several years ago from seeds obtained from commercial sources in the Netherlands, Germany, and the U.S., and from the Hebrew University in Israel. Plantings typically were being grown from seed and reportedly exhibited a high degree of variability. Average flower production was low and losses from diseases often high. However, seedlings from this "pool" appeared to exhibit all of the characters deemed necessary for a California-grown crop. One, later designated G-1, produced large numbers of long-stemmed yellow flowers that stayed open at night and kept well in the vase, and whose semi-quilled petals were resistant to bruising, tangling, and shattering during post-harvest handling operations. Other desirable seedlings were subsequently selected and crossed to this plant. More recently, 21 highly diverse progeny were selected to serve as parents of our experimental population.

Crosses were made at Davis each spring, and flower production recorded for six months of the ensuing fall, winter, and spring. The most productive plants were further selected first for flower and stem acceptability and then for vase life. The survivors became the next generation's parents. Some of the more desirable ones were also cloned and grown alongside the next generation of seedlings. This procedure allowed later yield comparisons between different generations and between selected clones from different generations without the confounding effects of different years. Parents were also self-fertilized to determine the feasibility of developing inbred lines. In addition, a number of selected parents were evaluated for a year at the San Jose Field Station—a facility located in a flower-producing area.

Annual flower yields were relatively high for the selected parents grown at San Jose. The highest producer was the third generation plant P-813 which yielded 84 flowers per square foot in the 12 months beginning June 10. The lowest producer was P-265, a second generation selection, which averaged 39 blooms. For comparison, G-1 produced 27 flowers, a figure which agrees with those obtained for this clone in earlier tests at San Jose.

Secondary selection to avoid genetic deterioration of flower quality was apparently successful, based on subjective ratings and color frequency. Percent doubles and semi-doubles decreased from 38 to 21 in three generations but stem length remained satisfactory. Secondary selection to avoid genetic deterioration of vase life was also apparently successful. Mean vase life was 14 days for generation three at Davis and 11.8 days for all selections at San Jose. A single generation of self fertilization, on the other hand, resulted in a mean inbreeding depression of 40 percent. Many selfs died although one did yield more flowers than one of the original parents.

This study shows that gerberas can be selected for much higher yields without appreciable losses in flower acceptability, stem length, or vase life. More intense selection for flower form could undoubtedly increase the percentage of doubles in the population if this were considered by growers to be important. Genetic variance for yield was not diminished after three generations, and it now appears that 125 to 150 blooms per square foot per year may not be an unreasonable goal for breeders to pursue.

The genetic resources necessary for yield (or other) improvement ought not to be difficult to reproduce from commonly available seed sources. Gerberas are grown extensively from seed for use as landscape plants, and a great deal of genetic variation is maintained simply because many of the characters judged to be deleterious in cut-flower clones are either not thought of as detrimental in the landscape or are considered too unimportant to cause them to be eliminated. In fact, diversity of characters within a seedling population often appears to be advantageous.

This may not be the case in other flower crops where specific forms are popular and "off-types" are considered unaesthetic. And if certain characters that are not now considered important or in vogue suddenly become necessary for the commercial continuance of the crop, a gene "pool" to provide the necessary source of genetic variation for further selection may be hard to come by. It does not seem to be realistic to expect that such a pool is, or will be, maintained by commercial breeders. They operate within economic parameters that would appear to limit their ability to act as "banks" for the maintenance of unused genetic materials. Most likely, the university would be an appropriate repository for the conservation of ornamental plant germplasm that might otherwise be lost or, at best, difficult to recover.

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Cultivated alfalfa and its closely related wild relatives are probably native to the Middle East, particularly what is now Iran. It is said to be the only forage crop cultivated before recorded history.

From its original home in Iran, alfalfa spread westward to Greece, Italy, and North Africa, and then to Spain, probably carried by conquering armies as feed for their horses. The Spaniards brought it with them in their conquests in the New World, where it became an established crop in Chile and Peru.

Except for the humid tropics, alfalfa is now distributed world-wide, indicating considerable variability in its germplasm. This variation can be attributed to the fact that it is cross-pollinated and is a tetraploid plant; that is, it has four sets of chromosomes rather than the usual two.

Alfalfa may have been used at some of the southern missions in California; it was established in northern California during the Gold Rush days. There is a record of a planting made at Benicia in 1851. Alfalfa is now grown in nearly every county in California, and ranks high in both acreage occupied and cash value. It is particularly important to the poultry and dairy industries, and as a soil improving crop.

Although the alfalfa introduced into California was well adapted to this climate due to its Mediterranean origins, by the 1920s growers began to notice that the life of their alfalfa stands was becoming shorter. Efforts to control bacterial wilt disease, identified as a major cause of stand decline, were responsible for the initiation of several alfalfa breeding programs, in California as well as other states. Alfalfa introduced from Turkistan in 1898 and from Ladak province in India in 1900 contained plants with a high level of resistance to the disease. This resistance was transferred to the California-adapted variety California Common by a backcross program. The new variety, named Caliverde, was the

Genetic resources in alfalfa and their preservation

Ernest H. Stanford

first non-dormant and wilt-resistant variety.

Breeding for resistance

In the 1930s the stem nematode, *Ditylenchus dipsaci*, was causing heavy losses in alfalfa stands, particularly in the Antelope Valley area of Los Angeles County. Again, material from Turkistan was found to have some plants which were resistant, and a new variety named Lahontan was developed and released. Subsequently it was found that an introduction from Iran with less winter dormancy had plants with a high level of stem nematode resistance, and this variety is being used in breeding work at Davis.

The fungal disease Phytophthora root rot was causing severe loss of stands, particularly on poorly drained soils, soils with a compacted layer, and in over-irrigated spots. A survey of available material revealed that the variety Lahontan had a good level of resistance, and plants in a 1902 introduction from Arabia had an even higher level of resistance. Lahontan is used today on soils with poor water penetration; the Arabian material is being used to develop more resistant varieties of the non-hardy type for warmer areas.

In the 1950s, root knot nematode was causing considerable alfalfa damage on some soils in the Central Valley—most commonly the light, sandy soils—by restricting root development. Studies at Davis found that three different nematode species of the Meloidogyne group were most commonly the cause, and that a single plant selected from the variety Vernal was resistant to all three species. This material has been made available for breeding programs.

The whole California alfalfa industry was threatened when the spotted alfalfa aphid appeared in 1954. The variety Lahontan again proved to be a source of resistance, as were some plants in the variety Africa. Resistant selections from the variety Africa were used to produce the variety Moapa, which was much better adapted to the San Joaquin and Imperial valleys than was Lahontan.

New races (biotypes) of plant diseases and of insects may attack plant varieties that were resistant to the old biotypes, and the problem of breeding for resistance is a continuing one. A classical example is that of rust resistance in wheat. A number of resistant varieties, developed over a period of years, lost their resistance as a consequence of the development of a new race of the pathogen by mutation or genetic recombination.

An example involving insects is that of the spotted alfalfa aphid, which has developed at least four new biotypes since its introduction into California, each able to attack a different set of alfalfa varieties. Fortunately Caliverde 65, derived from a Lahontan clone, has maintained its resistance to all known biotypes of the spotted alfalfa aphid.

Similarly, we have found at least four biotypes of the pathogen causing "Stemphyllium" leafspot in alfalfa. In 1974 we found a single plant in a closely related species, *Medicago hemicycla*, which was resistant to all known biotypes of the organism. The genes for resistance are being transferred to the cultivated type of alfalfa to be available for breeding programs.

Maintaining or increasing the high level of alfalfa productivity, and modifying alfalfa to meet the requirements for new uses in poultry ration or as a leaf protein source for humans, will demand that alfalfa breeders find new sources of needed genetic characters. As newly developed varieties displace old varieties, the genetic base may be narrowed. As new areas come under cultivation in Iran and adjacent areas, wild relatives which may be able to contribute genes for needed characters may become extinct, victims of the plow. The series of examples involving breeding for insect and disease resistance discussed above makes clear how imperative it is that these germplasm resources be preserved.

Maintenance of collections

The U.S.D.A. Plant Introduction Service has been largely responsible for the collection and preservation of alfalfa varieties and related species. Present collections have come through collecting expeditions and exchange with foreign workers. Most collecting has been done in terms of broad geographical coverage in a given region or country where a number of species could be collected. There is need for more intensive collecting now in Iran, and the Crimean-Caucasian area where related species may be found.

A system should be set up to evaluate collections for specific characters. Since alfalfa is a cross-pollinated crop, gene or genes for a desired character may occur at a very low frequency. The rare individual plants having the desired character need to be preserved by clonal propagation, or by self-pollinated seed, and stocks of the valuable characters must be maintained for future use.

To maintain species identity, plant stocks should be increased in isolation, which demands an unreasonable amount of space. Fortunately, alfalfa seed can be processed and stored so that it maintains a reasonable viability for 30 or more years.

At Davis we have been largely dependent on the U.S.D.A. collections for source materials, with occasional material from other stations. A concerted effort to collect, preserve, and evaluate germplasm resources is imperative. As we identify new characters of importance or potential importance, these materials are preserved and made available to breeders everywhere.

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