research requires several growing seasons. This phase of research is not yet complete enough to permit a prediction of buffalo gourd's rate of success as a crop.

This plant grows in the wild with 10 to 12 inches of rain. Field plantings in Tucson have flourished with 10 to 16 inches of irrigation. It has the potential for economic yields of vegetable oil, protein and starch. Processing techniques for these products are simple, and virtually identical to those used for similar products from established crops. Buffalo gourd starch has been studied as an ingredient for puddings, and as an additive in plastics to make them biodegradable. Its small granular structure makes it a unique starch. The high-protein meal left after oil is extracted from the seeds can be used as animal feed or refined into high-protein flour for baked goods.

Whether this plant will achieve economic importance is still unknown. Research on it at the College of Agriculture has been supported by the Arizona Agricultural Experiment Station and the National Science Foundation.

Jojoba

Jojoba is an evergreen desert shrub native to Arizona, California, Sonora and Baja California. It produces large seeds that contain 40 to 60 percent liquid wax. Jojoba is the only plant known to produce this wax, which has a very different chemical structure than oils from convential oilseed crops. The wax has many potential uses, though its cost now limits its actual uses. Wax from wild plants is already being used in cosmetics, as a lubricant additive and for candle wax. If cultivation of jojoba can reduce the price of the wax, many additional uses may become practical.

Research on jojoba first concentrated on collection of plants from throughout its natural range. These collections are now under testing for yield and other features. Learning how to propagate the plant vegetatively (without seed) has required much work, but this process is now well developed. Now, superior shrubs can be multiplied quickly for uniform field plantings. Plantings have been established successfully using seedling transplants, rooted-cutting transplants and direct seeding. With each method, time of year and irrigation at planting are critical.

Attempts to cultivate jojoba during the past few years have yielded much new knowledge, but many questions remain. Planting trials throughout southern Arizona quickly demonstrated that jojoba is much more cold-sensitive than previously thought. Young plants and flower buds on older ones often die when temperatures reach the low 20s (F). Older plants can survive temperatures in the 12 to 15 degree range, but their flower buds and many of their branches are killed at such temperatures. Plants appear to differ considerably in their tolerance to low temperatures, so it is possible that cold-tolerant varieties can be developed. Using today's planting stocks, though, successful growing of jojoba is unlikely where winter temperatures fall below 25 degrees F.

Preliminary studies suggest that jojoba requires only one or two feet of irrigation annually, and much less fertilizer than conventional crops.

Weed control tops the list of remaining problems with jojoba as a crop. Jojoba grows very slowly its first two years, so it can be overgrown by weeds quickly. Hand weeding is too expensive. Better methods are needed.

Wild jojoba plants are now hand-harvested. For jojoba wax to drop in price enough to compete for larger markets, mechanical harvesting methods will be necessary. As yet, an acceptable mechanical harvester has not been developed.

Also needed is tested planting stock with known high-yielding ability and with a shape adaptable to mechanical harvesting. Currently, seed collected from the wild is being used for planting stock. Plants produced from such seed vary considerably in yield and other traits.

A large number of other questions also remain: What diseases and insects will be problems? What plant population is best? What is the best ratio of male to female plants (both are needed for seed formation)? When is the best time of year to plant? What do nutrient deficiency symptoms look like? How and when should plants be pruned? When should plants be irrigated?

By current estimates, 10,000 to 15,000 acres of jojoba have been planted in the United States, several thousand in Mexico and smaller amounts in several other countries. It is impossible to predict what the acreage will be a year from now. The prospects for jojoba becoming a major crop depend upon the resolution of the technical problems described above, upon the generation of a reliable supply of wax, and upon evidence of its utility in additional markets on an economic basis.

Research on jojoba in the College of Agriculture has been supported by the Arizona Agricultural Experiment Station, the National Science Foundation, the Four Corners Regional Commission and commercial firms.

Guayule

Guayule produces natural rubber. It is a perennial shrub of the Chihuahuan Desert of north-central Mexico and southwestern Texas. The plant is bushy with dense branches, a thick cluster of silvery leaves, and an extensive root system with a thick crown. At maturity the plants stand 25 to 40 inches tall.

Rubber for guayule is chemically identical to Hevea (rubber tree) rubber, which is in all our tires and many other rubber products.

Natural rubber makes up one-third of all the rubber used in the United States. It cannot be replaced by synthetic rubber because the elasticity, resilience, tackiness and low heat-buildup of natural rubber is essential in tires. The United States now imports nearly one billion dollars worth of Hevea rubber annually. Guayule grown on two million acres in the southwestern states could easily supply these needs.

Unlike jojoba, buffalo gourd and gopher plant, guayule has a history of cultivation. It was first grown under domestication in 1912 to 1916 in southern California. In the 1920s and '30s, a small but viable guayule industry existed, with about 12,000 acres in California and Arizona. During World War II, when Hevea rubber was unavailable from the Far East, the U.S. government created the Emergency Rubber Project, which absorbed the small guayule industry into a massive commercialization and research effort. The work in variety development and rubber processing continued until 1959. No further work was done until the University of Arizona began a guayule program in 1976. Fortunately, the best varieties developed in the 1950s were still available. Also, new varieties were collected in Texas and Mexico.

The UA guayule program now includes breeding and variety testing, agronomic research, and studies of rubber production in relation to water use.

Whether a guayule industry becomes commercially feasible depends on the development of production and extraction technologies, on rubber supplies and demands, and particularly on production economics. UA agricultural researchers are cooperating very closely with rubber-company researchers. This insures an orderly development that will give guayule its greatest chance for success.

The full development of the guayule industry will take about 10 to 15 years. The plants are harvested at about four to five years of age. To establish a minimum of 5,000 to 10,000 acres and build a pilot processing plant will take about five to seven years. If the whole industry appears feasible, another five to seven years will be needed to develop 50,000 to 100,000 acres and an economic-size processing plant.

The economics of guayule in Arizona will depend on water availability, value of land, and the economics of the individual farms. Based on preliminary data, guayule requires about 28 inches of water (including effective rainfall) the first year and about 18 to 20 inches annually in following years.

Guayule research at the College of Agriculture has been supported by the Arizona Agricultural Experiment Station, the National Science Foundation, the Four Corners Regional Commission and USDA competitive grants.

Gopher Plant

Euphorbia lathyris is an herb in the poinsettia family that usually grows to a height of 20 to 80 inches. Its common name, "gopher plant," comes from its alleged gopher-repellant quality. In fact, in northern California, gopher plant has been interplanted with various fruit and nut crops to protect them from gophers. Its future value, though, may be as a living oil well.

Gopher plant is primarily a weed of the temperate zones and is not native to the arid Southwest. UA researchers are trying to adapt it to Arizona as a petroleum fuel crop. As a producer of a crude, oil-like extract, gopher plant has tremendous potential for future use in the petroleum industry.

The search for superior plant types has identified lines that produce relatively high percentages of crude oil. In addition, gopher plant oil has been shown to be of greater economic value than conventional crude oil.

Agronomically, researchers began with little information about the cultivation of gopher plant, since its eradication from fields has been common practice for many years. Two years of study have indicated that a September or October planting can produce at least three tons of gopher plant per acre with a total of two acre feet of water. That makes four barrels of crude oil per acre using wild, unimproved seed and without optimizing water, fertilizer and pest control. Selection and genetic improvement of the wild seed, and improvements in field practices, should make it possible to significantly increase these yields to an economic level.

The major problem with gopher plant now is its susceptibility to fungal disease organisms. Various techniques are being tried to protect the plant from these diseases. The best method yet identified in Arizona is to avoid infection by winter cropping.

Given the infancy of gopher plant research, predicting the future of this crop in Arizona is difficult. However, with the increasing costs of producing fuel oil from reserve supplies, the need for a renewable fuel source may bolster the demand for production of gopher plant in the foreseeable future.

UA research on gopher plant has been supported by the Diamond Shamrock Corporation, the Arizona Agricultural Experiment Station and funds from the UA Vice President for Research.

Other Options

The progress made to date on these potential crops offers encouragement that one or more, or even all of them, may find a place in the future of Arizona agriculture. Also, these studies indicate that we are on the right track, and that a closer look should be taken at other low-water-use plants to find additional crop candidates worthy of attention. While the four species currently under investigation are meritorious in themselves, there is adequate reason to pursue the idea of new arid-lands crops more vigorously.

Possible benefits of the UA work extend beyond Arizona. Many areas of the world with climates like ours also need such new plants as crops. Arizona's worldwide leadership in this field includes graduate student training and interactive research to encourage such work in other countries. This, in turn, benefits Arizona since breakthroughs elsewhere could be applicable here. International attention to plant domestication projects will also increase the availability of useful candidate plants and seed collections.