Germplasm sources of almond

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The almond is a uniquely California crop and 99 percent of U.S. product occurs here. Germplasm materials in California originated as chance seedlings from seeds and plants imported from the Mediterranean region between 1850 and 1900. The basic cultivars Nonpareil, Texas Prolific (now known as Mission), Ne Plus Ultra, Peerless, Drake, and I.X.L. originated with this material.

An extensive study of local and imported cultivars in the early 1920s by the U.S. Department of Agriculture was the forerunner of a joint breeding program with the University of California. Local and (a few) imported cultivars plus their offspring in breeding programs have provided the nucleus of the germplasm collection at the University of California at Davis supplemented recently by species and species hybrids.

None of the 45 new cultivars introduced to the industry since the mid 1930s has secured a permanent place in the industry. Consequently, there is a continuing need for superior cultivars with good economic potential. Emphasis is now on evaluation of previously developed cultivars and elucidation of specific breeding problems that have resulted in limited progress in earlier improvement programs. The germplasm collection provides the raw materials for these studies and is a potential source for material for further improvement programs.

Significant genetic characteristics

Time of bloom and time of harvest are the two main variables in cultivar selection. Time of bloom of different cultivars ranges from late January to nearly mid-March. Differences depend on chilling requirement to overcome rest periods (November-December) and heat requirement for flower development (January-February). Later bloom is desirable to escape frost, but differences in blossom frost resistance independent of time of bloom have been found among commercial cultivars and within certain species and species hybrids.

Pollination characteristics are critical because two or more cultivars must be cross-pollinated by bees. Self-incompatibility results from specific genes in the pollen. Some incompatible groups have been identified in the germplasm collection by both orchard and pollen-tube studies. Incompatibility factors provide valuable genetic markers to show genetic relationship and to trace origins of different species or varieties. Studies are being made of pollination efficiency of bees, of nectar production, and of pollen tubes. Speed of pollen tube growth is affected by genetic differences and by temperature. In some genotypes, faster growth occurs at lower temperatures; in others the reverse is true.

Self-fertile individuals have been identified by pollen-tube studies and orchard tests in interspecific hybrid populations. However, differences in speed of pollen tube growth when selfed as compared to out-pollination (crossed with other pollen) show variation in the level or degree of self-compatibility. Self-fertility genes may be more frequent in almond than thought, and procedures to screen large numbers of plants for self-fertility need to be improved.

Genetic materials are being evaluated for relative susceptibility to "almond leaf scorch" (ALS) a potentially serious infectious disease caused by bacteria, and to *Phytophthora* spp. Genotypes showing relative resistance to crown gall and bacterial canker have been identified. Resistance to the serious pest, navel orangeworm, which attacks the nut as the fruit ripens and splits open is currently emphasized. Susceptibility in commercial cultivars has been associated with the genetically distinct soft type of shells, thick fleshy hulls, slow uneven ripening, and fruit that is difficult to remove. The germplasm contains much genetic variability in nut and harvesting characters.

Another of our objectives is to refine methods to identify potentiality for non-infectious bud failure (BF), one of the "genetic disorders" characteristic of certain almond cultivars and breeding lines, and to screen germplasm materials for its absence. The characteristic defective shoot buds (which fail to grow) develop in particular vegetatively propagated lines (clones), especially when they are grown for long periods at high summer temperatures. The predisposing factor occurs in Nonpareil and has been genetically transmitted to offspring cultivars.

Maintenance of genetic materials free of systemic virus and other pathogens is an important part of a germplasm collection. Selections of Nonpareil and other commercial cultivars free of known viruses are maintained in the Foundation Seed and Plant Materials Orchard at Davis. Although primarily used for their commercial potential, they are also useful as germplasm materials.

Categories of germplasm

Approximately 500 separate items are growing in the UCD collection in addition to some seedling populations. In addition, several private breeders have established their own breeding lines.

Germplasm materials at UCD fall into the following categories:

■ Old or minor cultivars and unnamed chance seedlings collected from commercial orchards in California. New commercial cultivars have recently been placed in regional test orchards.

These and other genotypes in the collection provide a cross-section of economically significant traits such as tree character, time of bloom, and nut and kernel characters. Older materials represent selections from a relatively wide range of genotypes originally introduced into California. More recent selections are second generation offspring of commercial cultivars—Nonpareil, Mission, and others—and probably represent a significant narrowing of the genetic base. In this group, selection has been based on production and outstanding orchard performance, with somewhat less regard for the market quality of the product. This material has some susceptibility to noninfectious bud failure.

■ Selections of known pedigree and originating from controlled breeding programs of the University of California and the U.S. Department of Agriculture. Emphasis on high nut and kernel quality for specific industrial uses and on relatively high shelling percentages has tended to concentrate germplasm into specific breeding lines, some of which have been abandoned because of susceptibility to bud failure. Others have been characterized by such undesirable characters as difficulty to remove at harvesting. These materials could be bred to combine good features of various lines. The most important need is to screen the material for susceptibility to genetic disorders.

■ Foreign cultivars and selections.

The cultivated almond originated in central and southwest Asia, and spread into the Mediterranean countries and North Africa, and eventually to California, Australia, and South Africa. Each country and production area has evolved unique and characteristic germplasm materials representing separate evolutionary lines including both seedlings and local cultivars.

Endemic materials are being surveyed and evaluated in France, Spain, Italy, Greece, Bulgaria, Russia, Tunisia, Turkey, Iran, and Israel. Selections have been made for hardy types that produce well under adverse growing conditions: late blooming types have been developed in Russia and Bulgaria; self-fertile cultivars have been discovered in Spain and Italy.

The foreign collection at UCD is incomplete, but source material may be available by exchange with various Mediterranean countries.

■ Species and species hybrids. The cultivated almond is believed to have originated from three wild species—*Prunus bucharica, P. fenzliana,* and *P. ulmifolia.* Other species or subspecies growing from Yugoslavia and across southern Russia to Afghanistan and Iran, and extending into Israel, contain a range of tree and fruit characteristics. These species usually cross readily with almond.

P. webbi, P. argentea, P. bucharica, P. mira, P. fenzliana, P. scoparia, as well as some unidentified species, are currently growing in the UCD collection. Hybrids have been produced between some of these species and almond.

The peach crosses readily with almond and has provided a genetic source of self-fertility which has been incorporated into almond through backcrossing. The peach-almond hybrid produces a potentially promising rootstock for almond, peach, and plum. Immunity to nematodes can also be transferred from peach to this hybrid. Easy-to-root hybrid clones have been selected and are being tested for possible commercial use.

The collection also contains some species of the almond-like American *Prunus* from the deserts in the southwestern United States.

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Large size gerbera developed through germplasm selection.

Greenhouse gerberas

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Cut flowers are a sizeable commodity in California. Last year, according to the U.S. Department of Agriculture Crop Reporting Board, the three major greenhouse species alone—carnations, chrysanthemums, and roses—were valued in excess of $83 million at the nursery. In addition, about 50 other species, including field-grown, accounted for perhaps another $50 million. It appears that most of these flowers were initially selected for commercial culture for reasons other than flower productivity.

Color, "showiness," ease of culture, stem length, ability to survive the rigors of marketing—these are the kinds of things breeders have been looking for. And, although there have been some yield improvements, it is likely that most of these have been fortuitous. Now, however, growers are taking a closer look at flower productivity as fuel, shipping, and labor costs escalate. They are also looking for less labor-intensive crops. *Gerbera jamesonii* hybrida (Transvaal daisy) shows promise of filling the bill on both accounts.

Many crops have been selected for yield to the extent that their genetic variance for this character has been greatly diminished. Further selection for productivity, therefore, might not be expected to be readily effective. But this may not be the case for flower crops that have been selected primarily for their decorative value.

Gerberas were selected for night openness and other desirable commercial cut-flower traits at the University of California at Los Angeles beginning in 1960. Commercial producers, however, have made no serious attempts as yet to develop marketable clones. A major obstacle may be the low productivity of certain selections that have shown promise in other respects. Assuming that low productivity *is* an underlying reason for propagator and grower resistance, and assuming further that gerberas have not had a long history of selection for this character, it follows that mass selection might be an approach to overcoming the problem.

A study was begun, therefore, to determine how genetic resources could be readily assessed and whether flower yields can be increased appreciably through selection without an accompanying genetic deterioration in flower or stem acceptability and vase life. We also wanted to develop production data for selected genetic types grown under quasi commercial conditions in California.

Our genetic "pool" originated