Problems and Rewards in Improving Seeds

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THE NUMBER of acres that are planted to a variety of a crop may depend on the availability and cost of its seed.

The point is important and as simple as 1–2–3: Some farmers buy low-priced seed although they know it is inferior. The cheap seed often makes a poor crop. Seed can be produced at lowest cost when a heavy-yielding variety is planted.

Here are some examples:

Soybeans largely replaced cowpeas for hay and green manure purposes because soybeans give higher yields and the seed costs less.

Denton sorgho is an excellent sweet variety, but it was never popular because the heads bear few seeds. Scarborough No. 7 broomcorn produces excellent hurl fiber, but the heads have short seed branches. Yield of seed therefore is low, and the cost of its seed is high. Other strains of Scarborough that have poorer hurl fibers but are better seed producers are preferred by most growers of broomcorn seed.

Tift sudangrass and Narragansett alfalfa did not attain the popularity they deserved because the seed yields were lower than those of other varieties. Seedgrowers are reluctant to produce such varieties because the slightly higher price received is insufficient to offset the loss from lower yields of seed.

Birdsfoot trefoil is sown on a smaller acreage than it would be if its harvested seed yields were larger. Yields of seed of birdsfoot trefoil, lupines, reed canarygrass, and some other crops are low mainly because the seeds shatter as they ripen, although other seeds on the plants are not yet mature.

Good quality of seed therefore is important in maintaining the popularity of a crop variety.

Club kafir was a productive grain sorghum in Kansas when the field stands were adequate, but its soft seed, which favored seed rots, often produced thin stands and replanting often was necessary. Club kafir therefore was never popular with farmers.

Other crop varieties suffer from seed rots or seedling blights, which interfere with stand establishment.

Hybrid sorghum, which has largely replaced open-pollinated varieties in the United States, often produces better stands than the open-pollinated varieties, chiefly because of greater seedling vigor. This is important when seedbed conditions are unfavorable because of cold soil or the formation of a crust.

Yogo winter wheat is popular in Montana and Wyoming because it was bred particularly for resistance to extreme cold. It also has the capacity to germinate in a drier soil than do other varieties, a characteristic that was recognized after Yogo was widely grown on farms in the drier parts of the West.

Soft, starchy seeds of corn and sorghum are more subject to mechanical injury and to consequent rotting when planted in cool soil than are harder seeds, but they are less likely to require grinding before they are fed to livestock.

Inbred line WF 9 is used in producing a large proportion of the hybrid seed corn planted in the Corn Belt. It is a particularly popular seed parent because it produces a large percentage of medium-flat seed. Seed of this size and shape brings the highest price for planting.

The size and vigor of a seedling are associated closely with size of seed. In fact, a direct logarithmic relation often exists between weight of seed and the dry weight of the seedling.

Large seeds also permit a seedling to
emerge from deeper sowing. Larger seeds thus are particularly important in small-seeded species of forage legumes and grasses. Such seeds must be sown shallow so the seedlings can come up, but then the upper layers of soil may dry out before the seedling is established and the stand may be lost. Large seeds can be sown deep enough to permit the seedling roots to reach moist soil before the upper soil layer is dry.

Because large seeds in tomatoes, cucumbers, okra, eggplant, and watermelon are objectionable to consumers, little attempt may be made to breed varieties with larger seeds to enhance their value for planting.

Seed improvement of crops such as beans, peas, and sweet corn, whose seeds are eaten by people, must give full consideration to food quality as well as suitability for planting.

Temporary dormancy is a desirable characteristic in oats, sorghum, sweet corn, and other crops that are subject to field sprouting in the shock or on the standing stalk before the ripe seed is threshed.

Temporary dormancy is particularly helpful for natural reseeding of crimson clover and other winter annual legumes that mature and drop their seed in early summer. The seedlings that emerge in midsummer quickly perish from the heat, but the ones that come up in the fall usually survive.

On the other hand, dormancy is a handicap in northern winter wheat regions where the crop is sown soon after harvest.

Durum wheat intended for spring sowing often shows a poor germination in laboratory tests for several months after harvest. This dormancy makes it difficult to determine seed quality until shortly before the season for sowing.

Some seeds of certain strains of Hubbard Market and Grand Rapids lettuce remain dormant so long that they do not germinate until several months after harvest.

The presence of many hard seeds that do not germinate promptly in forage legumes such as alfalfa, sweetclover, and true clovers has imposed difficulties in establishing stands. Hard seeds sometimes are desirable, however, because they retain their viability and may germinate later to reestablish a stand.

Hard, or corneous, seeds of cotton, corn, and sorghum are more resistant to seed rots than are the softer seeded varieties of those crops.

Seed of many grasses, particularly native species, bear awns, hairs or long chaff, which prevent the seeds from passing through the seeding equipment readily.

Home gardeners often have poor stands of lettuce because most of the seed was covered with soil after planting. Certain varieties of lettuce require light for germination, and the buried seeds remain dormant. This light requirement could be eliminated by breeding.

Certain biennial crops, such as sugar beets and garden beets, and vegetable crops, such as cabbage, celery, lettuce, onion, and spinach, may tend to bolt and produce seed during the crop season. Such plants use food and energy to produce a seedstalk so that the root or top is not worth harvesting. It is essential to breed slow-bolting varieties of these crops, but the plants must be able to bolt during the seed-producing season.

The tendency to bolt under a given environment is controlled by hereditary factors, and the desired bolting characteristics are thus subject to improvement by breeding and selection.

Length of day or temperature or both determine the time at which a plant will bolt and flower. The hereditary makeup of the plant determines its response to light and temperature, but treatment with a chemical like gibberellic acid also may induce the plant to bolt.

The foregoing indicates some of the problems of producing seed, and some
of the many accomplishments in improving seed.

One of the achievements is the breeding of the monogerm sugar beet seed, which eliminates the need to thin the beets by hand. It came about 60 years after its need was recognized. Several varieties and hybrids of monogerm sugar beets are now in production.

They are descendants of one weak plant that had a single seed in each seedball. It was found in western Oregon in 1948. Plant breeders transferred this monogerm character to productive sugar beets by crossing, selection, and backcrossing.

Five varieties of crimson clover—Dixie, Autauga, Auburn, Chief, and Talledega—were selected for hard, dormant seed characteristics that permit the natural establishment of stands in the fall from seed that was dropped in early summer.

**Improvement** in seeds of forage and turf grasses by State and Federal breeders has resulted in varieties with better quality of seed or higher yields of seed.

The improved varieties produce as much forage or more than the unimproved ones. Nordan crested wheatgrass, released in 1953, produces more seed, and the seeds have fewer awns than the unselected type. Its larger seed provides greater seedling vigor. Two other strains of crested wheatgrass with large, awnless seeds were developed also at Mandan, N. Dak., but had not been released in 1961.

Two strains of intermediate wheatgrass, selected in Idaho, appear to have high yields of seed and are nearly free from awns and pubescence. Another selection made in South Dakota offers some improvement in yield of seed.

The Vinall variety of Russian wild rye yields more seed than the unselected type. The use of Russian wild rye has been restricted by its low yield and high price of seed.

The Penncross variety of creeping bent grass, released in Pennsylvania in 1954, produces vigorous plants for putting greens from direct seeding. Tualatin tall oat grass, released in Oregon in 1940, produces high yields of seed because of its resistance to shattering and to smut.

Butte, Trailway, and Coronado side oats grama have good yields of large seed, from which grow vigorous seedlings. Butte and Trailway were released in Nebraska in 1958. Coronado was released in Oklahoma in 1955.

The Georgia Selection and Lamont rescue grasses are good seed producers because they are resistant to smut. Lamont was released in Mississippi in 1957. Lancaster and Lyon smooth brome grass, which were released in Nebraska in 1950, give high yields of both seed and forage. Lyon also has improved seed quality and strong seedlings. Caddo switch grass, released in Oklahoma in 1955, gives heavy seed yields if conditions are favorable. Tifhi bahiagrass, released in Georgia in 1957, shatters less than other strains of bahiagrass; more seed thus can be harvested.

Selection for low seed dormancy in green needle grass has been effective.

Some difficulties have been encountered in efforts to improve the seeds of forage legumes.

Selection for increased percentage of hard seed in a variety of Persian clover has been partly successful. Selection for increased percentage of hard seed of legumes in Canada sometimes has reduced plant vigor.

Attempts to cross introduced large-seeded annual species of sweet clover with domestic species have not yet succeeded. A large-seeded sweet clover has been introduced from Turkey, however.

The vigor of birdsfoot trefoil seedlings has been increased by selection. Because they, like the unimproved type, are susceptible to root rots, however, it has been difficult to establish good stands in warm climates. Selection for reduced shattering and for a prostrate plant type has been partly successful.
A yellow lupine with nonshattering pods has been found, but this character is still lacking in commercial lupines for forage. Some lupine selections made in Georgia bear certain genetic markers that would permit the identification of a variety and a determination of its purity in the field. Such markers are greatly needed in many forage crops in order that the purity of improved strains can be maintained.

Improved vegetable seeds include Ferry's Round Dutch cabbage and Great Lakes lettuce. They are outstanding products of selection for resistance to bolting. Ferry's Round Dutch was selected to permit heading and eliminate bolting after periods of cold weather. Great Lakes was selected to permit heading during periods of warm weather, when most varieties of head lettuce bolt.

Genetic safeguards against loss from premature bolting are essential. It is possible to breed strains that will bolt and flower only under unusual conditions. Often, therefore, they produce no seed. An individual cabbage plant selection may or may not flower after the usual cold treatment of 2 months at 37° F.

The yield of commercial seed of Great Lakes and other slow-bolting varieties of lettuce was low until better seed-producing selections were developed.

Certain characters, such as nonshattering of seed, appear to have been developed during domestication because the wild forms of many crops drop their seeds as soon as they are ripe. Nonshattering of garden lettuce is of utmost importance in the commercial production of seed. The wild \textit{Lactuca serriola}, which depends for its existence on shattering of the seed, differs in this respect from garden lettuce by only a single dominant gene.

Most breeding of vegetables is concerned with the yield and the eating, preserving, and shipping qualities of the part of the plant that is consumed. Seed fields may contain individuals having such characters as heavy growth, numerous flowers, or large fruits, which favor high yields of seed. Selection for high yield of seed must avoid any concurrent selection of undesirable market types. The two breeding objectives must therefore be coordinated.

The areas producing vegetables for market and for seed often are widely separated, with different growing conditions, a fact that tends to complicate the breeding and maintenance of seed stock.

In melons, squash, and pumpkin, in which the fruit is eaten but the seeds discarded, the consumer may wrongly think that large seed is an indication of coarse texture of the flesh. Large seeds may also detract from the appearance of cut watermelon fruit. In general, seeds of medium size are preferred. Many think that a black seed gives a pleasing contrast to the red flesh of the watermelon, although a dark-brown seed also is considered acceptable. A dark seed may also be used as an indication of a desirable stage of maturity.

Seeds of tomatoes, cucumbers, eggplants, and peppers are eaten incidentally. They must be unobtrusive. A tough seedcoat may be objectionable in the slicing cucumber and in "seedless" watermelons. In the latter, the seeds abort because the plants are sterile triploids, the result of crossing normal diploid watermelons with special tetraploid strains that have the double number of chromosomes. The best seedless varieties produced thus far have been developed by doubling the chromosome complement of small-seeded, small-fruited varieties. The undeveloped coats of the aborted seeds are inconspicuous and are eaten with the melon flesh. Work on large-fruited varieties is in progress.

In crops grown for their seed, the size and shape of the seed must conform to accepted standards. The seed
varieties of lima bean may differ in size and shape, such as the large, thick seeds (potato type) and medium to small thin seeds (sievas). The latter is simple dominant to the former type. Differences in seed size among the thin sieva limas may result from complementary action of nonallelic genes.

Shape of seed is important in sweet corn. A relatively narrow, deep kernel is preferred for both fresh consumption and canning. Sweetness and tenderness are even more important.

Color of seed is important. Most commercial requirements are met by using only few of the rich assortment of colors and patterns that are available among the breeding stocks in the world.

In beans, the colors are in the seed-coat. Colored seed generally has given better germination and vigor than white seed, which canners prefer. Small amounts of color develop in the seed of colored sorts at a very early stage. Some of the color is released during processing, and the liquid gets a murky appearance. Because a clear liquid is preferred, much work has gone into the breeding of white-seeded varieties that germinate as well as those with colored seed.

Most sweet corn is yellow or white. The yellow color results from xanthophyll, cryptoxanthin, and carotene in the endosperm. The carotene gives added nutritive value compared with white corn. The yellow color varies, depending on the genes present, from pale yellow to deep orange. The color usually deepens for each gradation as the kernels mature. Most sweet corn hybrids are a light yellow, which avoids the appearance of overmaturity, although the deeper yellows supply larger amounts of carotene. Another vitamin, niacin, ranges from 18 to 62 micrograms per gram of air-dry kernel. Selection for higher niacin content should prove effective.

Green cotyledon is preferred to yellow cotyledon in garden peas and in lima beans, especially the smaller sievas. The desire to avoid the appearance of overmaturity is also a factor favoring the selection of green cotyledon. The degree of maturity of green seeds is difficult to detect by visual inspection, and such lima beans sometimes are overripe when harvested.

The inheritance of seed color and pattern often is rather complicated. The anthocyanin colors depend for their expression on a few “basic” genes, which can be suppressed by a dominant inhibitor. The depth and shade of color result from a number of independent genes that complement each other. On this complex are superimposed the genes for pattern, whose effect often is affected by the point of seed attachment. Color and pattern are useful in the identification of seed as to variety.

Tenderness of the seedcoat is important for any crop whose seeds are consumed. Tenderness often is associated with thin seedcoats, and thickness increases with maturity. Comparisons should be made at equivalent stages of maturity, as determined by content of dry matter. The puncture test is not so accurate as weight determination. In sweet corn, the tenderness of the pericarp is inherited on a multiple-factor basis.

Tests for sweetness, consistency, and flavor also are essential in selecting sweet corn for improved quality. Success in selection for high germination and vitality of white-seeded beans suggests that the color genes are not primarily involved but are linked on the same chromosome with other genes that affect viability of the seed. Once the linkage is broken, the white-seeded beans germinate and grow as well as the colored.

Some lines of sweet corn produce a good stand early in the season while growing conditions are still unfavorable. This means that such lines germinate and grow well at relatively low temperatures and resist the attack of soil organisms that cause decay. Tests
that try to reflect such conditions are the basis for selection.

Seed dormancy is valuable in moderation, but it may be disastrous in either extreme.

Total lack of dormancy means premature germination before the seed matures properly. Many genetic factors can be responsible for premature germination in sweet corn. Sometimes the supplemental effects of two or three recessive factors are required. Some of these genes affect the plant adversely.

Dormancy results from a physiological influence of some part of the seed on the embryo or some condition within the embryo itself. In cabbage, this influence is concentrated in the seedcoat. Individual seeds vary as to the degree or length of dormancy under conditions that are favorable for germination.

Dormancy that is unduly extended interferes with normal crop procedures. Some lettuce may even remain dormant until vitality is lost.

Longevity of seed is an important consideration in the selection of desirable lines. Certain homozygous recessive characters reduce the vitality of corn seed after a relatively short time.

Seeds of cool-weather crops that are planted in late summer must be able to germinate at high temperatures. Four varieties of head lettuce—Imperial 456, Imperial 17, Imperial 101, and Great Lakes—germinate better at 79° than do Imperial 44 and Imperial D. All germinate better at this temperature than does Imperial 615.

Seed defects of snap beans have been greatly reduced in recent years through breeding. So-called hard seeds, while normal in appearance, are undesirable because they lack ability to absorb moisture readily when planted. This delays germination to the detriment of production. Hard seeds also require more cooking. Differences among individuals and breeding lines in this respect permit its elimination through selection.

Split seedcoat occurs in lima beans, snap beans, and soybeans. Soybeans also have a netted cracking of the seedcoat. All such defects result from the presence of recessive genes. Cracking of the seedcoat after wrinkling occurs in the concentrated Fordhook variety of lima bean. Fordhook 242 is little affected.

Deformity of the cotyledons in snap beans can be minimized by selection. This and other defects contribute to difference between varieties with respect to the amount of thresher injury, which has been greatest in the newer high-quality varieties, such as Topcrop and Wade. White-seeded varieties usually appear to be more susceptible to thresher injury than those with colored seed, but the exceptions hold promise for the development of improved new white-seeded varieties. Differences in the amount of thresher injury have also been found among varieties of lima beans.

Yield of seed among the seed-consumed crops has received much attention. In sweet corn, it is related to number of rows and number of kernels per row, but from a practical standpoint the desirable ear size is largely determined by fresh market requirements. An ear just above medium size is preferred to one that is either larger or smaller.

A high yield of seeds is important in such crops as peas, black-eyed peas, field beans, and lima beans. The most effective method of increasing their potential yields has been to breed varieties that are resistant to diseases.

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