Germplasm resources of oilseed crops—sunflower, soybeans, and flax

Benjamin H. Beard

Sunflowers (*Helianthus annuus* L.) are presently grown on a limited acreage in California, but because of their potential we maintain two germplasm collections: (1) domestic types, of both oilseed and confectionary varieties, and (2) wild species, including *H. annuus* and 25 other species.

Collection

The domestic types have been donated by plant breeders and others in the United States and Canada. Many of these varieties and lines were originally received from foreign countries, especially Russia and Romania. The more interesting wild-species collection of about 450 entries has been gathered from various sources. In addition to collections from California, Idaho, Nevada, and northern Mexico, contributions have been received from around the United States.

Seventy of the entries collected by the author on a trip from Davis to Miami Beach, Florida in 1972 are in the present collection, and other entries have been collected during hunting, fishing, and vacation trips.

Use

The domesticated sunflower germplasm has been used to develop material better adapted to California environments, for use in our inbred line development program. Two germplasm pools have been established, each grown in isolation, with bees mixing the different lines through cross-pollination. In one germplasm pool we are selecting for earliness, high oil content, and high yield per head. The other germplasm pool is maintained without any man-imposed selection.

The wild *Helianthus* collection is probably the best source of insect resistance and unusual combinations of fatty acids. Many tests have been conducted here and elsewhere to determine environmental effects on the genetic expression of factors controlling the fatty acid composition of the oil. No significant differences have been found in any domestic sunflower. We have, however, found large fatty acid differences in some wild species entries and three entries have seed oil extremely high in oleic acid.

In California, the sunflower moth (*Homoeosoma electellum* Hulst.), causes substantial yield losses in sunflower fields—estimates vary from 6 to 50 percent. The wild *Helianthus* collection appears to offer the best source of additional resistance to this insect. In cooperation with colleagues from the U.S.D.A. Western Regional Research Center at Albany, California, we found some wild x domestic crosses that appear to have higher levels of some diterpenoid acids (substances appearing to restrict sunflower moth larval growth). This may

Fatty Acids and Iodine Value of the Seed Oil of 34 Wild *Linum* Species and 266 Introductions and Varieties of Domestic Flax

Species	Fatty Acids					Iodine value
	Palmitic	Stearic	Oleic	Linoleic	Linolenic	
			percent			
Wild species	3 to 11	1 to 8	8 to 33	11 to 69	3 to 63	140 to 218
Flax	4 to 7	2 to 4	14 to 38	7 to 18	35 to 66	162 to 196

Source: Yermanos, D.M., B.H. Beard, K.S. Gill, and M.P. Anderson. 1966. Fatty acid composition of seed oil of wild species of *Linum*. Agron. J. 58:30-32.

lead to better resistance than has been known.

Maintenance

Maintenance of the domestic sunflower germplasm collection is more complicated than for some other crops because of high self-incompatability and because *Helianthus* is mainly a cross-pollinated species. The simplest way to maintain an entry with most of its characteristics is to grow it in isolation. When a collection is of useful size this becomes impossible, so isolation is sought by covering the heads with paper bags to exclude foreign pollen carried from head to head mainly by bees and other insects.

To overcome the problem of self-incompatability, we bag at least six heads from different plants. When these are at the proper stage, we mix the pollen from all bagged heads and use this bulked pollen to pollinate each head. Thus sunflower germplasm entries are maintained by sib pollinations. This procedure helps to maintain heterogeneity in the population and most of the time avoids any chance selfing. Selfing, if allowed to occur, would soon lead to a very significantly altered plant because of inbreeding depression and loss of heterozygosity and heterogeneity.

Maintenance of the wild *Helianthus* species is even more complex than for the domestic collection. We have a greater problem with self-incompatability because it is usually more complete in the wild species. There is need to sib-pollinate but, in addition, the seeds are usually difficult or next to impossible to germinate without special treatments to break dormancy.

Cyclic freeze-thaw treatments that seem to break sunflower seed dormancy in nature have been used in greenhouse pot cultures but this has not proved practical at Davis. Instead, the dry seeds are soaked in a 10 percent aqueous solution of ethylene at 50°C for 1 hour, then blotted dry and stored at 5°C for 10 days before planting. With most species the germination increase is sufficient to maintain entries. A few entries of other closely related genera *(Phoebanthus, Tithonia,* and *Viguiera)* are also maintained along with the wild *Helianthus* collection.

Soybeans

Soybean (*Glycine max* [L.] Merr.), grown on a few farms in California, has never occupied a large acreage here. The available varieties were developed for other areas and are not particularly adapted to our environment. Thus, the large soybean germplasm resources collected and maintained by the U.S. Department of Agriculture, Agricultural Research Service, may be extremely valuable for our use. Large segments of this collection have been test grown in California in the last 20 years.

The first planting, in 1957 at the Imperial Valley Conservation Research Station, Brawley, was used to study soybean tolerance to salts in the soil or irrigation water. No entry of maturity groups V, VI, VII, and VIII of the world collection was better than the variety Lee, which had been grown in the Imperial Valley on soils with less than 5 to 7 millimhos electrical conductivity per centimeter of saturation paste extract.

All entries in maturity groups II and III were grown at the West Side Field Station, Five Points in 1967, in search of spider-mite resistance and boron tolerance. This work, and later, more precise greenhouse tests showed P.I. 70212, P.I.88492, P.I. 157409 and 'Guelph' arrested mite reproduction. These and a few others from the world collection are presently used as parents in varietal pest resistance development programs in California, Hawaii, and Kentucky.

Fourteen of the collection entries showed slightly more tolerance to excess boron than the common varieties. We are using P.I. 85437 and P.I. 90579 as parents to increase boron tolerance.

All of the entries in early maturity groups OO, O, I, II, III, and IV were grown at Davis in 1976. Many selections for adaptability will be tested further. Germplasm pools will be established and grown at locations throughout California to allow natural selection to develop adapted types.

The early-maturity collection of groups OO through IV is maintained at Urbana, Illinois; the later maturing groups V through X at Stoneville, Mississippi. Both total about 8,000 entries and small seed lots are available to qualified plant breeders on request.

Flax

Flax *(Linum usitatissimum* L.*)* has almost disappeared as a crop in California, but in the late 1940s it was grown on 500,000 acres annually. The varieties grown in the San Joaquin Valley usually came from the northern production area (Minnesota and North Dakota) but varieties suited to the Imperial Valley had to be developed through introduction of germplasm with better adaptation to the farming practices and environmental conditions there.

In 1927, work was started with only a spoonful of seed from a variety obtained from the Punjab of India. Through selection and increase at the Imperial Valley Field Station, El Centro, 2 acres of seed were sown in 1931, and in 1933 the first commercial crop of 11,000 acres was grown in California. The development of this variety, Punjab, started the California flax industry. Later, disease outbreaks were countered with resistance introduced from varieties developed in Minnesota and North Dakota. The varieties Imperial (developed by the University of California), and New River and Dunes (developed by U.S.D.A.) were better than variety Punjab because of added resistance to Fusarium wilt.

The U.S. Department of Agriculture and the University of California, Davis had a cooperative flax research program at the Imperial Valley Conservation Research Center from 1951 to 1971. During the program's last 10 years germplasm development was a major objective. Another important aspect was helping to maintain the U.S.D.A. flax collection. While kept at St. Paul, Minnesota many of its entries cannot reproduce in that environment, and were grown in California for seed increase.

The wild *Linum* species collection, started in 1961, now contains 108 entries with viable seed. Although analysis of the seed oil of many entries has shown extreme variation in the fatty acid components (see table) which would be useful if they could be incorporated into domestic flax, and although rust resistance has been found, the California wild *Linum* collection will not be maintained.

Germplasm collections should be maintained and expanded. Even though the wild species of many crops look like collections of weeds, they are the probable sources of useful characteristics to fit our changing needs. With our constantly increasing need for food production and expansion of crops into new environments, we will continue to require additional characteristics, some not presently considered important. By maintaining this broad base of germplasm, including wild species for each crop, we will be better prepared for situations that arise in the future.

Benjamin H. Beard is Research Geneticist, U.S. Department of Agriculture, Agricultural Research Service, Agronomy and Range Science, University of California, Davis.