Men who grow vegetable seeds for sale engage in a specialized and highly competitive farming operation. They compete to maintain superior strains of most standard varieties and to develop new varieties. Most of the large vegetable seed companies have well-qualified staffs to develop and maintain stock seed, from which is produced seed for the market, mostly by farmers who have contracts with the companies.

The producers of vegetable seeds must know the cultural requirements of the vegetables they are growing throughout the life of the plants, not just until they have reached an edible stage. As a food crop, a biennial such as carrot or onion, for example, requires but one year of growth, but as a seed crop it requires two. On the choice between leaving a biennial in the ground over winter or storing it in a cellar may depend the yield and quality of the seeds harvested the following year.

The growers must know whether their crops are self- or cross-pollinated and, if the latter, whether insects or wind carry the pollen. On such facts depend the necessary isolation distances between fields.

Harvesting seeds differs with different vegetables, both in the method of cutting or the picking of the crop, as well as in the operating speed of the threshing machine. Seeds of fleshy-fruited vegetables like tomatoes are extracted—often with variations of food-processing equipment—rather than threshed, as dry seeds are.

This explains in part why the saving of home garden seed is normally not so simple or satisfactory as it might seem. Experienced seedsmen can grow seeds of good type and true to name for less cost than the home producer, who has a small planting and faces hazards of cross-pollination from nearby plantings of which he may be unaware.

Vegetable seeds are grown in many States, but most seed acreage is in the West, mainly because of the climate. Dry air and lack of rain during summer and fall, when many seed crops mature, facilitate the harvesting and threshing. In some western irrigated areas, absence of rain throughout most of the growing season favors the production of disease-free seeds—a tremendous advantage, particularly with beans and the cabbage family.

The largest variety of vegetable seeds is produced in California, where a wide range of climatic conditions within a relatively short distance enables seedsmen to supervise diverse crops from a central place.

Cabbage and closely related crops and garden beets and spinach thrive best in a cool, marine-type climate, and seed production is concentrated in the Pacific Northwest, particularly around Puget Sound.

Beans, peas, sweet corn, melons, squash, carrots, onions, lettuce, turnips, radish, and other dry-seeded crops are grown in various interior places in the Western States.

Seed acreages of tomatoes and sweet corn are common in the North Central and Eastern States.

Pimiento pepper, eggplant, watermelons, okra, and edible cowpeas are grown for seed in the Southeast and South.

Fewer than 200 thousand acres a year are planted for vegetable seeds in the United States. About 85 percent of this acreage is required for three large-seeded crops—garden peas, garden beans (including limas), and sweet corn. Thirty-five small-seeded vege-
tables take the rest—fewer than 30 thousand acres in some years.

About 200 million pounds of vegetable seed may be grown some years, and about 1.4 million pounds are imported. Most of this seed is used in the commercial production of vegetables valued at around $1,111 million dollars.

Peas and green beans are grown for seed almost entirely in the West in localities where the atmosphere is dry. Soil moisture, with one notable exception, is mostly supplied by irrigation.

The exception is in the Palouse areas of northern Idaho and eastern Washington, where most of the seed of smooth-seeded garden peas is grown. Since the irrigated sections of southern Idaho have large acreages of beans and peas, Idaho accounts for the greatest production. Plantings are also common in eastern Washington and in California.

Peas and beans, which are self-pollinated legumes, are grown for seed in much the same way.

Peas are hurt by severe frost, but they should be planted as soon as that danger is past, for they produce higher yields of seed in cool weather.

Beans are sown after all danger of frost is over.

Both crops require at least moderate fertility, but in general they are not fertilized when they are grown for seed. Both require a fair amount of irrigation, but peas usually respond more favorably to additional water.

All but the dwarf varieties of peas usually are sown with a grain drill at rates of 200 to 250 pounds to the acre.

Dwarf peas and all varieties of beans are planted in rows 20 to 30 inches apart, depending on the variety and the equipment that has to be used for other crops in the rotation.

Peas are commonly harvested for seed in midsummer. Beans are harvested in late summer and early fall.

Unlike many cross-pollinated plants, plantings of peas and beans need little isolation. Accidental crossing can take place, however. In the production of stock seed, varieties planted side by side commonly are separated by one or two rows of corn or sunflower. Such barriers help to prevent chance crossings and mixtures at harvesttime.

Roguing—the removal of offtype plants—is done in fields of stock seed. That and a program of rigid control of the quality of stock seed largely eliminate the need to rogue the market-seed crops of peas and beans.

Because both crops are naturally self-pollinated, pure lines can be built up from single plants of the right type. It is essential in such a program that true-to-type plants be selected to protect a variety from gradual change.

Peas and beans are harvested when pods are nearly dry. Pea vines in the Palouse are allowed to dry completely. Then they are combined directly on the stump. A harvesting machine cuts the dry plants close to the ground and elevates them immediately to the threshing cylinders. The seeds are collected in suitable containers—usually large boxes, each of which holds 3 thousand pounds of seeds. All that is done in one operation.

Peas and beans in irrigated areas are commonly cut and wind rowed and then allowed to cure until they are dry enough to thresh. The seeds are less likely to be injured if they still have a moisture content of 12 to 15 percent.

Threshing machines especially developed for peas and beans have two or more spike-tooth cylinders or rub bars and a pair of rubber rollers. To avoid serious injury, especially to beans, cylinder speeds should not normally exceed 350 revolutions per minute.

Lima beans are handled much like green beans but require a longer growing season. The climate should be warm, but excessively high temperatures or extremely dry air are undesirable, because they may cause excessive blossom drop and therefore low yields.

Large-seeded lima bean seed consequently is grown usually in southern California, where length of season and temperature are favorable and the air usually is somewhat more humid than it is farther inland. Some of the small-
seeded lima beans are grown in Idaho. Cowpeas, or southern peas, have climatic and cultural requirements like those of lima beans. Seed is grown in the Southern States and California. The "black-eyed pea" of commerce is a variety of cowpea.

Sweet corn, another large-seeded vegetable, is grown in much the same way as field corn. Corn does best on productive soils with abundant moisture and when the average monthly temperature is about 70° F. A season of at least 120 days is required for seed production. Dry weather during harvest is desirable.

About 80 percent of all sweet corn produced in 1960 was F₁ hybrid. About 80 percent of all hybrid seed is grown in southwestern Idaho. Some, notably open-pollinated varieties, are grown in the Corn Belt, Connecticut, New York, and California.

The wide use of hybrid varieties has revolutionized the growing of sweet corn for seed during the past several decades. The F₁ hybrid is a cross between two inbred lines. A hybrid must be superior to open-pollinated varieties in one or more characteristics, such as yield, uniformity, and quality, to warrant release as a variety.

The seed breeder today has to know how to develop inbreds and to test their combining ability with perhaps hundreds of others. He also must know how to maintain the satisfactory inbreds over the years and how to produce profitably the market seeds from them.

When a gardener uses seed of hybrid sweet corn, he has to buy new hybrid seed each year if he expects to maintain the yield and quality of the ears he is accustomed to producing. As seed saved from a hybrid crop does not reproduce another crop of the same high yield and quality as the seed from which it was grown, a grower can hardly afford to use such seed. The seed trade therefore requires a large amount of hybrid seed each year. That demand has led to the highly specialized business of growing such seed.

Methods and times of planting, cultivation, and weed control with sweet corn are practically identical with those used in the production of seed of field corn, whether open pollinated or hybrid. Similar distances of isolation need to be observed. Methods of harvesting and curing sweet corn seed and the use of special drying plants also resemble the practices followed in producing field corn seed.

Seed of popcorn is produced in much the same way as that of sweet corn.

Fleshy-fruited vegetables present a special problem because at harvest the seed is wet, rather than dry. These vegetables include several related crops—tomatoes, peppers, and eggplants, and some unrelated vine crops—cucumbers, melons, squashes, and pumpkins. Seed of tomato, pepper, and eggplant is produced in a number of States, but mostly in areas in which they are grown also for processing.

Considerable tomato seed is produced in connection with the processing of tomatoes in some eastern and north-central localities, but many planters prefer to obtain seed that is produced apart from any food-processing operation.

A moderate soil fertility, a uniform supply of soil moisture, mean summer temperatures of 70° to 75°, and a long frost-free season of 4 to 6 months favor high yields of fruit and seed. A grower obtains an average of 6 to 15 pounds of tomato seed from each ton of fruit.

As tomatoes are primarily self-fertilized, the isolation of seed fields presents no difficulty. Because bumble bees sometimes visit tomato flowers and may cause some crossing, a distance of at least 50 feet is desirable between varieties. Greater distances should certainly be planned where stock seed is produced.

Only plantings of stock seed of tomatoes normally are rogued. Offtype plants should be removed before they flower to prevent any chance of cross-
pollination. If too many of the fruits on a plant fail to meet established requirements, the entire plant should be removed.

A grower harvests tomato fruits for seed much as he would harvest fruit for market or processing, except that it does not matter if the fruit is overripe, cracked, or injured.

When extraction of seed is the main concern, the fruit is dumped directly in the field into a mobile seed extractor, which cuts the fruit and separates most of the seed and juice from the mass of pulp and skin.

The seed which is surrounded by a mucilaginous sheath is separated from both the sheath and the juice by an acid treatment, or fermentation, in which the pulp and juice ferment for about 2 days in large vats, preferably at temperatures around 75° to 80°. A lower temperature takes more time. Stirring hastens the disintegration of the tissues surrounding the seed, which settles to the bottom. The pulp and other material float to the top, where they can be removed.

In the acid method, about 2 gallons of hydrochloric acid are added to each ton of juice and pulp. The seed separates from the pulp in 15 to 30 minutes. Little equipment is needed, but a disadvantage is that the bacterium that causes canker disease is not killed, as it is by the fermentation process. The seed therefore has to be treated with 0.8-percent acetic acid if there is danger of bacterial canker.

Regardless of the method of extraction, the tomato seed must be washed thoroughly in shaker washers or in a sluiceway before it can be dried. Sun drying in screen-bottom trays is common in the West. Drying in heated, moving air is commoner in the East. Further processing is sometimes necessary to break up clumps of seeds and remove light seeds.

The production of seeds of pepper and eggplant resembles that for tomato. Both crops need greater isolation than tomatoes, as they are often cross-pollinated by honey bees and other insects. Between two varieties of the same type, one-fourth mile is enough, but the distance between the sweet and pungent types of pepper should be much greater.

The culture of the vine crops (cucumbers, cantaloupes, watermelons, squashes, pumpkins) for seed parallels the culture required for market production. Seed acreages are scattered through many States.

Cucumbers and squashes, because of their cooler climatic requirements, are planted generally in Michigan and Oregon and other Northern States.

Seed acreages of watermelons exist all the way from Kansas and Texas to Florida. California and Colorado produce seeds of all the vine crops.

The vine crops require fertile soils with a good organic content and a good moisture supply, but moisture should not be excessive. Fields in the West usually are irrigated.

Honey bees are essential for pollination and high yields in vine crops.

Cucumbers, cantaloupes, and watermelons belong to different botanical species and hence do not cross with each other.

Varieties of squashes and pumpkins belong to four botanical species of the genus Cucurbita. Crosses may occur among some of them. The need for isolation therefore depends on the species to which a variety belongs—not on whether it is a "squash" or a "pumpkin."

This diagram indicates the crosses that can or cannot occur:

- **C. pepo** \rightarrow \text{C. maxima}
- **C. moschata** \rightarrow **C. mixta**

Species joined by a solid line do not cross, but crossing may occur between species connected by a broken line.

Although nearly all the winter squashes are in \text{C. maxima}, summer squashes and pumpkins are found in **C. pepo**, **C. moschata**, and **C. mixta**.
The producer therefore has to know the species to which his varieties belong to determine proper isolation distances. If a cross may occur easily, the crops should be at least one-fourth mile apart. A much greater distance is desirable if stock seed is being grown.

$F_1$ hybrid seed of cucumber and squash now is produced commercially. The male parent is planted in a row after every third to fifth row of the female parent, from which the seed is harvested. Every morning workers carefully remove all the male flowers from the seed plants. As in the production of hybrid seed of sweet corn, the seedsman has to develop and find satisfactory inbreds—populations that have been self-fertilized for several or even many generations—and test their ability to combine with other inbreds.

Growers should rogue all vine crops fairly early and at least twice. If all plants that are obviously off type can be removed before they flower, considerable contamination (through pollination) of seeds on other plants is prevented. The removal later of all plants with any off type young fruits reduces greatly undesirable cross-pollination between late opening flowers.

At harvest, the vines of cucumbers and squashes often are dead and actually may have been frosted before the fruit is gathered. Cucumbers, muskmelons, and watermelons are juicy enough to be handled by equipment and methods like those used for tomatoes. Fermentation is commonly used for the final separation.

With winter squash—mostly *Cucurbita maxima*, but some *C. moschata*—which has a hard rind, the fruits often are split open, and the seed is scooped out. Fermentation of squash seeds should be avoided, as the process may discolor and injure the seed. Pulp and seed are gradually separated by lightly rolling, raking, and similar action.

All vine seed has to be washed thoroughly (as suggested for tomatoes), but often vine seed needs also some screening and fanning to eliminate dry parts of pulp and seeds of subnormal size. Methods of drying vine seeds are similar to those for tomatoes.

**Seeds of Lettuce**, endive, salsify (vegetable oyster), chicory, dandelion, and globe artichoke are produced almost entirely in the Western States, particularly in California and Idaho.

Areas with rain-free harvest seasons are preferred, for rain may cause shattering and delay normal maturity.

Lettuce may be planted early in the spring or in the fall and winter if the climate is suitable. Fall planting and overwintering are feasible in some northern areas, especially if a snow cover lasts all the winter. Such a method is not practiced generally by commercial seedgrowers, even though it enables one to harvest seed from late varieties as early as July or August.

Lettuce is sown on raised beds in rows 20 to 22 inches apart or in single rows 22 to 30 inches apart. Plants are thinned to stand 8 to 12 inches apart. Growers rogue lettuce before or during the market stage of development.

Extreme isolation is unnecessary because lettuce is mostly self-fertilized. A distance of 25 feet between plantings of market seed may be satisfactory, but a distance of several hundred feet is preferable between fields of stock seed. Because wild lettuce (*Lactuca serriola*) crosses readily with cultivated lettuce, all wild lettuce should be removed in and near seed fields.

One difficult task in growing seed of the crisp-headed varieties is to remove or open up the head, so that the seedstalk can develop normally. Some growers cut them open with knives.

Another way is to hit the head downwards with the palm of the hand and then lift it off; the central core with its growing point is left intact.

Timing is important with any of these methods. Deheading should be done just as the heads reach full size and before the core within has begun to elongate.

Lettuce seed is harvested in several ways. One is to shake the seed into containers from plants. Standing plants
sometimes are threshed with a combine. The first method, repeated at weekly intervals, gives maximum yields, but is feasible only when labor is cheap. Combining saves labor but saves less seed and makes necessary the immediate drying of the threshed material to avoid discoloration of seed and reduction in germination.

Intermediate methods of harvesting involve cutting the plants by hand or with machines and windrowing them to cure before threshing.

Spinach is an annual of the same botanical family as the garden beet, which is a biennial.

Planted early in the spring, spinach produces seed the same year, but as it is winter hardy, it is also sown in the fall in some localities; then the seed is harvested the following year.

Spinach is unique among vegetables because it has four types of plants: Extreme males; vegetative males; monoecious plants (those which have both male and female flowers); and female plants.

Extreme male plants are small. They bolt early. They are undesirable therefore in a market or home-garden crop. Because these characteristics can be transmitted to seed-bearing plants when crosses occur, growers try to rogue out all extreme male plants.

Monoecious plants are the most common type. For production of F1 hybrid seed, lines are desired that consist of pure male and pure female plants. The males are rogue d out of the female parent line as they become recognizable.

Spinach flowers are borne in clusters in the leaf axils. They are small and lack petals and so are rather inconspicuous. Male flowers produce pollen which flies into the air like dust, when the flowers open and the plant is jarred. A completely female plant produces no pollen.

The pollen of spinach is small and may be carried far by wind. Varieties should be isolated by 1 mile at least, especially in the direction of the prevailing wind. Advantage should be taken of any natural barriers, such as stands of tall trees.

The seedstalks are cut when the late-maturing ones begin to turn yellow. The entire crop dries in windrows. Then it is threshed with a pickup combine.

Spinach is one crop with which fairly high cylinder speeds may be used in threshing.

The common type of radish, sprouting broccoli, mustard, and Chinese cabbage are annuals in the large cabbage family. Each differs from the others as a vegetable, but methods of producing their seeds are much alike.

The acreage devoted to the production of radish seed often exceeds that of any other member of the cabbage family, including cabbage itself.

All are sown early in the spring in northern sections. They can be planted in the fall in southern areas, as for lettuce. Isolation to prevent cross-pollination by pollen-carrying bees between varieties of any one kind should be about one-fourth mile for market, and 1 mile between stock seed plantings. All should be rogued in their vegetative state. For the production of stock seed of radish, the roots are usually dug, rogued for type, and replanted.

The crops are cut and windrowed when a noticeable proportion of the pods have turned yellow. When dry, they can be threshed with a pickup combine. Threshing radish often is facilitated by having a pair of rubber rollers in the machine to help crush the pods, because radish pods do not split lengthwise as do those of the other cabbage members.

Seed production of the biennial vegetables is more complicated because they have to be carried over into the second year.

The cabbage family includes the largest collection of biennial vegetables. Many of them, including both leaf and root vegetables, can be grown for seed either by seed-to-seed (that is, overwintering the plants in the field),
or by storing the crop under cover during winter. Market seed is generally produced by the first method, and stock seed by the latter.

The cabbage family is pollinated by insects. Satisfactory isolation between the different members and between varieties is one of the most difficult and complicated in the seed industry. That is because cabbage, cauliflower, collard, kale, kohlrabi, brussels sprouts, and the annual sprouting broccoli all belong to the same botanical species, Brassica oleracea.

Furthermore, cabbage alone falls into distinct varietal groupings based on head shape, season, and foliage color. Cross-pollination between any of these varietal types or any of the other vegetables within the botanical species inevitably gives rise to noticeable off-type plants. To avoid such crossing, seedsmen try to maintain for market seed production minimum isolation distances, which range from one-eighth mile to 1 mile depending on the kinds of vegetables involved. For plantings of stock seed, a distance of several miles is preferable.

When seed is to be grown from cabbage that is to be stored over winter, the crop is grown the first year much as it would be for market, except that the time of planting must be adjusted so that the head matures just ahead of winter.

The crop is rogued as the individual plants are lifted from the ground. The outer leaves are removed from the head. Plants that meet varietal requirements are placed in storage in a single layer on shallow shelves to reduce losses from decay. Storage temperature should be just above 32°. Relative humidity should be high to prevent dehydration of the cabbage. The crop is replanted in the spring.

In seed-to-seed production, seedbeds of the late varieties are planted first, beginning about May 15, and the early varieties last, about July 15. Plants are transplanted in August to the seed fields in which they overwinter. Highly selected stock seed is essential, as the plants never produce fully mature heads and no opportunity comes to rogue the crop critically. The plants also need some protection from freezing and thawing, even in the Puget Sound area. After roguing is completed, therefore, soil is thrown against the plants so that only the upper part is visible. The partly buried plants can withstand temperatures of 5° to 10°.

Seedstalks develop during the second year if interrelated factors (low temperature, chiefly) have been satisfactory. A cross-cut—two cuts at right angles to each other—may have to be made in heads of cabbage overwintered in storage to allow the head to burst and the seedstalk to develop.

When a good proportion of the pods of all these cabbage-type crops have turned yellow, the seedstalks are cut individually and piled in windrows, where they may cure one to several weeks before threshing. When dry, the crop threshes easily, and cylinder speeds should not be higher than is necessary. As the seeds of all the crops in the cabbage family are similar, seedsmen take care to avoid mechanical mixtures.

Of the cabbage-type crops, cauliflower has the most exacting climatic requirements. These include uniformly cool and relatively humid atmospheric conditions, without danger of sub-freezing temperatures.

Among the other biennial crops are a number of fairly important vegetables. They are not related botanically, but they are root or bulb crops and are grown for seed by similar cultural methods. They are carrots, onions, garden beets, turnips, and many related crops of less importance.

Seed of all of them is produced either by root (or bulb)-to-seed or seed-to-seed methods.

In the former, which is consistently used for production of stock seed, the crops are grown the first year in much the same way that they are grown in a garden or for market. With all except onions, time of planting has to be de-
layed somewhat so that the roots reach marketable size just before winter stock-
age. Medium-sized roots (or stecklings, as they are called) and medium-sized bulbs are preferred to large ones. Storage temperatures should be about 40° for all these crops. Relative humidity should be high, except for onion, for which low humidity is preferable.

When seed is grown by the seed-to-
seed method, planting has to be done so that the crop goes into the dormant winter season when the edible root or bulb is only partly developed. Onions should not have formed bulbs. If the crops are developed too far, they are more subject to decay during the winter; if they are underdeveloped, they are more likely to be killed by freezing and thawing during the fall or spring.

Experiments in Utah have shown that moderate or even infrequent ir-
rigation is associated with high seed yields of carrots, the fibrous roots of which extend down 5 feet or more.

In 1946–1950, carrot stecklings were set out for seed production in experi-
m ents in which three soil moisture con-
ditions (high, medium, and low) and various spacings were studied simul-
taneously. Soil moisture stress was re-
corded periodically by means of gyp-
sum blocks to depths of 5 feet.

The onion, which is shallow rooted, usually responds to fairly frequent irri-
gation with high yields, but even under low soil moisture conditions, a spacing as close as 9 inches between seed-to-
seed rows may triple the yield normally expected when rows are 30 inches or more apart.

Seed yields of onions, turnips, and garden beets often are higher when moderate amounts of nitrogen have been included in the fertilizer.

All these crops, except beets, are pollinated by insects, so that varieties of each vegetable need to be isolated from others at least by one-fourth mile and much farther when the colors of the roots are different—white-rooted and yellow-rooted carrots, for example.

The pollen of garden beets, like that of spinach, is carried so easily by the wind that varieties should be separated about a mile for market seed and twice that or more for stock seed.

As garden beets cross easily with Swiss chard, sugar beets, and stock beets, the distance between them should be at least 2 miles.

Through the development of male-
sterile onions (plants that produce no viable pollen), many hybrid varieties of this vegetable are being grown. Some production procedures are simi-
lar to those followed in growing seed of hybrid sweet corn. Several rows of male-sterile plants, from which the hybrid seed is harvested, are planted for each pollen row. A good supply of honey bees is essential for satisfactory yields. To avoid mechanical mixtures, the seed of the pollen rows should be removed before the hybrid seed on the other rows is harvested.

In all production of onion seed, the seed heads have to be handpicked and cured before threshing. Some growers cure the heads on canvases or in trays exposed to the sun. Others dry the crop indoors in a stream of warm air.

The plants of carrot and beet are pulled and windrowed when a good proportion of the seeds have turned brown. Turnip is pulled when the pods are turning yellow or a few have dried. Curing may require 4 or 5 days or much longer, depending on the weather and the maturity of the crop when it is harvested. A combine with pickup attachment is suitable for all three. In some dry localities, where turnip matures during July, the crop can be combined like grain as it stands in the field without too much loss from shattering.

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