VEGETABLE SEED PRODUCTION

in Oregon

By

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Foreword

The vegetable seed industry is another example of the diversification of Oregon's agriculture. It represents also a remarkable achievement because the industry had its beginning during a period of national need a decade ago.

Supplying a badly needed stock of vegetable seeds when foreign shipments were cut off during World War II, the industry rapidly took root in the fertile lands of the state.

Problems that beset the establishment of the industry and its continuation through the post-war period have been examined carefully by the Oregon State College Agricultural Experiment Station. Started in 1942, the research has made an invaluable contribution to this phase of Oregon farming.

While individual crops and problems have been discussed in earlier information releases, this bulletin records in detail for the first time the complete report of the vegetable seed production research program.

F. E. Price
Dean and Director

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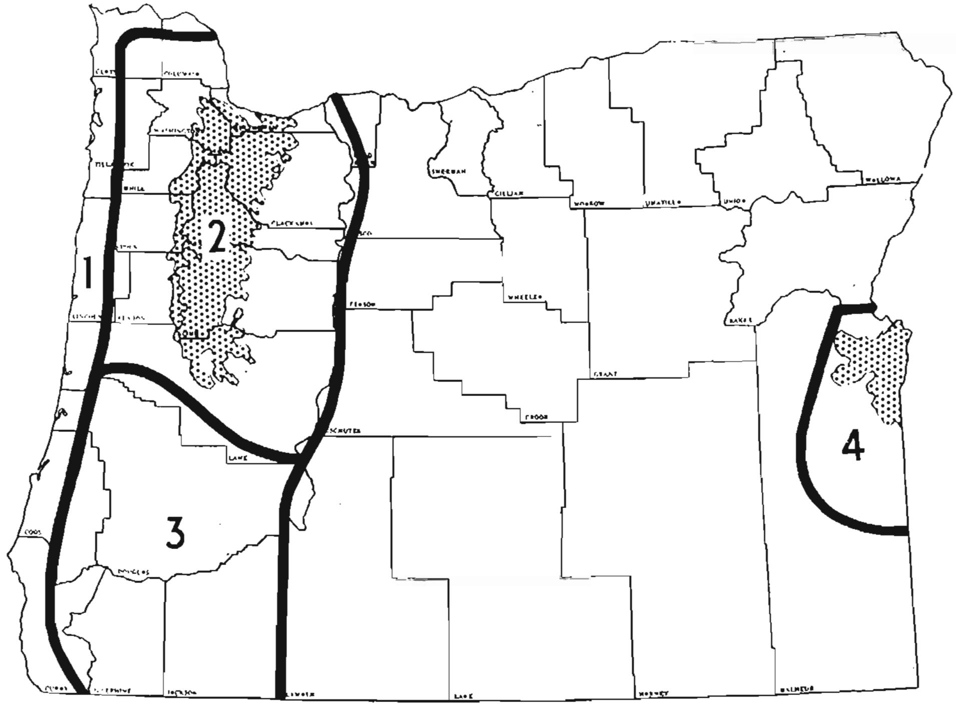
(Shaded portions produce more than 90 per cent of Oregon's nonedible vegetable seeds.)



Vegetable Seed Production
in Oregon

By H. L. Schudel
Farm Crops Department

OREGON, with its diverse soil and climatic conditions, has long been recognized for its production of high quality seed crops, both field and vegetable seeds. It was not until World War II, however, when our nation was faced with the necessity of growing domestic supplies of garden seeds, that Oregon's potentialities for the production of vegetable seeds was recognized. During the peak production year of 1944 nearly 10,000 acres of vegetable seeds were harvested in Oregon, which contributed an estimated $2,000,000 to the agricultural wealth of the state. With the return of imports from foreign countries, the vegetable seed industry has declined markedly. Nevertheless, a small but significant acreage of vegetable seed crops continues to be grown and contributes in a minor way to Oregon's $32,000,000 a year seed industry.

In 1942, in an attempt to meet the many problems which arise with the production of new crops in a new area, the Oregon Agricultural Experiment Station started a research program on the production of many small-seeded vegetables for seed. Research was continued in a minor way for some of the major crops through the crop year 1950. It is the purpose of this bulletin to outline some of the findings of the research program and to point out a few of the principles and details involved in the production of the more important, nonedible vegetable seed crops.

Acknowledgments: Information contained in a bulletin of this kind and scope represents the combined efforts of many individuals.

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Major Production Areas

The Willamette Valley is the principal vegetable seed producing area in Oregon (6).[1] More than twenty different kinds of vegetables have been grown successfully for seed in this area. Here, mild winter temperatures permit field overwintering of many biennial and winter annual crops. Summers are especially favorable for maturing and harvesting seed. Also, many farmers in the area are experienced seed growers and numerous seed companies have the necessary facilities for processing the different kinds of seeds. Some of the more important crops which are grown as biennials or winter annuals are: cabbage, onion, table beet, turnip, rutabaga, parsnip, and spinach. The main spring-sown crops are: mustard, radish, turnip, and in recent years, the vine crops such as cucumber, squash, and pumpkin.

The second area of importance in Oregon is in the irrigated section near the Oregon-Idaho border in Malheur County. Here, the combination of a long growing season, warm temperatures, fertile soils, and an abundance of irrigation water favor the production of a wide variety of crops. The leading seed crops in this area are: bean, onion, carrot, lettuce, and sweet corn. Warm season crops which require a long frost-free period, such as watermelon, can be grown here successfully. This area corresponds very closely to the intensive vegetable seed production area in Canyon County, Idaho. The problems are similar and the results obtained from the intensive vegetable seed experiments at the Parma Experimental Station, Parma, Idaho, are applicable to the irrigated Malheur section.

In Jackson and Josephine counties of southern Oregon, several kinds of vegetable seeds were produced successfully during the war years. The full potentialities of this area for vegetable seed production purposes have not been fully determined, however. This area combines many of the features of the Willamette Valley and of eastern Oregon. Winter temperatures are mild enough to allow the overwintering of most biennial crops such as cabbage, onion, and sugar beet. Growing and harvesting conditions are nearly ideal for many crops. The heavy soils which tend to predominate over much of the area, however, impose certain limitations and restrict most of the acreage to the lighter and better drained soils.

The coastal area of Oregon, although ideal from the standpoint of isolation in the narrow mountain valleys, has not been developed to any extent as a vegetable seed producing area. There are several

[1] The number in parenthesis refers to literature cited, page 79.

reasons for this.. First, and of prime importance, is the seriousness of the weed problem. Grasses particularly are troublesome since they tend to grow under lower temperature conditions than do most of the vegetable seed crops. Second, the scarcity of suitable lands limits production. Many of the soils which characterize the coastal area are extremely acid in reaction and are too heavy and poorly drained for the successful culture of many of the seed crops. Third, the disease problem is more severe in the coastal region because of the more humid conditions prevailing there.

In the central Oregon irrigated sections attempts have been made to grow vegetable seeds with varying degrees of success. Only the quick maturing, spring sown crops such as radish, turnip, and mustard have shown promise to date. Others will undoubtedly be tried in the future and will perhaps offer limited possibilities in the less frosty areas. In the Klamath irrigated region, most vegetable seed crops are limited because of the short growing season and otherwise rigorous climatic conditions. Here, it is thought by commercial seedsmen, such crops as onion, parsnip, radish, turnip, and possibly mustard might offer the best possibilities for success.

Factors to Consider

Before undertaking the production of vegetable seeds, there are certain principles which are more or less fundamental to success and which should be understood by the grower.

Vegetable Seed Production Is a Specialized Business

Vegetable seed production is a specialized industry. In general, the problems presented by the cultivation of vegetable seed crops are more difficult and more numerous than those encountered in the production of many common field seeds. These specialty crops are more subject to disease and insect hazards and other risks than those commonly grown. They require intelligent and diligent care and oftentimes above average skill on the part of the producer. On the whole, more hand labor is required and a greater amount of attention is needed from the time the crop is first planted until it is harvested. Much of the success attained in the production of these intensive crops, therefore, will depend upon the personal qualifications of the grower together with full consideration being given to various production factors.

Table 1. ADAPTATION OF VARIOUS VEGETABLE SEED CROPS ACCORDING TO CROPPING AREAS IN OREGON.*

Cropping area	Crops easily produced for seed				Crops poorly adapted (doubtful for seed production)	
	Most consistent yielders		Least consistent yielders			
	Biennials	Annuals	Biennials	Annuals	Biennials	Annuals
Willamette Valley	Swiss chard Mangel Parsnip Table beet Rutabaga Turnip Onion Kale	Cucumber Squash Pumpkin Spinach Chinese cabbage	Kohlrabi Cauliflower Brussels sprouts Cabbage	Radish Broccoli Mustard Turnip (spring)	Carrot	Lettuce Watermelon Bean Sweet corn
Malheur, Hermiston, and Milton-Freewater irrigated sections	Onion Carrot Rutabaga Turnip	Lettuce Bean Sweet corn Turnip (spring) Mustard Tomato Watermelon		Spinach Cantaloupe Squash Cucumber Watermelon Pumpkin Pea	Cabbage Kale Table beet	
Southern Oregon	Onion Cabbage Rutabaga Parsnip	Chinese cabbage Turnip Mustard Watermelon Cantaloupe Tomato				Carrot Pea Bean
Central Oregon irrigated area including less frosty areas in Klamath Basin	Onion	Turnip (spring) Mustard (spring)		Radish Spinach Pea	Cabbage Kale Table beet	Sweet corn Bean
Coast area	Similar to Willamette Valley except that weeds are more of a problem, suitable lands are scarce, soils are low in available phosphorus, and harvest conditions are poor.					
Columbia Basin	Dry peas are main vegetable seed crop. Other crops cannot usually compete with peas and wheat under dryland farming conditions.					

* This is a tentative classification based on growers' experiences and research findings to date. It may be revised from time to time as more information becomes available.

Choose Profitable Crops Best Adapted to Area

A large number of vegetable seed crops can be grown in Oregon but the same plants are not equally adapted to the climatic and soil conditions of the different sections. The problem of adaptation must be carefully considered and its solution found before it can be determined whether or not such crops can be grown profitably in any region.

In Table 1 various vegetable seed crops have been listed according to their seed production capabilities for the different seed producing regions in Oregon. This information, although incomplete in many respects, represents the observations of Experiment Station and Extension Service personnel together with the experiences of commercial seedsmen who have grown seed in the various production areas. These data, which may be considered a measure of adaptation for the various crops, should be used as a general guide only. Some of the crops which have been listed as being less consistent in seed producing ability might prove to be consistent yielders under certain conditions since so much of the success of vegetable seed production in any area depends upon the individual grower, soil, facilities, etc.

If one assumes, however, that all of the environmental conditions are favorable, it does not necessarily mean that the various vegetable seed crops can be produced at a profit. Such factors as the value of the land, the cost and availability of labor, and the possible returns from the other crops for which the land could be used, must all be considered. Since the relative importance of these factors is not the same in all localities, a crop might prove to be profitable in one location and unprofitable in another. Unqualified statements, therefore, concerning the ease and profitableness of vegetable seed production should not be taken too seriously.

Nearly All Seed Is Contracted

In Oregon, as well as in other vegetable seed producing states, nearly 100 per cent of the crops are grown under contract between farmers and commercial seed firms. Growers who produce vegetable seeds without a contract often find that they have no market for their crop. This is particularly true for certain vegetable seed crops where a relatively small acreage can easily result in overproduction of seed. A contract, or seed growing agreement, as it is sometimes called, is therefore essential since it assures the grower of a market for his seed.

The most common type of contract in Oregon usually provides that the farmer will devote a certain area of suitable land for the production of the seed crop. He agrees to prepare the land properly, plant it with seed suitable to the seedsmen and to cultivate, harvest, care for, and clean the crop in such a way as to secure the largest return of seed fit for commercial use. Most contracts state that the entire resulting crop must be delivered to the contracting seedsman on or before a certain date. The seedsman, in turn, agrees to furnish the "stock seed" and to pay an agreed price for all of the seed in excess of the amount furnished for planting. Provisions are usually made in most agreements for the "roguing out" or the destruction of any plants that seem to be of a different variety or of noticeably inferior quality. This is done either by the farmer or the seedsman, or both. Often times seedsmen employ trained personnel for this type of work.

The Best Soils Are Preferred

To produce consistent and profitable seed yields, good productive soils, reasonably high in organic matter and well supplied with plant nutrients, are required. In western Oregon, river bottom soils are generally preferred to the upland soils since they tend to be somewhat lighter in texture, better drained, and as a rule more productive. Medium textured soils such as sandy loams and loams offer a real advantage for crops like spinach, mustard, and turnip, since they can be cultivated and planted early in the spring.

In the Willamette Valley, the Chehalis and Newberg soils are used extensively. Chehalis is more desirable than the Newberg series because of its higher level of fertility. These are recent alluvial soils adjacent to streams and are generally subject to overflow (Figure 1). For overwintering row crops on this type of land the erosion hazard is great and provisions should be made to hold the valuable top soil in place. The planting of interrow crops such as Abruzzi rye, winter barley, and winter oats has proved valuable for this purpose (Figure 2). Rows should be planted at right angles to the prevailing water currents as this helps to reduce the erosion hazard.

Good seed crops have also been produced on the older alluvial benchlands not subject to overflow, including Willamette and the better grades of Amity. These soils, especially the Amity series, have more compact subsoils than the Chehalis and are not as easy to work as the river bottom soils.

Figure 1. Soil erosion is a real hazard with fall-planted crops on overflow lands unless some protective measures are taken.

Figure 2. A cover crop of winter barley seeded between cabbage rows protects the soil and minimizes soil losses on overflow lands. Note silt deposit in foreground. Cover crop can be destroyed by cultivation or rotatilling early the following spring.

Fertility Problems Must Be Met

Fertilizer requirements vary according to kind of crop, fertility level of the soil, amount of water available to the crop, and various other factors. As a whole, field experiments have shown that vegetable seed crops respond to liberal applications of commercial fertilizer. Economic levels are usually higher than those used for grass and legume seed crops. For crops which produce heavy vegetative growth, the demand for plant food is usually quite large. For those that make smaller vegetative growth, the demand is considerably less. On fields where the level of fertility is quite low, large amounts of commercial fertilizer are needed to produce satisfactory crops. Even on soils with a high fertility level, relatively large amounts are needed to produce the highest seed yields.

Nitrogen is most limiting

Of the various plant food elements, nitrogen is the most restricting and is the key to vegetable seed production in Oregon. Experiments have shown that nitrogen gives the highest seed yields and that other elements usually give but little response. There is some indication, however, that for the Willamette Valley, where nitrogen is combined with an adequate supply of other nutrients, particularly phosphorus, yields may be somewhat superior to those of nitrogen alone. The experimental data are inconclusive in this regard, however. Undoubtedly, as soils become more and more depleted of some of the more basic elements, the need for the balanced application of fertilizers will become more apparent and necessitate changes in the present recommended fertilizer practices.

In southern Oregon, in the Medford area, the soils of the Medford series are favorable for vegetable seed production. They are usually well drained and high in productivity. Other soils of the Medford area suitable for vegetable seed production include the Neal, Sams, and the Columbia series.

In the Redmond area of Oregon, the deeper soils such as the Deschutes and Metolius loams and sandy loams are preferred.

Soils in the irrigated Malheur area have not yet been mapped but it is known that numerous vegetable seed crops thrive here on soils that are deep, fertile, and well drained.

Black alkali soils should be avoided since the physical properties of such soils are undesirable for the production of row crops. Vegetable seed crops vary in their tolerance to salt concentrations in the soil solution. Those which are most apt to succeed with high salt contents are table beets and kale. Those with moderate salt tolerance are tomato, onion, squash, carrot, canteloupe, lettuce, and spinach (12).

Other soil deficiencies exist

Although it is known that phosphorus is assimilated by plants for seed production purposes in relatively large quantities, there is very little evidence of its need to improve the yield and quality of seed for most of the vegetable seed crops. A few crops, however, have responded to high levels of phosphorus but only to a limited degree in comparison to nitrogen. Where one suspects phosphorus deficiencies, applications should be made at the time of seeding or in the seedling stage since most plants use a large portion of their phosphorus relatively early in the growing period. Pendleton, working with sugar beets, suggested a split application of nitrogen and phosphorus, a small amount being applied in the fall and the remainder in the following spring (10). Theoretically, the ideal fall application would be one where the plants would use nearly the full amount of nitrogen and phosphorus in order to attain a vigorous, healthy growth condition before going into the winter. Excessive fall applications should be avoided since it results in a waste of nitrogen by leaching and a reversion of phosphorus to a form less available the following season.

As with phosphorus, the results obtained from the use of potassium in western Oregon soils are not conclusive. The general use of potassium for the production of vegetable seed crops is of questionable value at this time.

Nearly all of the soils in the Willamette Valley, Malheur County, and in the Medford area are known to be deficient in sulfur. This need can best be met by supplying sulfur in the form of gypsum for Willamette Valley soils and elemental sulfur for the other two areas. For plants heavily fertilized with nitrogen, part of the sulfur should probably be supplied in the form of ammonium sulfate (25 per cent elemental S) in order to meet the heavy demands of the growing crop for this element.

Most of the soils in the Willamette Valley are deficient in boron. The effect of boron deficiency for garden beets was noted by Powers and Bouquet in 1940 (11). Pendleton, in 1950, reported increased seed yields of 150 pounds per acre for sugar beet seed when boron was added to the soil (10). Where boron deficiencies exist a small amount of borax, 25 to 30 pounds per acre, should be applied either as a broadcast application or in a mixture with gypsum. Excessive application should be avoided since an over-supply is toxic to plant growth, particularly for the more tender crops such as cucumber, watermelon, etc.

Irrigation Facilities Are Desirable

Approximately one-half of the vegetable seed crops grown in Oregon require supplemental irrigation to obtain profitable seed yields. The returns from irrigation vary greatly according to type of crop, rainfall, soil condition, and other factors.

Irrigation is a necessity for establishing plant beds during the early summer months for such crops as cabbage, table beets, and carrots (Figure 3). At the time of transplanting, irrigation is also

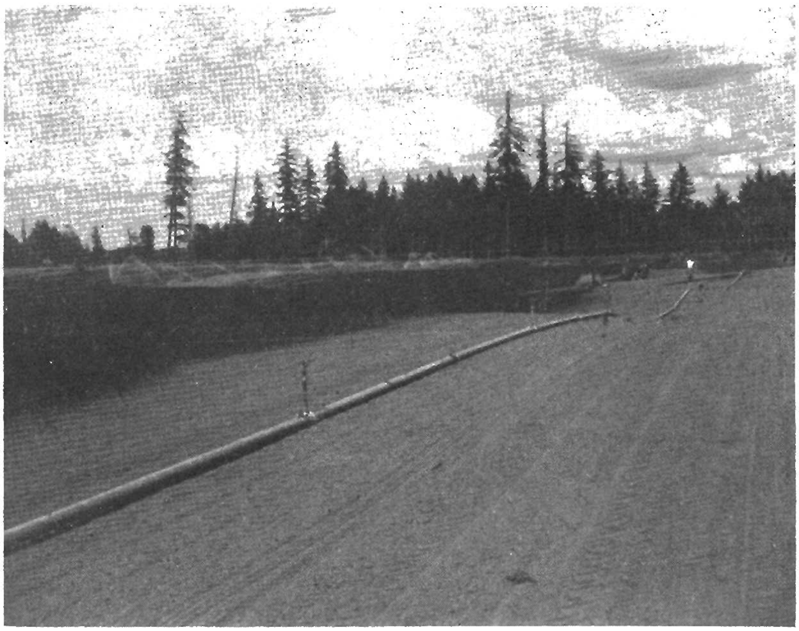


Figure 3. Irrigating root-bed for table beets in the Willamette Valley. Seed is being "irrigated up" because of dry soil conditions. Irrigation facilities are a necessity for vegetable seed crops planted during the dry summer period.

needed to get the plants off to a good start. For the biennial seed crops, which are grown by the seed-to-seed method, supplemental irrigation is often necessary to put the soil in a suitable condition for planting. For the summer growing crops such as cucumber, squash, and pumpkin, irrigation water properly applied more than doubles the seed yields. Even for early spring sown crops, such as mustard and turnip, which mature early in the season, outstandingly high yields have been obtained with good water and fertilizer management.

In the Willamette Valley the sprinkler system of irrigation is commonly used because of the uneven topography of most of the locations. Most of the irrigation in the eastern and southern Oregon areas is by the furrow method. The number of irrigations necessary and the amount of water to apply will depend on the type of the crop, weather, and local soil conditions. A good supply of moisture should be maintained until within a few days of harvest. Over-irrigation should be avoided since it is wasteful of both water and plant nutrients.

Soil Building Practices Pay Off

Vegetable seed growers should follow recommended cropping practices which build up and maintain a good supply of organic matter in the soil. Soils well supplied with organic matter produce more seed per acre, are less subject to erosion, and require less water and commercial fertilizer than those with a low level of this vital component.

Many of the garden seed crops provide an excellent opportunity for growing cover crops for green manure purposes. For late spring or summer planted seed crops, cover crops attain good growth and can be turned under in time to allow for partial decomposition of the green material before the crop is planted. For overwintering crops on land subject to overflow, some growers have successfully planted cover crops between the rows and rotatilled them into the soil early the following spring. This adds valuable organic matter to the soil. On heavy soil types where cultivation has to be delayed because of wet soil conditions, this practice is somewhat questionable since the cover crop may grow too rank before it can be returned to the soil.

A good rotation involving the use of a legume every three or four years is recommended. Under irrigated conditions small grain, clover, and the vegetable seed crop make a suitable rotation. The clover can be turned under the second year and utilized for green manure. Where alfalfa is used in the rotation, the vegetable seed crops should be planted after alfalfa.

Weed Control Is Mandatory

Proper and timely weed control is extremely important since the vegetable seed crops, as a group, respond favorably to clean culture. The grower should recognize that producing the vegetable seed crop is simply carrying the vegetable to a later stage of maturity. Failure to pay attention to some of the fundamentals of weed control has resulted in the loss of many fields of vegetable seed crops in western Oregon (Figure 4).

Figure 4. Weeds take their toll in vegetable seed crops as well as other crops. Many overwintering crops such as the onion field above are lost each year because of inadequate weed control practices. A fall application of IPC would have eliminated most of the grasses without injury to the onions.

The cheapest and usually most effective method of weed control is by cultivation. Growers should avail themselves of suitable cultivation equipment adapted to the row spacing of the crop. If possible, cultivators should be equipped with fertilizer attachments in order that the cultivation and fertilization can be carried on simultaneously. Expensive methods, such as hand pulling and hoeing, should be avoided if possible.

For overwintering crops, a cultivation as late in the fall as possible and one as early in the spring as the soil conditions permit will greatly lessen the weed competition to the seed crop.

For spring or summer sown crops, every effort should be made to kill a crop of weeds before the main crop is planted.

In recent years, much emphasis has been placed on chemical weed control. The use of preemergent sprays such as Dinitro General and light oil have been successfully employed to kill weeds in their early stages of growth. The principle involved here is one of thorough land preparation followed by delayed planting. The spray material is applied as the weeds emerge and three or four days prior to the time of crop seedling emergence. This allows for the killing of weeds without injury to the crop. For crops well established, selective weed killers such as potassium cyanate in onions, oil in carrots and parsnips, and sodium chloride in beets have proved successful. Fall and winter applications of IPC have given excellent results in controlling unwanted grasses which exist in many beet, cabbage, and onion fields in western Oregon. As a result, the costs of hand weeding have been markedly reduced during the early spring months. Undoubtedly more IPC will be used in the future for many of the overwintering seed crops.

For specific recommendations relative to weed control, State Experiment Station specialists or the local County Agricultural Agent should be consulted.

Diseases and Insects Always a Threat

Plant pests have long been a menace to the vegetable seed industry in Oregon and should be guarded against by the grower.

Fortunately, Oregon is relatively free of diseases for most of the seed crops. Onion mildew is perhaps one of the most serious diseases for any one particular crop in western Oregon (Figure 5). Outbreaks of this disease, however, are more or less sporadic depending upon weather conditions for any given year. Root rot organisms are often destructive to carrot and table beet in storage where sanitation measures and proper storage precautions have not been taken. Certain leaf, pod, and stem diseases have occurred occasionally in the crucifers. Seedling disases have caused occasional losses of stands in the vine seed crops, crucifers, and table beets. At the present time, the Experiment Station pathologists are studying this problem in an attempt to find improved methods and materials for seed treatment. The grower should follow a good crop rotation scheme and good farming techniques as it is generally recognized that these practices will discourage soil-borne diseases which might threaten the various crops.

Figure 5. An onion seed field in western Oregon infected with Downy Mildew (*Peronospora destructor*). This disease is most prevalent in lowland areas with poor air drainage, and when present weakens the stems and causes considerable loss from lodging.

Insects cause greater losses of seed yields and quality than do diseases. Oftentimes, this loss can be attributed to neglect on the part of the grower for not having made timely or proper application of insecticide materials. With the development of new and better insecticides and superior equipment for application there is little reason for letting insects gain the upper hand and ruin an otherwise good seed crops (Figure 6). Growers should observe their crop carefully throughout the various stages of growth since most seed crops are vulnerable throughout their life span to insect attack. Insects such as the seed corn maggot and wireworms, for example, are known to attack seed at the time of planting. During the seedling stage such insects as the flea beetle and eleven-spotted cucumber beetle can destroy young plants in the relatively short time of a day or two. From the seedling stage to maturity most of the crops are subject to attack by various kinds of leaf-eating and sucking insects. For the crucifers, aphids, flea beetles, and pod borers are most serious. Thrips oftentimes damage onion flowers thereby causing decreased seed yields. Lygus bugs are thought to have a deleterious effect on the viability of table beet seed.

—Courtesy Livingston Air Service

Figure 6. Dusting cabbage for the control of aphids. Growers of vegetable seeds must be prepared to cope with the insect problem which is a constant threat to many of the vegetable seed crops.

Growers should check their crops frequently for the possibility of encroachment of insects. If they can be observed in the initial stages of infestation, their spread to nearby areas can oftentimes be prevented by spot dusting.

Inquiries relative to the recommended control measures for plant diseases and insects should be directed to Experiment Station pathologists and entomologists, respectively, at Oregon State College.

Isolation Requirements Must Be Met

All of the operations of seed growing should be aimed at the production of the best possible commercial seed. Only the best stock seed should be used and seedings made on land that is free of volunteer plants of other varieties of the same kind. For crops which cross readily by wind and insects, special attention should be given to the matter of proper isolation of the fields with respect to one another. The need for strict adherance to proper isolation distances is accentuated by the large number of varieties for most of the different crops. Careful seedsmen recognize the significance of proper isolation and usually are in a position to advise the grower in this regard.

For the self pollinated crops such as bean, pea, lettuce, chicory, endive, and tomato, very little attention need be given to separating varieties within each group. Morrison suggested, however, that varieties of each group be separated by at least 10 rods in order to avoid mechanical mixtures and occasional crossing which occurs within each self-pollinated group (8).

For the cross-pollinated crops, exact isolation requirements have not been determined under Oregon conditions. Pendleton, Finnell, and Reimer state that seed producing fields of the beet group (table beet, mangel, sugar beet, and swiss chard) should be separated at least one mile (10). This group is pollinated by air-borne pollen as is the corn group (sweet corn, pop corn, field corn) and the spinach group (all smooth and prickly seed varieties and savory leaf and flat leaf varieties). Placing of all kinds and varieties within the same group in direct line of prevailing winds should be avoided insofar as possible.

Insect-pollinated vegetables should be isolated from one another by a half mile or so, preferably a mile or more, with due regard to locations of colonies of domestic and wild bees (8).

Vegetables pollinated by means of insects and whose varieties are interfertile are the cabbage group (cabbage, cauliflower, broccoli, kale, collard, kohlrabi), carrot, celery, asparagus, chinese cabbage, onion, pepper, parsley, parsnip, radish, rutabaga, mustard, turnip, eggplant, cucumber, the muskmelon group, (muskmelon, cantaloupe, honey dew, casaba), watermelon, squash, and pumpkin. All of the types and varieties listed in each group should be isolated from one another. Chinese cabbage will not cross with kinds and varieties of the regular cabbage group nor with mustard. Rutabaga does not cross with turnip, radish, nor cabbage. Turnip does not cross with mustard nor Chinese cabbage. Neither muskmelon, cantaloupe, nor cucumber will cross with any of the other vine seed crops. Watermelon, on the other hand, crosses readily with related citrons but does not cross with other vine crops. In the squash and pumpkin groups, summer squash crosses with certain of the pumpkins such as Connecticut field pumpkin but will not cross with the winter squashes. Varieties within the summer and winter squash groups are interfertile and therefore must be separated in order to maintain pure seed supplies.

Specialized Equipment and Facilities May Be Needed

Ordinary machinery can be adapted for use in growing most vegetable seed crops in Oregon. Since nearly all of the crops are grown in rows, ordinary row crop implements used for commercial cannery production are usually quite satisfactory. Where specialized planting and harvesting equipment are required, the contracting company often furnishes these implements to the grower on a loan or nominal fee basis. Certain growers, however, have been very adept and ingenious and have developed specialized equipment to meet their particular needs.

For planting operations, the ordinary grain drill with plugged spouts, or the corn planter with special plates, have been found useful in seeding cucumbers in rows. For the smaller seeded crops such as mustard, turnip, spinach, radish, cabbage, etc., the Planet-Junior drill is commonly used. For transplanting operations with carrot, table beet, cabbage, and similar crops, specialized transplanting machines have been developed to meet the need.

The combine and stationary thresher are the common methods of harvest for most of the vegetable seed crops in Oregon. Crops which do not shatter badly and which ripen evenly are often combined directly from the field. Mustard and spinach are occasionally harvested in this manner. Where shattering losses and proper curing of the seed following cutting are major considerations, the crops are windrowed or shocked and then threshed with the combine or stationary thresher. Table beet, lettuce, carrot, cabbage, swiss chard and radish are usually harvested in this manner. For rank and tall growing crops like parsnip, the corn binder and stationary thresher combination has been used successfully. For vine seed crops, highly specialized harvesting, washing, and drying equipment are required. In the Willamette Valley, seed companies furnish these facilities to the grower or make arrangements with some larger grower and processor to do the work for them.

Not all vegetable seed crops can be handled by mechanical means. Hand harvest methods still prevail for onion, for example, where the seed heads are cut by hand and placed on trays for drying. Cabbage and table beet must likewise be cut by hand in order to allow for proper curing before threshing.

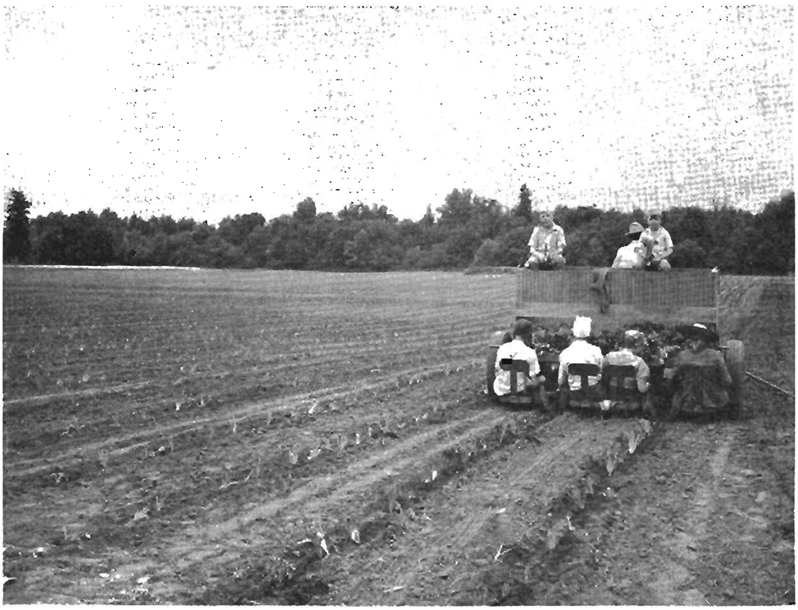
For crops which require bulb or root storage such as table beet, carrot, and onion, provisions must be made for their safekeeping and proper storage until planting season. These facilities are often provided by seed companies or by some grower who has special facilities for handling the crop.

Culture of Various Vegetable Seed Crops

In the following paragraphs an attempt is made to describe the cultural practices involved in growing some of the vegetable seed crops produced in Oregon. Part of the information is based upon experimental data and the remainder on the experiences of seedsmen and growers for the particular crop. It should be pointed out that not all of the problems have been solved experimentally for any one crop. Much more basic research is needed before all of the problems can be answered. Likewise, it should be borne in mind that growers and seedsmen do not always agree as to what is the best method of production for any one particular crop. The descriptions which follow are intended to point out some of the main production problems and to give a general idea on some of the most successful techniques and methods used for planting, growing, and harvesting the various crops under Oregon conditions.

Cabbage

When growing cabbage seed the practice usually followed is for the seed contractor to raise plants for his producers in one large plant-bed and then to distribute them to the growers at the time to transplant in early fall (Figure 7). The plants then overwinter in the field in a semidormant state, bolt in February and early March, and are harvested during the following July and August.



—*Courtesy Chas. H. Lilly Co.*

Figure 7. Transplanting cabbage on typical Willamette Valley river-bottom land in early September. Note that cabbage plants have been defoliated in order to reduce transpiration losses.

Time of seeding and transplanting

Planting and transplanting schedules should be arranged so that each variety will reach a size sufficient to insure its bolting the following spring (Figure 8). Most varieties should reach a loose head stage by December 1. The common experience is that plants not sufficiently advanced at this stage remain vegetative in the spring or do not bolt properly. If the plants are too mature by December they tend to die in severe winters or succumb to soft rot, if the winter is mild.

Seedsmen's experiences in the Willamette Valley have shown that late varieties of cabbage such as the Ballhead strains, Late Flat Dutch, and Mammoth Red Rock should be planted June 1 to 10, that midseason varieties such as Stein's Flat Dutch, All Seasons, Glory of Enkhuizen, Ferrys Round Dutch and Marion Market should be planted June 10 to 25, and that the early varieties such as Jersey Wakefield, Charleston, Copenhagen Market, and Golden Acre should be planted June 25 to July 10.

Figure 8. Cabbage varieties respond differently to various dates of planting and transplanting. Note the difference in plant development of the varieties in the plots in foreground. Early maturing varieties such as the one on the left should be planted and transplanted later than late maturing varieties. Cover crop is winter barley.

Transplanting begins about August 10, the varieties being set in order of their maturity range, with completion about the middle of September.

Spacing and staking

The usual spacing for cabbage in western Oregon is 5 feet between rows and 1½ feet between plants in the row. Two years results on two soil types have shown that the closer spacings both between and within rows give the highest seed yields per acre (Table 2). Dutch seedsmen also report highest yields with the closer spacings, the rows being spaced only 2 feet apart.

At the time of pod formation, cabbage plants often become top heavy and, unless supported by stakes and string, will topple over (Figure 9). This staking practice is common in the Mt. Vernon, Washington, cabbage seed producing area, but has not been followed by many of the Oregon producers. Experimental results at Corvallis have shown that staking failed to give measurable increases in seed yields (Table 2).

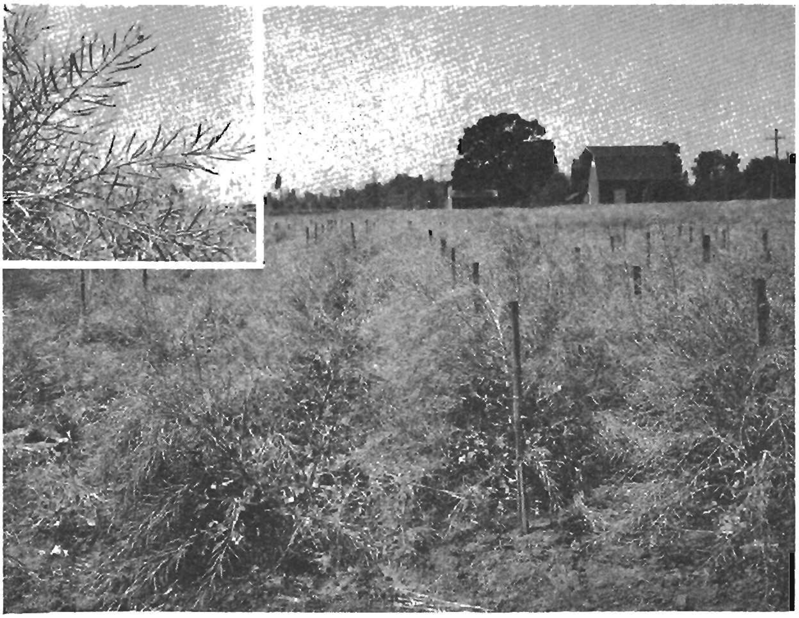


Figure 9. Ferrys Round Dutch cabbage nearing maturity in July. Plants on right were staked and supported in upright position; those on left were not. Experiments show no yield advantage in staking.

Fertilization

Cabbage fertility experiments on Willamette, Chehalis, and Newberg soil series have consistently shown that nitrogen is the key to seed production (Figure 10). Phosphorus and potassium have given no measurable response. Boron and sulfur should probably be applied to most soils, although experimental results are not conclusive in this regard.

Fall applications of 100 to 200 pounds of 20-0-0, or similar fertilizer, are commonly used by growers. Under certain soil and plant conditions this is quite likely a desirable practice. Results of preliminary experiments with undersized plants for transplanting show that light applications of nitrogen tend to hasten the growth and make the plant more vigorous before going into its semidormant winter condition (Figure 11). Where the transplants are of the proper size and maturity and where soils have a fairly high fertility level this practice is somewhat questionable. One year's results on a fertile Willamette clay loam revealed that fall fertilization does not in-

Figure 10. Nitrogen is the key fertilizer element for cabbage seed production. Row on left was treated with 100 pounds of nitrogen in February; row on right was a check. Liberal amounts of P_2O_5 and K_2O were applied to both rows the fall previous. Note that nitrogen delays blooming but increases plant vigor.

crease the yield over spring fertilization (Table 3). In other words, under similar conditions, it is usually more profitable to save the fertilizer for spring application, the time from which one can normally expect the greatest boost in seed yield.

Upon examination of the time-and-rate-of-nitrogen experimental data, the most economical level appears to be near the 150-pound rate (Table 4). Where irrigation is not feasible, however, nitrogen should be reduced to approximately 75 to 100 pounds per acre. February and early March treatments tend to stimulate bolting and give higher seed yields than those made in April and May. Broadcast applications are satisfactory at this time of year since spring rains normally leach the nitrogen downward into the root zone.

Split applications of nitrogen, the second one being side-dressed in May during early bloom stage, have failed to increase yields over single applications made at an early date. No experimental information has been obtained with the sprinkler method of fertilization.

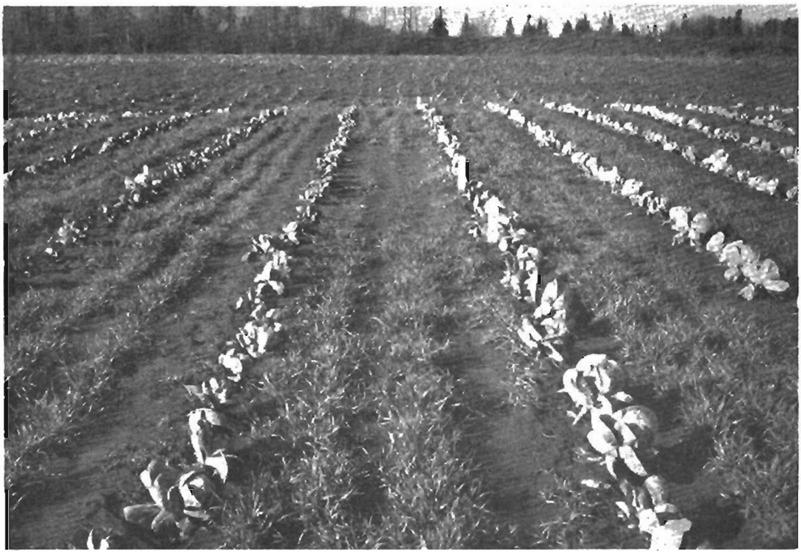


Figure 11. Effect of fall applications of nitrogen on plant development. Plot on left foreground received no nitrogen; plot on right received 50 pounds of nitrogen per acre at the time of transplanting. Both were fertilized with 200 pounds of P_2O_5 and 100 pounds of K_2O per acre. Photographed March 3, 1948.

Harvesting and threshing

Cabbage harvest usually begins in mid-July and extends into August. The stage to cut cabbage depends somewhat on the variety but for the most part should commence when the plants have taken on an over-all orange to brownish cast, when the majority of the pods at the top of the plant have brown seeds in them, and before shattering becomes a problem. The plants are usually cut off by hand with corn knives, piled in shocks or windrows, and allowed to cure for a week or two before threshing. When thoroughly dry, the plants are either hauled to a stationary thresher in a canvas lined conveyance or are pitched gently into a combine. Since cabbage threshes readily and the seed is easily cracked, the cylinder speed of the threshing rig should be set at 1,000 RPM, or less, and some of the concaves removed, about the same as for vetch and peas.

Table 2. EFFECT OF SPACING AND STAKING ON SEED YIELD OF FERRYS ROUND DUTCH CABBAGE UNDER IRRIGATION.

Spacing between rows and year*	Yield per acre for various spacings within row					
	One-foot rows		Two-foot rows		Average, both years†	
	Staked	Not staked	Staked	Not staked	Staked	Not staked
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Four feet						
1949	1,862	1,860	1,491	1,438	1,697	1,725
1950	1,998	2,067	1,436	1,533		
Five feet						
1949	1,625	1,614	1,396	1,224	1,482	1,530
1950	1,830	1,913	1,076	1,371		
Six feet						
1949	1,258	1,276	1,155	1,200	1,313	1,237
1950	1,549	1,470	1,289	1,003		
Average, all spacings, 1949 and 1950	1,687	1,700	1,307	1,295	1,497	1,497

* 1949, Chehalis clay loam; 1950, Willamette clay loam.
† Differences for spacing between and within rows were highly significant (statistically) at the 5 per cent level for both years.

Table 3. THE EFFECT OF FALL APPLICATIONS OF NITROGEN AND PHOSPHORUS ON BOLTING AND SEED YIELD OF FERRYS ROUND DUTCH CABBAGE.

(Willamette clay loam following subclover, 1949-50.)

Treatment	Fall treatment*		Bolting	Seed yield per acre†
	Nitrogen	P_2O_5		
	Pounds	*Pounds*	*Per cent*	*Pounds*
Treatment 1	None	None	96.4	1,432
Treatment 2	50	......	96.3	1,448
Treatment 3	100	......	99.7	1,338
Treatment 4	50	200	94.5	1,221
Treatment 5	100	200	96.1	1,389
Treatment 6	......	200	98.2	1,550

* All plots received blanket application of 100 pounds of nitrogen in early spring.
† Differences not significant at the 5 per cent level.

Table 4. EFFECT OF TIME AND RATE OF NITROGEN ON BOLTING AND SEED YIELD OF FERRYS ROUND DUTCH CABBAGE.

(Irrigated Willamette clay loam soil, 1949-50.)

Nitrogen per acre	Date of nitrogen application					
	March 4		March 24		April 29	
	Bolting	Seed yield per acre	Bolting	Seed yield per acre	Bolting	Seed yield per acre
	Per cent	*Pounds*	*Per cent*	*Pounds*	*Per cent*	*Pounds*
None	94.5	669	94.5	669	94.5	669
75 pounds	96.4	1,285	96.4	1,461	98.2	983
150 pounds	100.0	1,573	92.5	1,308	87.2	926
225 pounds	98.1	1,518	95.9	1,319	88.6	961
Average	98.2*	1,459†	95.0*	1,362†	91.4*	957†

* Difference for significance at the 5 per cent level (bolting per cent for various dates) = 4.7.
† Difference for significance at the 5 per cent level (seed yields for various dates) = 160.

Turnip and Rutabaga

Both turnip and rutabaga can be grown as winter annual crops for seed production purposes in Oregon. Considerable acreage of the Shogone variety, a spring-sown turnip, is grown for seed in the Willamette Valley. During recent years much of the fall planted turnip in the Malheur area has winter-killed because of extremely cold winters. Experiments at Parma, Idaho, during the last two years have indicated quite conclusively that these losses can be overcome by selecting the proper planting date (August 23 to September 10) and by sowing the seed in the bottom of a listed furrow (4).

Observations show that rutabaga is hardier than turnip and also somewhat later in seed maturity. Both crops can be produced over a wide range of soil types, although the better soils, which are relatively free of weeds, are preferred since above average yields are required in order to make the crops profitable to the grower. Average contract prices have been quite low, ranging from 12¢ to 15¢ per pound for the last 10-year period.

Cultural practices similar

Cultural practices from the time of planting until harvest are similar for both crops. They are sown directly in the field in early September, go through the winter, and bloom and mature early the following year. The usual procedure is to plant in rows spaced 22" to 24" apart and fertilize with a light application of nitrogen and phos-

Figure 12. Turnip in windrows for drying prior to harvest. Windrowing is the most popular method for handling similar crops which are subject to shattering losses.

phorus at the time of seeding. In early spring from 200 to 300 pounds of 16-20-0, or its equivalent, are applied as a side-dressing, the amount depending upon the fertility level of the soil.

Insect pests which are the most troublesome are the aphids and pod-borers, the same as for cabbage. Control measures should be aimed at the eradication of the insects in the early stages of infestation. As turnip and rutabaga reach maturity, songbirds often cause considerable damage, particularly to small, isolated fields. No satisfactory control measure has yet been devised to handle this type of problem.

Both turnip and rutabaga should be cut a little on the green side since the seed shatters rather badly if allowed to ripen fully. The usual method of harvest is to cut and windrow when the plants have taken on a greenish-yellow tinge and before appreciable shattering has taken place (Figure 12). Following a curing period of from 1 to 3 weeks, the combine, with retarded speed and lowered cylinder, is used to thresh the crop.

Experiments with irrigated, spring-sown turnip

Since very little was known about the performance of spring-sown turnip under irrigated conditions, experiments were conducted at the Central Experiment Station at Corvallis to determine what yields could be obtained under these conditions, the best time to plant, and the fertility requirements of the crop. All plantings were seeded in rows 24" apart. Two years results on a Chehalis sandy loam showed that plantings made in April were superior to those made in May and June (Table 5). Seedings made from the middle of June on failed to bolt and mature seed properly.

Exceptionally high seed yields, up to 1,450 pounds in 1949 and nearly 2,000 pounds in 1950, were obtained where plentiful supplies of nitrogen and water were supplied during the growing season. High rates of nitrogen nearly doubled the seed yields (Table 6). Applications of nitrogen above the 150-pound level, however, caused considerable lodging of the crop (Figure 13). Considering this and the successively small increases in seed yield with increased rates, the optimum level appears to be somewhat below 120 pounds of

Figure 13. Too much nitrogen causes lodging of Shogone turnip under irrigated conditions. Plot on left received 60 pounds of nitrogen shortly after emergence. Plot on right was treated with 120 pounds of nitrogen and has lodged. Both plots received 225 pounds of P_2O_5 per acre. Inset of same crop at blooming time shows the characteristically taper-pointed pods.

actual nitrogen per acre. Phosphorus, when applied at rates up to 200 pounds per acre, failed to give significant increases in seed yields. Perhaps if higher levels of phosphorus had been used this element would have bolstered the seed yields significantly.

Table 5. SEED YIELDS OF SHOGONE TURNIP FOR VARIOUS DATES OF PLANTING.

(Irrigated Chehalis sandy loam)

Date of planting	Date of harvest	Seed yield per acre*
Year 1949		*Pounds*
May 2	August 25	1,560
May 24	September 6	1,359
June 13	Not harvested†	....
Year 1950		
April 28	August 8	1,793
May 30	August 20	475
June 30	Not harvested†	....

* F value significant for both years.
† Did not mature properly.

Table 6. EFFECT OF NITROGEN AND PHOSPHORUS ON SEED YIELD OF SHOGONE TURNIP.

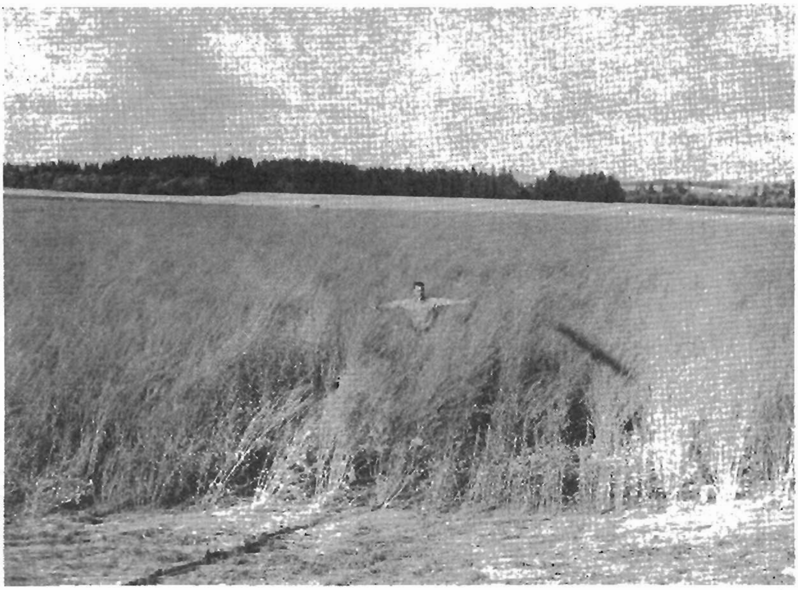
(Irrigated Chehalis sandy loam, 1949 and 1950)

Nitrogen per acre	Seed yields per acre with various amounts of phosphorus						
	None	75 pounds P_2O_5	100 pounds P_2O_5	150 pounds P_2O_5	200 pounds P_2O_5	225 pounds P_2O_5	Average, all rates P_2O_5
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
*Year 1949**							
None	577	769	....	752	....	688	697
60 pounds	1,073	1,098	....	1,116	....	1,020	1,077
120 pounds	1,268	1,275	....	1,200	....	1,266	1,252
180 pounds	1,399	1,483	....	1,484	....	1,450	1,454
Average	1,080	1,156	....	1,138	....	1,106	1,120
Year 1950†							
None	1,097	....	1,007	....	912	....	1,005
50 pounds	1,445	....	1,450	....	1,596	....	1,497
100 pounds	1,677	....	1,868	....	1,653	....	1,733
150 pounds	2,057	....	1,688	....	1,802	....	1,849
200 pounds	1,879	....	2,096	....	1,942	....	1,972
Average	1,631	....	1,622	....	1,581	....	1,611

* Year 1949
Difference for significance at the 5 per cent level for nitrogen means = 160.
Differences not significant at the 5 per cent level for phosphorus means.
† Year 1950
Difference for significance at the 5 per cent level for nitrogen means = 172.
Differences not significant at the 5 per cent level for phosphorus means.

Mustard

Mustard is another low value seed crop with growth habits and cultural requirements similar to turnip (Figures 14 and 15). This



—*Courtesy of Chas. H. Lilly Co.*

Figure 14. Field of Giant Southern Curled mustard approaching maturity in Willamette Valley. Note that the closely spaced rows are nearly indistinguishable. This field was later swathed and threshed with a field combine.

crop is used primarily for greens and most of the seed produced in Oregon is shipped to the southern states where it is quite popular in the diet of the southern people.

Spring planting preferred

Mustard is grown by the seed-to-seed method, and is usually planted in early spring. Spring plantings are preferred since fall seedings are more subject to such natural hazards as flooding, poor harvest conditions during June when the crop matures, and lack of sufficient pollinating insects during the early blooming stage.

Care should be taken to avoid planting on land infested with wild mustard since this weed, like lambs-quarter and rough pigweed, is extremely difficult to separate from the crop in seed cleaning operations. Also, many seedsmen believe that some crossing occurs between the tame and wild types when grown together.

Experiments with Giant Southern Curled mustard

Experiments conducted on an irrigated Chehalis sandy loam have shown that unusually high yields can be obtained where a plentiful supply of water and nitrogen are used (Table 7). Seed yields have been somewhat higher than Shogone turnip with over 1,500 pounds per acre being produced in 1949 and 1950. Phosphorus

--Courtesy of Chas. H. Lilly Co.

Figure 15. A curly leaf type of mustard in two-foot rows prior to bolting in early spring. Note the absence of weeds and uniformity of the crop, both attributes being very important to the production of high quality seed.

failed to give measurable increases in yield. As for nitrogen, the most economical level appeared to be somewhere between the 100- and 120-pound level. In contrast to turnip, no lodging took place even with the higher rates of nitrogen. Excessively high levels of nitrogen appear to have more of a depressing effect on mustard yields than on turnip yields, however.

Table 7. EFFECT OF NITROGEN AND PHOSPHORUS ON SEED YIELD OF GIANT SOUTHERN CURLED MUSTARD.

(Irrigated Chehalis sandy loam, 1949 and 1950)

Nitrogen per acre	Seed yields per acre with various amounts of phosphorus						
	None	75 pounds P_2O_5	100 pounds P_2O_5	150 pounds P_2O_5	200 pounds P_2O_5	225 pounds P_2O_5	Average, all rates P_2O_5
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
*Year 1949**							
None	731	863	....	812	....	815	805
60 pounds	1,444	1,743	....	1,428	....	1,480	1,524
120 pounds	1,828	1,940	....	1,839	....	1,991	1,900
180 pounds	1,839	1,795	....	1,963	....	2,175	1,943
Average	1,461	1,585	....	1,511	....	1,615	1,543
Year 1950†							
None	1,269	....	1,328	....	1,220	....	1,272
50 pounds	1,807	....	1,907	....	1,826	....	1,847
100 pounds	2,079	....	1,921	....	1,786	....	1,929
150 pounds	2,007	....	2,034	....	1,904	....	1,982
200 pounds	1,992	....	1,946	....	1,832	....	1,923
Average	1,831	....	1,827	....	1,714	....	1,791

* Year 1949
Difference for significance at the 5 per cent level for nitrogen means = 209.
Differences not significant at the 5 per cent level for phosphorus means.

† Year 1950
Difference for significance at the 5 per cent level for nitrogen means = 223.
Differences not significant at the 5 per cent level for phosphorus means.

Table 8. SEED YIELDS OF GIANT SOUTHERN CURLED MUSTARD FOR DIFFERENT DATES OF PLANTING.

(Irrigated Chehalis sandy loam)

Date of planting	Date of harvest	Seed yield per acre*
Year 1949		*Pounds*
April 16	August 20	1,782
May 4	August 25	1,900
May 24	September 6	1,526
Year 1950		
April 28	August 10	2,491
May 30	August 23	430
June 30	Not harvested†	....

* Difference for significance at the 5 per cent level (1949) = 252. *F* value significant at the 5 per cent level (1950).

† Did not mature properly.

Growers' experiences have shown that under dryland conditions mustard should be seeded in March or early April to obtain the highest seed yields. Under irrigated conditions, however, where it is possible to maintain better soil moisture conditions throughout the growing period, satisfactory yields have been obtained where the plantings were delayed until the middle of May (Table 8). Planting beyond this date would be somewhat questionable according to present experimental information.

Chinese Cabbage

Chinese cabbage is grown as an annual, being very similar to mustard and Shogone turnip in growth habits. The main two varieties grown for seed in the Willamette Valley are Chihile and Wong Bok. Average contract prices are as a rule higher for Chinese cabbage than for mustard and turnip.

Soil requirements are quite high for this crop and good fertile soils are essential for high yields. Irrigation is not usually required although in certain dry years it would probably be the difference between a profitable and an unprofitable seed crop.

Chinese cabbage is usually solid seeded in early March in rows 22" to 24" apart. Bolting difficulties have been experienced with late spring plantings. Fertility and other cultural requirements are similar to those described for mustard and spring-sown turnip. Growers of Chinese cabbage should be prepared to control troublesome insects such as the pod-borer, aphid, and flea beetle.

The crop can be harvested either from the swath or taken standing directly from the field. The latter method is preferred by certain experienced growers, provided that the field is free of weeds and uniform in maturity. Seed yields have been fairly consistent and have ranged from 500 to 1,200 pounds per acre under Willamette Valley conditions.

Kale

Curly Kale is the most popular type grown in western Oregon as a seed crop. When grown for seed it is an early maturing biennial, well adapted for seed production in the Willamette Valley. Seed production is either by the seed-to-seed method or by the transplant method.

General cultural procedures, such as row spacing, fertilization, etc., are similar to those of fall sown turnip. Experience has shown, however, that kale must be planted earlier than turnip in order to obtain high yields. Dwarf kale varieties should be planted from the middle of June to July 15 whereas the Siberian variety yields highest if planted later- -August 15 to September 10. Supplemental irrigation is often needed to get the plants started but is usually not required the following season.

Kale is harvested with a combine, either from the swath or taken directly from the field. Seed yields of 1,000 to 2,000 pounds per acre are not uncommon for the Siberian variety. The dwarf varieties are lower in yielding ability, 500 to 800 pounds per acre being an average yield.

Cauliflower

Only a few attempts have been made to grow cauliflower for seed in western Oregon. Yields are often quite low, with 200 to 300 pounds per acre being the average yield obtained for the Snowball summer varieties.

Cauliflower is similar to cabbage in some respects but appears to be more exacting in its soil and climatic requirements. Plants are more difficult to overwinter than cabbage and usually will not survive the more severe winters in the Willamette Valley without some special protection.

The usual method of producing this crop is to seed thinly in out-of-doors plant beds about September 1 or to seed directly in cold frames or in a nonheated greenhouse about October 1. When the plants grown out-of-doors are of sufficient size to transplant toward the last part of October, they are placed in pots or veneer bands and transferred to protective cold frames or greenhouses. Plants that are started in the greenhouse or cold frames can be transplanted any time between November and February, where they remain until setting out in the field in late March or early April.

The care of the crop the second year is similar to that described for cabbage. Spacing between plants is usually closer, however, with early varieties being spaced in 3½-foot rows and about 2 feet apart in the row. Cultural and fertilizer procedures should be aimed at getting the plants to head as early and uniformly as possible without retarding the growth. After the plants have bolted and matured seed, they are cut off above the old head area, shocked, and allowed to dry. The regular combine thresher and any standard cleaning mill can be used satisfactorily in the threshing and seed cleaning.

Considering the large amount of hand labor necessary to produce cauliflower seed and the relatively low yields obtained, it is doubtful if the Oregon producer can ever compete effectively with the California and European growers of this crop.

Kohlrabi

Kohlrbai, when grown for seed, is handled as a biennial crop. Limited experience with plantings in the Willamette Valley has indicated that seed-to-seed production is successful if plantings are made from July 15 to August 15. Cultural requirements and handling practices are similar to those described for fall-sown turnip.

Brussels Sprouts

Most of the brussels sprouts being grown for seed in the Pacific Northwest are produced in the Mt. Vernon, Washington, area. In Oregon it is a minor crop but appears to be well adapted for seed production in the western part. When grown for seed it is usually handled like cabbage.

Onion

During the past 10 years, onion has been one of the major vegetable seed crops produced in Oregon. Most of the production has been in the Snake River Valley irrigated sections of Malheur County, the area to which the onion appears to be best adapted. A small acreage is also grown in the Willamette Valley but the seed yields do not average as high and a greater risk is involved in production because of downy mildew (*Peronospora destructor*) (see Figure 5).

Onion grown for seed is handled as a biennial. The seed grower has the problem of growing the bulbs, carrying them over winter satisfactorily and producing the seed crop the second year. Because onion varieties intercross readily, attention must be given to proper isolation distances in locating seed fields.

Growing the bulbs

Bulb production for seed does not differ greatly from commercial onion production with the exception that planting rates should be somewhat heavier in order that more bulbs can be produced per acre. Oftentimes, seed companies contract with certain growers to produce the bulbs for the onion seed growers. In other instances, the growers produce their own bulbs for planting. In either case, the bulbs should be grown on soils which are of high fertility and of a loose and porous nature, such as well-decomposed muck. The exact fertilizer requirements for producing bulbs for seed production purposes in Oregon are unknown. Some growers are of the opinion that excessive nitrogen fertilization results in bulbs of poor keeping quality. For this reason these growers have refrained from heavy nitrogen applications. Commercial growers in southern Oregon have found that liberal applications of phosphate and particularly potassium produce bulbs with superior keeping qualities.

Seeding usually is done in the spring as soon as the soil can be prepared. The usual method is to seed with 4-row drill planters at a relatively heavy rate of 4 to 6 pounds per acre. The rows are spaced 14 to 16 inches apart in beds which in turn are 20 to 24 inches apart. The possible damage from onion root maggot should be kept in mind and thinning delayed until damage from this pest no longer threatens.

Harvesting bulbs for seed purposes is similar to that of harvesting table stock. Bulbs should be well matured and carefully cured. This is of particular importance for bulbs which are to be stored over winter. As soon as three-fourths of the tops fall over, the bulbs should be lifted and placed in windrows to cure. Another method is to lift and top the onions and then cure them in slatted field crates.

If the bulbs are to be held over for planting until the following spring, storage conditions should be cool, well ventilated, and dry. Ordinary potato and apple storage facilities are usually unsuitable for onion bulb storage because of too moist conditions. An average temperature of around 35° to 40° F. should be maintained at all times.

Producing the seed

Seedsmen generally agree that the transplant method is preferred to the seed-to-seed method for the production of superior quality seed. During the war, however, when labor shortages existed, considerable acreage was grown on a seed-to-seed basis. This method was reasonably successful, particularly where careful attention was given to the use of good pure stock seed and where winter-hardy varieties were used.

With the transplant method, the grower should select bulbs carefully and discard off-type, diseased, and otherwise undesirable bulbs. This can be done during the time that the mother bulbs are being harvested or at the time of transplanting or both.

Time to plant

Fall transplanting is recommended in Oregon (Table 9). All plantings in western Oregon should be made by October 15 if at all possible. In eastern Oregon, planting should be done sufficiently early so that the bulbs can get well rooted before the ground freezes. If spring planting is practiced, it should be done as soon as the soil can be prepared, in March or early April (Figure 16).

Figure 16. Comparison of fall transplanted onions on right with spring transplanted onions at left. Spring plantings usually are more weed-free but do not yield as high as fall transplanted onions.

Experiments at the Parma, Idaho, Branch Experiment Station have shown that the varieties Ebenezer, White Portugal, and Yellow Globe are winter hardy (14). Sweet Spanish, on the other hand, is not quite as hardy and will not survive all winters in that area. For such varieties, it is advisable to follow either a spring planting program entirely or a combination program, where a portion of bulbs are planted in the fall and the remainder in the spring.

Planting the bulbs

Finnell found that medium sized bulbs (2¼ to 3 inches in diameter) are best for planting (Table 10). Although the larger bulb size gives slightly increased yields and increased number of culms per plant, the amount of increase usually does not justify the extra expense in handling additional tonnages of bulbs. Even with medium sized bulbs, if spaced 6 inches apart in 3-foot rows, from 7,500 to 10,000 pounds of bulbs are required to plant an acre.

Table 9. COMPARISON OF FALL- AND SPRING-PLANTED EARLY YELLOW GLOBE ONIONS.

(Willamette clay loam, 1948-49)

Time of transplanting	Average number of culms per plant	Seed yield per acre*	Germination
		Pounds	*Per cent*
Fall, October 16 and 17	3.04	445	94.5
Spring, April 3	2.42	383	94.0

* F value significant at the 5 per cent level.

Table 10. EFFECT OF ROW SPACING AND SIZE OF BULB ON SEED YIELDS OF FALL PLANTED EARLY YELLOW GLOBE ONION.

(Chehalis sandy loam, 1945. Yields composited for October and November plantings)*

	Seed yield per acre with various bulb sizes			
Spacing in row	Small bulbs (up to 2¼")	Medium bulbs (2¼ to 3")	Large bulbs (3" or more)	Average seed yield per acre
	Pounds	*Pounds*	*Pounds*	*Pounds*
4 inches	386	590	608	528
8 inches	300	357	384	347
12 inches	164	258	325	249
Average	283	402	439	375

* Data from Oregon Agricultural Experiment Station report by H. E. Finnell.

Table 11. EFFECT OF BULB PLACEMENT ON SEED YIELDS OF SOUTHPORT WHITE GLOBE ONIONS.

(Willamette clay loam, 1949-50)

	Seed yield per acre with various depths of planting			
Bulb position	Surface	1" depth	2" depth	Average seed yield per acre*
	Pounds	*Pounds*	*Pounds*	*Pounds*
Right side up	464	543	541	516
On side	366	469	426	420
Wrong side up	206	258	201	221
Average, all positions	345	423	389	

* Difference for significance at the 5 per cent level for position means = 149.

In field operations, the bulbs generally are planted upright in rows 3 feet apart with individual bulbs being spaced 2 to 6 inches apart, depending on the size. Experiments with medium sized bulbs on Willamette clay loam have shown that the 4- to 6-inch spacing in the row is optimum (Table 10). If bulbs are placed wrong side up, yields are reduced more than half. Even when bulbs are placed on the side, yields are considerably less than for those placed in an upright position (Table 11). The common practice is to place the bulbs so that the top of the bulb is near the level of the soil surface. Experiments indicate that under Willamette Valley conditions there is little difference as to whether fall planted bulbs are planted at the surface or 2 inches below the surface. With shallow planting, support must later be provided to the seed stalks by hilling up. When fall planting is undertaken in eastern Oregon, extra covering should be provided by hilling up before the ground freezes.

Fertilizer requirements

The fertility needs of the onion plant for seed-production purposes have not been determined for eastern and southern Oregon. For the Willamette Valley, however, fertility experiments on Wil-

Figure 17. A good, complete fertilizer program is essential to high onion seed yields in Oregon. Plot on left received treatments of nitrogen, phosphorus, potassium, lime, and gypsum. Plot on right received only gypsum and lime. Note the increased vigor and greater abundance of seed heads in the NPK plot.

Table 12. THE EFFECT OF VARIOUS FERTILIZER TREATMENTS ON THE SURVIVAL, NUMBER OF CULMS PER PLANT, SEED YIELD, AND GERMINATION OF EARLY YELLOW GLOBE ONIONS.

(Willamette clay loam, 1948-49)

Treatment	Fertilizer per acre						Total plants per plot	Culms per plant	Seed yield per acre	Germination
	Nitrogen (fall)	Nitrogen* (spring)	P_2O_5	K_2O	Gypsum	Lime				
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*			*Pounds*	*Per cent*
Treatment 1 (none)	....	......	......	......	......	....	43	2.0	318	95
Treatment 2 (NPK)	50	100	200	100	......	....	46	2.6	430	92
Treatment 3 (NPK + G)	50	100	200	100	175	....	47	3.2	531	98
Treatment 4 (NPK + G + L)	50	100	200	100	175	1,200	52	3.4	632	98
Treatment 5 (NPK + L)	50	100	200	100	......	1,200	49	2.8	396	88
Treatment 6 (G)	....	......	......	......	175	....	40	2.2	240	96
Treatment 7 (G + L)	....	......	......	......	175	1,200	53	2.3	405	98
Treatment 8 (L)	....	......	......	......	......	1,200	49	2.3	327	95

* All fertilizers were applied in the fall at time of transplanting except nitrogen, which was applied in both fall and spring. Starred column indicates spring treatment.

lamette clay loam have shown that several elements, including nitrogen, phosphorus, gypsum, and lime are important in seed production (Figure 17).

Experiments with Early Yellow Globe onions in 1948-49 showed that nitrogen, phosphorus, and potassium, when applied as a uniform application, significantly increased seed yields and number of culms per plant, over the lime (1,200 pounds), gypsum (175 pounds), and check treatments (Table 12). Gypsum, when used alone, gave some response but to a much lesser degree than the nitrogen-phosphorus-potassium combination. The presence of lime resulted in a higher rate of plant survival than the other treatments and imparted a healthy green appearance to the plants. In 1949-50, experiments with Southport White Globe onions showed that the spring application of nitrogen had a highly significant effect on seed yield whereas fall nitrogen treatments did not (Tables 13 and 14). The average yield with applications of 0, 75, 150, and 225 pounds of nitrogen per acre applied on March 12 in combination with phosphorus and potassium were 427, 596, 520, and 403 pounds of seed per acre, respectively (Table 15). The optimum amount of nitrogen for onion seed production, therefore, appears to be somewhere around 75 pounds per acre. To determine the exact amount, would require further investigation.

Varying amounts of phosphorus, when used alone, either in spring or fall, had no significant effect on seed yields (Table 16). When used in combination with nitrogen, however, seed yields had a tendency to climb steadily with increased increments of P_2O_5 (Table 15). Thus, it appears that phosphorus, if used at heavy rates in combination with nitrogen, may contribute in a minor way to increased seed yields. Potassium gave no indication of increasing seed yields.

Harvesting and threshing

Onions usually are ready to harvest in late July or August. Seed heads should be gathered when a fair percentage of the heads are showing some opened fruits and exposing the black, ripened seeds. The heads are cut by hand with a short piece of stalk attached and are dropped into a burlap sack or bucket supported at the waist of the cutter (Figure 18). Sometimes two or three pickings are required in order to obtain a large percentage of the ripened seed. After picking, the seed heads are hauled out of the field and transferred to curing sheds, drying crates or canvasses (Figure 19). Care should be taken to keep the heads from heating which will lower the seed germination. Good ventilation is required and during the

Figure 18. Harvesting onions for seed. Workers cut off only the ripened heads and drop them into picking sacks supported at the waist. Seed heads must then be dried prior to threshing.

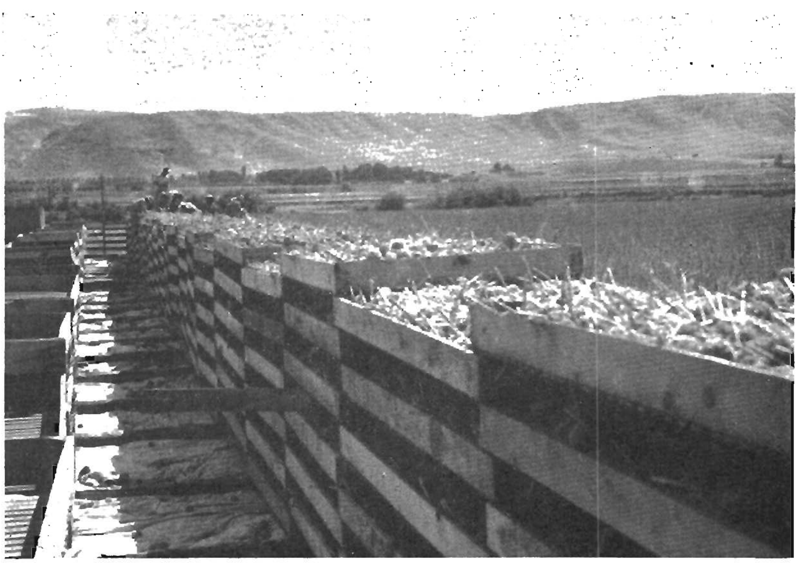


Figure 19. Onion seed heads in shallow trays for drying purposes. Note that trays are arranged so as to provide for adequate air circulation to the seed heads.

first few days of drying, occasional stirring may be necessary.

As soon as the seed heads are sufficiently dry, threshing is done by various methods including the use of the ordinary grain separator, combine harvested, or special built machines, by flailing where small quantities of seed are involved, or by rolling on canvas sheets. Where machine methods are used, care should be taken so as not to get too close an adjustment because of the danger of injuring the seed by too much scarification. Undue breakage of the "button" (receptacles of the individual flowers) should be avoided since this material has the same specific gravity as the seed and cannot be easily separated once it is broken up.

Seed yields vary somewhat from year to year but on the whole have been fairly consistent throughout Oregon. Yields generally range from 300 to 500 pounds per acre, with more than 1,000 pounds of seed per acre being reported occasionally.

Table 13. EFFECT OF FALL APPLICATIONS OF NITROGEN ON SEED YIELDS OF SOUTHPORT WHITE GLOBE ONIONS.

(Willamette clay loam, 1949-50)

Fall nitrogen per acre*	Seed yield per acre†
	Pounds
None	325
50 pounds	310
100 pounds	330
200 pounds	278

* Borax and gypsum were applied uniformly to all plots in the fall. No fertilizer treatments were made in the spring.

† Differences not significant at the 5 per cent level.

Table 14. EFFECT OF SPRING APPLICATIONS OF NITROGEN ON SEED YIELD OF SOUTHPORT WHITE GLOBE ONIONS.

(Willamette clay loam, 1949-50)

Spring nitrogen per acre*	Seed yield per acre†
	Pounds
None	427
75 pounds	596
150 pounds	520
225 pounds	403

* Phosphorus and potassium were applied on an average of 200 pounds each to all plots in the fall. Nitrogen was the only spring treatment.

† Difference for significance at the 5 per cent level = 98.

Table 15. SEED YIELDS FOR 36 DIFFERENT COMBINATIONS OF NITROGEN, PHOSPHORUS, AND POTASSIUM*, FOR SOUTHPORT WHITE GLOBE ONIONS.

(Willamette clay loam. 1949-50)

Amount of phosphorus and potassium per acre†	Seed yields with various amounts of nitrogen per acre‡				
	No nitrogen	75 pounds nitrogen	150 pounds nitrogen	225 pounds nitrogen	Average, all rates nitrogen
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*
100 pounds phosphorus					
100 pounds potassium	480	560	399	386	456
200 pounds potassium	413	625	513	388	484
300 pounds potassium	452	540	589	321	475
200 pounds phosphorus					
100 pounds potassium	459	586	488	396	482
200 pounds potassium	314	661	449	412	459
300 pounds potassium	411	585	592	398	497
300 pounds phosphorus					
100 pounds potassium	458	563	557	467	511
200 pounds potassium	406	663	527	414	502
300 pounds potassium	453	584	571	446	514
Average, all phosphorus and potassium treatments	427	596	520	403	486

* Borax and gypsum applied uniformly to all plots in the fall. Phosphorus and potassium were applied in the fall and all nitrogen was applied in the spring.
† Differences not significant at the 5 per cent level for phosphorus and potassium means.
‡ Difference for significance at the 5 per cent level for nitrogen means = 98.

Table 16. EFFECT OF TIME AND RATE OF APPLICATION OF PHOSPHORUS ON THE SEED YIELD PER ACRE OF SOUTHPORT WHITE GLOBE ONIONS.

(Willamette clay loam, 1949-50)

Treatment*	Time of application and rate of phosphorus per acre		Seed yield per acre†
	Fall	Spring	
	Pounds	*Pounds*	*Pounds*
Treatment 1	100	None	541
Treatment 2	50	50	504
Treatment 3	None	100	491
Treatment 4	100	100	489
Treatment 5	200	None	563
Treatment 6	None	200	448

* All plots were treated uniformly with 200 pounds of gypsum, 15 pounds of borax, 100 pounds of potassium, and 50 pounds of nitrogen in the fall. Spring treatment on March 11 consisted of a uniform application of 100 pounds of nitrogen per acre.
† Differences not significant at the 5 per cent level.

Carrot

Most of the carrot seed produced in Oregon is grown in the irrigated section of Malheur County. While the better soil types in western Oregon will produce good yields of carrot seed, the widespread occurrence of wild carrot (*Daucus carota*) is a menace to the purity of the seed grown in this region.

Both the transplant method and the seed-to-seed method have produced satisfactory seed crops. The usual method of growing carrot seed, and the one most generally accepted by the majority of seed growers, is the transplant method which requires two full seasons. During the first year the roots are grown, selected for type and then stored during the winter. The spring of the following year the roots are planted and the seed resulting therefrom is harvested during late summer.

Producing and storing roots

Roots are produced in the same manner as for market or for winter use (Figure 20). They should be grown on well-drained, deep loamy, or sandy loam soils. Good drainage is essential for carrots since bacterial soft rot may develop in roots grown on soils that retain moisture too long. At least 2 years, or preferably more,

Figure 20. Field of carrot stecklings planted in mid-July in the Malheur area. The roots will be dug, stored, and transplanted the following spring. This field has been selectively weeded with a light oil.

should elapse between growing crops susceptible to Sclerotinia rot and Botrytis (such as beans, peas, and lettuce) and growing carrots (3).

Seeding date, fertilization, thinning and irrigation practices should be aimed at the production of uniform, medium sized roots (1⅛ to 1¾ inches in diameter). Seeding should be made in early summer on a moist, well-prepared and weed-free seed bed. On dry land or where irrigation is not available it may be advisable to sow the seed in early April to insure getting a good stand. Row spacing will vary from 14 to 30 inches, depending on the method of cultivation to be used. Seeding rates vary from 2 to 4 pounds per acre, each acre providing enough roots to set out 5 to 8 acres for seed the next year.

The need for hand weeding in carrots has practically been eliminated as the result of selective weed control. The well-known Stoddard solvent and other light oils, if used at rates of 20 to 60 gallons per acre, have been highly effective in reducing weeds in the cultivated rows.

When the roots are dug in the fall only those that are clean, sound, and well topped (not closer than ½ inch from crown) should be stored. Those which have been bruised, caked with soil, and topped carelessly are subject to heavy storage losses. Idaho's recommendations for cellar storage point out the need for sanitary facilities. All refuse from previous storage should be properly disposed of. The floors, racks, and bins of the cellar should be sprayed thoroughly with a copper sulfate solution. If crates are not used for storage, the roots should not be piled more than 2½ to 3 feet deep on slatted decks, leaving about 18 inches of air space between the top of the pile and the next higher deck. Temperatures throughout the storage period should be as near 33° F. as possible. If roots are stored in a pit, it is important to locate the pit in clean soil, on an elevated site and on land which has not previously been in carrots. A narrow, nonventilated type of pit has been used successfully in British Columbia. The roots are placed in trenches in narrow, shallow layers from 6 to 10 inches deep and are left uncovered except during prolonged cold periods (13).

Producing the seed

Soil types best suited for the seed crop year are deep silt loams and clay loams with good drainage and high fertility. They should be deeply worked and in good tilth at the time of transplanting.

Early in the spring when danger from severe frosts is over, carrot roots or stecklings should be planted directly out of storage.

Experiments in southern Idaho have shown that a drastic reduction in yield occurs where roots are removed from storage longer than 7 days prior to planting.

In the transplanting operation, the soil should be firmly tamped around the roots and the crown should be even with the surface or slightly under the top of the soil. For rows spaced 36 inches apart, a spacing of 8 to 12 inches within the row is better than the wider spacings (3).

Experience has shown that carrot responds to heavy applications of fertilizer and that high fertility is one of the most important considerations in insuring a satisfactory crop. Growers commonly apply from 500 to 1,000 pounds of 5-10-10 or similar fertilizer at the time of planting and side-dress in May or early June with a light application of nitrogen fertilizer.

The blooming period for carrot plants extends over a long period (Figure 21). As a result, the seed clusters vary considerably in time of maturity. The crown set or top seed cluster matures first, followed by the secondary, and finally the tertiary bloom. As a result of this uneven maturity, a small percentage of the seed may be lost by shattering. In small plantings or in extremely weedy fields, individual seed heads should be picked by hand as they ripen. Three

Figure 21. Close-up of carrots for seed in second year of production in the Malheur irrigated area. Note the branching habit of the carrot plants and the lack of uniformity of maturity of the umbels.

or four pickings are usually necessary to obtain all of the seed by this method. Under ordinary field conditions, however, harvest should be done at a time when the majority of the seed clusters are dark brown and before all the tertiary seed clusters are fully mature. This stage of maturity is usually reached about the first of September in the Malheur irrigated area.

The crop can be mowed or bound into bundles and put in windrows or shocks for curing. When thoroughly dry, either the combine or stationary thresher, if properly set, is satisfactory for threshing the seed. Scarification, or the removal of spines on the carrot seed, is necessary and may be accomplished during the threshing or as a separate operation after threshing.

Yields ranging from 600 to 800 pounds are considered good by experienced growers. Several producers in the Snake River Valley, however, have reported yields of more than 1,000 pounds of seed per acre on soils of above-average fertility.

Table Beet

Nearly all of the table beet seed acreage in Oregon is confined to the Willamette Valley area. One of the main factors which restricts table beet seed production in eastern Oregon is the prevalence of the Curly Top disease in that area. Many problems exist in connection with growing and handling this crop and considerably more basic research is needed before full cultural recommendations can be made.

The usual method of production is by the transplant method. Some crops, however, have been produced satisfactorily on a seed-to-seed basis. Certain seedsmen, however, voice two major objections to this latter procedure. The first objection, and one of major importance, is the lack of winter hardiness of the table beet plant. Considerable risk is involved in safely overwintering the crop in western Oregon since table beets are less cold resistant than sugar beets, carrot, cabbage, etc. Secondly, no opportunity is afforded for discarding off-type roots as is the case with the transplant method.

Producing and storing roots

Table beet roots should be grown in about the same manner as beets produced for the cannery or the fresh market. Deep, friable loam or sandy loam soils are preferred since they allow growth of well-formed roots and aid in their subsequent handling. Irrigation usually is essential in order to put the soil in proper condition for planting and to keep the roots growing steadily until digging time in the fall.

Prior to planting, borax at the rate of 20 to 30 pounds per acre should be broadcast and worked into the soil in order to prevent beet canker. In addition, 200 to 300 pounds 5-10-10 is often used, the object being to supply enough plant food to produce good sound roots.

The best roots for seed production are grown from seed sown in early June. Seed is usually drilled at the rate of 8 to 10 pounds per acre in rows spaced 16 to 20 inches apart. Growers usually aim at the production of medium-sized roots, about the size of tennis balls, mainly because of less storage and handling costs as compared to the larger roots. If table beets are being produced by the more hazardous seed-to-seed method, planting can be delayed until mid-July, the same as for sugar beets.

With the transplant method, the beets are lifted and topped late in the fall before danger of heavy frosts. Care should be exercised to avoid bruising the roots or injuring the terminal buds. Some growers accomplish the topping process easily and effectively by running a mowing machine over the field prior to digging.

Roots can be stored by one of two methods: (1) shed storage with controlled temperature conditions and (2) field storage where outdoor temperatures must be reckoned with.

With shed storage, the roots are placed in crates, stacked in tiers and are held at a constant temperature of around 40° F. Sanitary precautions similar to those described for carrot root storage apply equally well to table beets.

With field storage, several methods can be used with varying degrees of success. One of the older methods of handling the roots is to place the roots in pits and pile them to a height of 2 feet or more above the ground. A heavy layer of straw usually is placed over the roots with soil being added as the weather becomes colder. Such pits should be located on a high, well-drained site with adequate ventilation being provided. Otherwise, considerable loss may be expected from rot organisms during years when mild winter temperatures prevail. Another method, and one which has been used successfully by a few growers in the Willamette Valley, is to pull and place the beets on the top of the ground in long windrows, 1 to 1½ feet high. Two rows are laid together with the tops being placed outward and the row is then covered with a few inches of soil. Still another method is the nonventilated type pit which is being used successfully by British Columbia seed growers (13). With this method, a long, narrow furrow is excavated and roots are piled in to a depth of 18 inches or so. Soil is then plowed over the roots before heavy frosts occur to provide winter protection.

Producing the seed

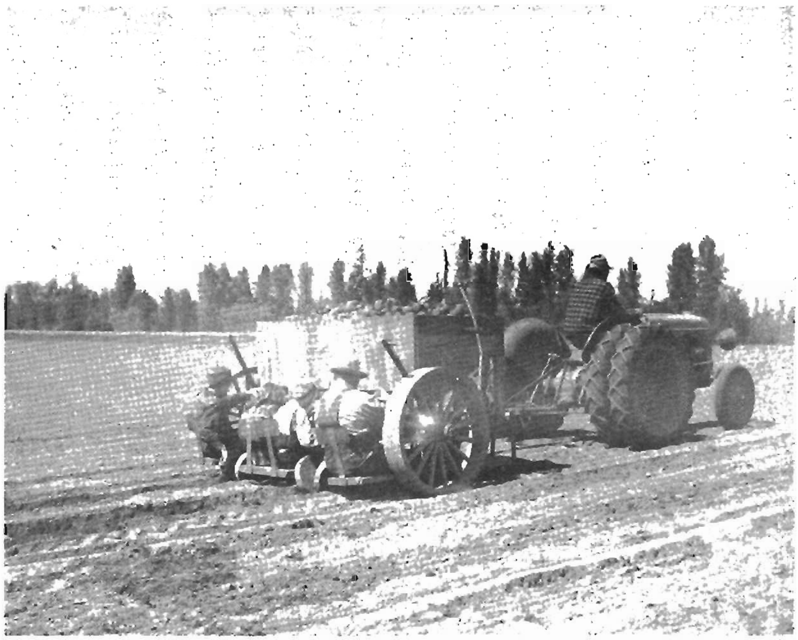
In the spring when the roots are removed from the pits, all diseased and off-type ones should be discarded. Late March and early April plantings usually are preferred, since progressive delays beyond this time result in a corresponding increase in reversal to bolting.

Because of the high positive correlation between size of root and seed yield, it is desirable that more root tissue develop after the roots are transplanted. Pendleton accomplished this experimentally with beet plants which were partially reverted to a vegetative condition after having been well conditioned for bolting, i.e., by (1) topping back the table beets transplanted in April, (2) delaying transplanting of the stored roots and (3) exposing the roots to warm temperatures for relatively short periods of time prior to transplanting (9). These results, however, have not been demonstrated successfully in field practice.

Specialized transplanting machines similar to those for planting cabbage are often used to set out the roots. Several special-built, two-row machines with large hoppers capable of holding 10 to 15 sacks of roots are in general use in the Willamette Valley (Figure 22). The roots should be placed in an upright position in rows spaced 3 to 3½ feet apart and 1 to 2 feet apart in the row, depending upon the size of the roots. The crown should be set at about the depth at which it grew or a little lower. If the ground is inclined to crust, care should be taken not to cover too deeply. Observations have pointed out the advisability of firmly tamping the soil around the roots following transplanting.

Results of fertility trials with table beets have been erratic and do not justify recommendations on the basis of the data obtained (Table 17). Nitrogen, however, appears to be the key element which one must consider. The general field practice is to side-dress with approximately 300 to 400 pounds of 16-20-0 or similar fertilizer after the roots are set out and later on, after the beet plants have bolted and flowered, to apply additional nitrogen through the sprinkler irrigation system. Liming, although it did not prove beneficial in the fertilizer trial conducted on a river-bottom soil, would probably increase yields on extremely acid soils. Beets are known to be sensitive to high soil acidity and will not make optimum growth where soil reaction shows a higher acidity than pH 5.5.

Particular attention should be given to adequate weed-control practices in the early stages of plant development since the control of weeds by mechanical means in the later stages of maturity is impossible without excessive mechanical injury to the plants. Often it is necessary to go over the seed field with a hoe in order to elimi-



—*Courtesy of Chas. H. Lilly Co.*

Figure 22. Transplanting table beets in early spring on riverbottom land. Note the fine and deeply worked condition of the seed bed. Press wheels of the transplanting machine pack the soil firmly around the roots.

nate late growing weeds or those that were missed in the earlier part of the season.

A common but perhaps somewhat questionable practice characteristic of table beet seed growing is to top or cut off the terminal seed stock of the beet plant to about knee height. This practice presumably forces a greater development of the seeds on the lower lateral branches and at the same time reduces the lodging tendency.

During early bloom stage, beet fields should be checked for lygus bug infestations. Lygus bugs are definitely known to lower sugar beet seed germination and probably are partly responsible for the low-germination problem in red beets. Entomologists recommend dusting with 5 per cent DDT to control lygus bug infestations.

Beets are considered ready for harvest when the base of the stalks and branches are quite brown, when the seed in the middle portion of the stalk is in the hard dough stage, and when the seed at the tips is still somewhat immature. Delaying the cutting operation beyond this stage results in considerable loss by shattering. To date, no suitable mechanical means for harvesting has been devised for this crop. Hand methods still prevail. The beet plant is pulled from the ground and the old root is removed with one stroke of the corn knife. The tops are then laid in small shocks or windrows for curing. When dry, the plants can be threshed easily with any good grain combine or stationary thresher. With either method it is necessary to reduce the cylinder speed and wind blast considerably and to open the concaves sufficiently to prevent hulling.

Seed yields in the Willamette Valley usually range from 800 to 2,000 pounds per acre. Yields nearly twice as high as the latter figure have been reported, however. Where roots have been carefully stored over winter and properly set out in good soil, yields of around 1,000 pounds per acre normally can be expected.

Table 17. EFFECT OF NITROGEN, LIME, AND PHOSPHORUS ON SEED YIELD OF DETROIT DARK RED TABLE BEETS.

(Irrigated Chehalis sandy loam, 1949)

Fertilizer elements other than nitrogen, amount per acre	Seed yields per acre with various amounts of nitrogen				
	No nitrogen	75 pounds nitrogen	150 pounds nitrogen	225 pounds nitrogen	Average, all rates nitrogen
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*
None	1,310	1,136	1,526	1,326	1,325
P_2O_5, 200 pounds	724	1,558	1,344	1,423	1,270
Lime, 3,000 pounds	1,252	1,160	1,584	1,401	1,349
P_2O_5, 200 pounds, plus lime, 3,000 pounds	1,132	1,474	1,594	1,279	1,370
Average, all treatments	1,104	1,340	1,512	1,358	1,328

Swiss Chard

Swiss chard, one of the oldest vegetable crops, has been grown successfully for seed production purposes in the Willamette Valley. This crop crosses readily with other members of the beet group and particular attention must be given to isolation from fields of sugar and table beets.

In the Willamette Valley, both the transplant and the seed-to-seed method have been used successfully. When grown by the transplant method, the root bed is established in about the same number as that described for table beets. The seed is planted around the middle of June and the plants are left in the field rather than stored as is the case with beets. In the spring the roots are plowed out and transplanted in the same manner as described for beet roots. Producing the seed crop from then on is about the same as growing table beets for seed.

When grown by the seed-to-seed method, chard is handled in a manner similar to sugar beets. Plantings can be made any time during midsummer provided irrigation water is available to start the seeding. If irrigation facilities are not available, seedings made in late May will usually produce enough growth by fall without irrigation. As with sugar beets, irrigation is not absolutely essential to produce a seed crop, but when available contributes considerably to increased yields.

One of the big problems is that of harvest. Good chard seed crops resemble sugar beet seed crops in that the plants are 7 to 8 feet tall and are meshed together in jungle-like fashion. The sugar beet harvester, a specially built windrower equipped with two cutter bars, is ideal for chard seed harvest (Figure 23). After curing in the swath the seed can be threshed with any good combine with a pickup attachment. Seed yields for chard have been quite high and average about the same as for beets.

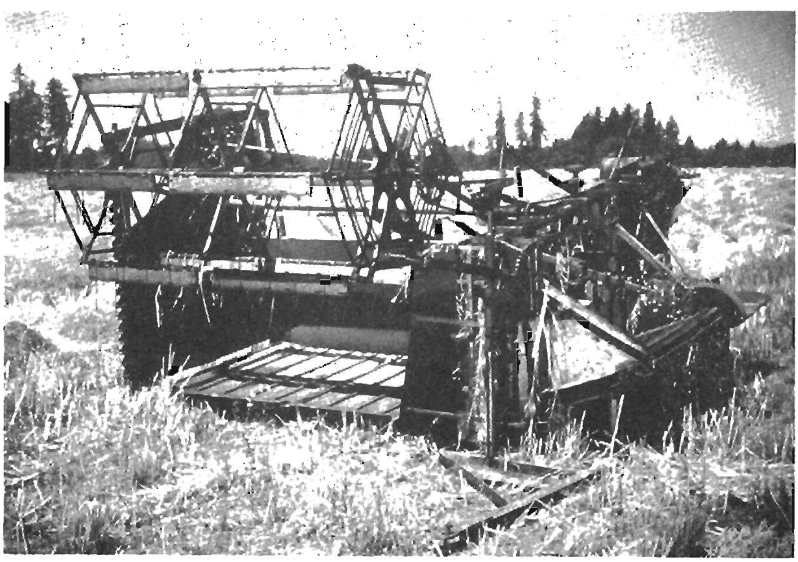


Figure 23. Windrower, commonly used for sugar beet seed harvest, is well adapted for cutting and windrowing such crops as swiss chard, mangel, and other heavy crops which cannot be harvested standing.

Mangel

Mangels have been grown successfully for seed purposes in western Oregon (Figure 24). This crop is very similar to sugar beets and swiss chard in general cultural and handling requirements and procedures. Excellent yields are often attained under dryland conditions because of the ability of the mangel root to draw on moisture reserves at the lower soil depths. Cultivation and harvest equipment suitable for sugar beets and swiss chard generally can be adapted for the production of mangel seed. Seed yields compare favorably with the aforementioned crops.

—Courtesy of James Gardens

Figure 24. Field of mangels for seed. The jungle-like growth habit of this biennial is similar to swiss chard and sugar beets.

Parsnip

Parsnip is a hardy, tall growing biennial particularly well adapted to Oregon for seed production purposes.

The root requires a long growing season, but in the second year it bolts quickly and the seed matures early, about the last of July in the Willamette Valley. Acreages, principally of the Harris Model variety, have been small because of the small amounts of seed required to meet the needs. Yields as high as 2,400 pounds of seed per acre have been reported for the Willamette Valley, with 1,500- to 1,600-pound yields being quite commonly attained.

Parsnip varieties cross readily and will likewise cross with wild parsnip. Cow parsnip apparently will not cross with the cultivated parsnip, but it is a host plant for the parsnip web worm, a very serious insect pest which may reduce the crop by as much as 75 per cent.

Seed can be produced either by the seed-to-seed method or the transplant method. The first method, being the most economical, is preferred for commercial seed production purposes. Where the main interest is one of growing stock seed of high quality, then the transplant method is preferred. Preliminary experimental information indicates that seed-to-seed production has a slight yield advantage over the transplant method.

With the seed-to-seed method, parsnip is sown thinly in rows 3 to 3½ feet apart sometime between May 15 to June 15 at rates varying from 3 to 4 pounds per acre. Since parsnip is slow to germinate, it is usually well to prepare the seedbed early in the spring and destroy a crop of weeds before seeding. It is advisable to mix a small quantity of a rapid growing crop, like radish, with the parsnip so that cultivation can begin earlier. Irrigation may be necessary to put the ground in a suitable condition for planting, depending on the season. The common practice is to fertilize at seeding time with 100 pounds of 16-20-0 per acre and to side-dress again in the fall with approximately double this amount. Early the next spring, following field overwintering, applications of nitrogen fertilizers such as ammonium sulfate, at rates of 100 to 150 pounds per acre, should be side-dressed on. All fertilizing and cultivating work should be accomplished as soon as possible in the spring since parsnip gains height very rapidly. Some growers make the practice of thinning the plants to a distance of 8" to 12" apart in the row. Others let the crop go through until maturity with a relatively thick stand in the row. Parsnip grown by the seed-to-seed method usually grows taller but develops less lateral spread than when produced by the transplant method.

Roots for the transplant method of production are produced in the same way as for the seed-to-seed method except that the rows should be spaced closer together and slightly heavier seeding rates should be used. Instead of going through to maturity in an undisturbed condition, the roots are plowed out either in late fall or in early spring, carefully sorted for type, and transplanted into a freshly and deeply worked soil. Transplanting of roots may be done in the fall but it is usually more convenient if done in early spring as soon as the ground can be worked. Rows are ordinarily spaced 3 to 4 feet apart and the roots spaced from 1 to 2 feet apart in the row. Finnell, however, found that spacing of plants within the row (1, 2, or 3 feet) made very little difference in the seed yield of transplanted parsnip. Furthermore, he determined that roots over 1 inch in diameter were slightly superior to roots less than 1 inch in diameter (2).

Parsnip seeds are produced in umbels or heads with two seeds being formed together flat against each other. When these begin to separate and the majority of the seed in the center umbel turns brown and the remainder of the umbels begin to take on a brownish cast, the seed is ready to harvest.

For small acreages, the plants are usually cut with corn knives and laid in windrows to cure. For larger areas, parsnip is either cut with a mower, by hand, or in the case of seed-to-seed parsnips, with a corn binder. With mechanical means the plants should be cut at a

—Courtesy of James Gardens

Figure 25. Threshing parsnip with a field combine. The crop had been cut and laid in windrows for curing prior to threshing. Parsnip is hardy, a high seed yielder, and is well adapted to Oregon.

slightly immature stage to prevent excessive shattering. Parsnip seed threshes easily when dry and can be threshed with conventional farm equipment (Figure 25). Breaking up of the flower parts should be avoided insofar as possible since they are extremely difficult to separate from the seed except with the aid of special cleaning equipment. Even at best, parsnip seed is difficult and costly to clean.

Some growers do not like to grow and handle parsnip because of its toxic effect on the skin, particularly from flowering time on through maturity. The toxic substance causes blisters on exposed skin parts. When working with parsnip, precautions should be taken to cover all exposed skin parts, insofar as possible.

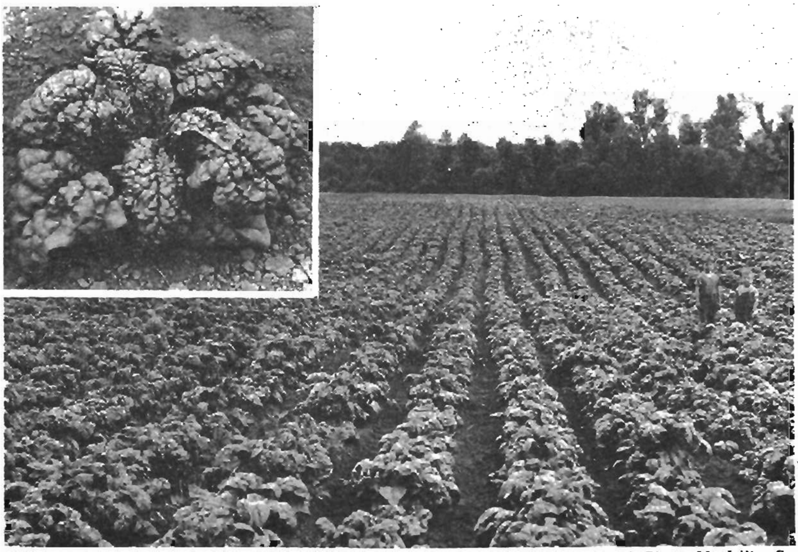
Spinach

Spinach is one of the cool season crops well adapted to seed production in the Willamette Valley. It is quite hardy, having the ability to withstand temperatures of 10° to 15° F. below freezing (7). At the present time, most of our spinach seed requirements are being supplied from Holland and Denmark.

Although spinach is classified as a biennial, it will produce seed the first season under Oregon conditions. This crop can be planted either in the fall or early spring. If fall seeded, the preferred month is September. If spring seeded, plantings should be made in March or early April (Table 18). The object of early spring planting is to obtain good sized plants capable of high seed yielding ability before the long days cause premature bolting. Germination is usually not a problem with early plantings since spinach seed will germinate satisfactorily with soil temperatures as low as 40° F. Soils selected for growing spinach seed should be near neutral in reaction, extremely fertile, and well supplied with moisture and organic matter. The seed is usually sown in rows spaced 18 to 24 inches apart at the rate of 6 to 8 pounds per acre (Figure 26).

For spring sown spinach, fertilizer should be side-dressed on at the time of seeding. Experiments with different fertilizers on a Chehalis sandy loam showed that nitrogen was the key element and that from 75 to 150 pounds were needed to obtain peak seed yields under irrigated conditions (Table 19 and Figure 27). Excessive rates of nitrogen, 225 pounds per acre, caused considerable lodging and delay in seed maturity. Phosphorus and potassium, when used alone or in combination with nitrogen, failed to give a yield response.

Spinach produces both male and female plants and only the latter type produce seed. Several growers have rogued for extreme



—*Courtesy of Chas. H. Lilly Co.*

Figure 26. Spinach being grown for seed purposes. Note the excellent vigor of the plants and the weed-free condition of the field. Spinach for seed can be planted either in fall or early spring in western Oregon.

Figure 27. The effect of nitrogen on spinach for seed. Plots from left to right were treated with 0, 75, 150, and 225 pounds of nitrogen per acre. Optimum level for seed purposes is somewhere between the second and third levels.

males before flowering but have reported very little success in eliminating this undesirable characteristic. For certain strains it may be necessary to do considerable roguing in order to eliminate off-type plants. The first roguing should be done before the plants bolt since it is easy to differentiate between types in the rosette stage of development. Later roguings may be necessary.

Two methods of harvest prevail in the Willamette Valley. One is to let the plants ripen fully, standing, until the seed is bone dry and then harvest with a combine. Considerable danger is involved with respect to shattering losses and to bird damage with this method, however. The other method is to cut and windrow the crop after the latest ripening plants have commenced to turn yellow, let cure in the field for a period of time, and then thresh.

Varieties vary greatly in their yielding ability under western Oregon conditions. From 500 to 600 pounds of seed might be considered average while under good soil and climatic conditions, more than 1,000 pounds per acre have been obtained.

Table 18. EFFECT OF DATE OF PLANTING ON SEED YIELD OF BLOOMSDALE SPINACH.

(Chehalis sandy loam, 1949)

Date of planting	Date of harvest	Yield per acre*
		Pounds
April 16	August 15	1,737
May 4	August 24	996
May 20	September 1	704

* Difference for significance at the 5 per cent level = 110.

Table 19. SEED YIELDS OF BLOOMSDALE SPINACH FOR DIFFERENT FERTILIZER TREATMENTS.

(Irrigated Chehalis sandy loam, 1949)

Treatment	Fertilizer per acre			Seed yield per acre*	Lodging
	Nitrogen	P_2O_5	K_2O		
	Pounds	*Pounds*	*Pounds*	*Pounds*	
Treatment 1	0	0	0	800	None
Treatment 2	75	0	0	1,254	None
Treatment 3	150	0	0	1,586	Some
Treatment 4	225	0	0	1,508	Considerable
Treatment 5	0	100	0	643	None
Treatment 6	0	200	0	675	None
Treatment 7	......	......	100	769	None
Treatment 8	150	200	100	1,542	Some

* Difference for significance at the 5 per cent level = 408.

Radish

Radish is a relatively easy seed crop to grow and appears to be adapted to all of the major farming areas in Oregon (Figure 28). The main problem in its production, however, has been one of inconsistent seed yields. In some years, from 500 to 800 pounds of seed are obtained easily whereas in other years, under slightly different conditions, yields are very low. Experts have difficulty predicting crop yields even when they appear most promising. Danish and Dutch seedsmen report this same difficulty under their conditions.

Commercial seed production of radish is usually on a seed-to-seed basis. Stock seed, however, should be produced with transplanted roots with attention being given to the careful selection of roots as to uniformity of size, shape, color, etc.

Plantings under dryland conditions should be made from March to April 15. Under irrigation, where a plentiful supply of water and plant nutrients are available, seedings made as late as early May have

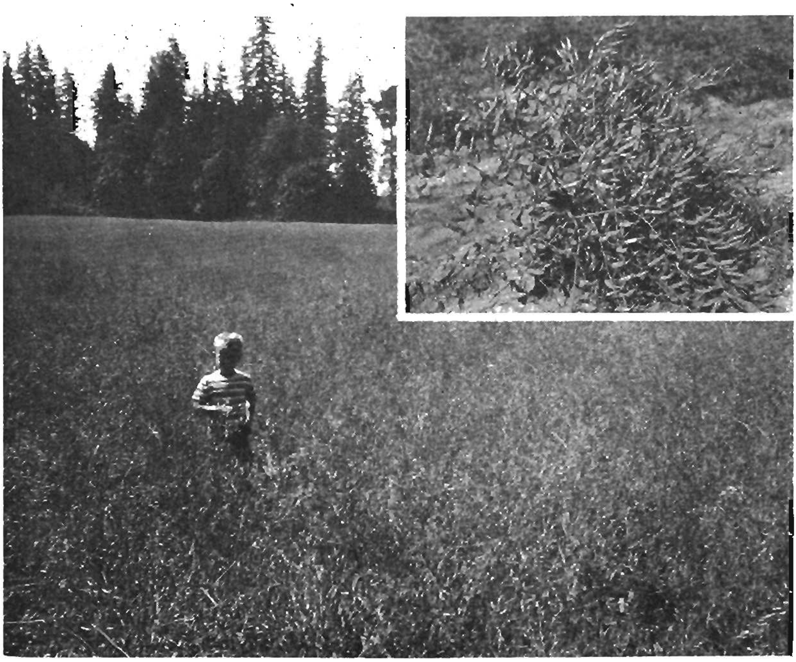


Figure 28. Comet radish for seed in the Willamette Valley. Meshed appearance of the seed pods makes the rows almost indistinguishable. The heavy pod set as shown in the inset is not always indicative of high yields.

matured successfully. Since the radish plant is a poor competitor with weeds, row plantings are recommended over solid seedings. In the early stages of plant growth, flea beetles are often a severe problem and have caused the loss of many stands. Growers should be set to control these insects particularly during the cotyledon stage of growth, the time when the plants are most susceptible to insect injury. Blooming extends over a long period and the seed usually reaches maturity about September 1 in the Willamette Valley and October 1 in central Oregon.

Finnell, in 1943, found that various row spacings of 2, 2½, and 3 feet had no significant effect on seed yields. Further, in studying the different methods of seeding, he found that the ordinary method of surface planting was as good as furrow planting or where the plants were ridged with 2 inches of soil along the rows (Table 20).

Table 20. SEED YIELD OF VICS SCARLET GLOBE RADISH FOR VARIOUS ROW WIDTHS AND METHODS OF PLANTING.

(Nonirrigated Chehalis sandy loam, 1943)*

Row width	Seed yields per acre from various methods of planting			
	Drilled on surface	Drilled in 2" furrows	Drilled on surface, later 2" ridged	Average, all methods
	Pounds	*Pounds*	*Pounds*	*Pounds*
2 feet	386	398	388	391
2½ feet	429	367	405	400
3 feet	416	436	428	427
Average	410	400	407	406

* Data from Oregon Agricultural Experiment Station Report by H. E. Finnell.

Radish does not appear to be too exacting in its soil requirements and can be grown on a wide range of soil types. The best yields are usually obtained on the better soil types, however. One year's results with the Comet variety on irrigated Chehalis soil showed that both nitrogen and phosphorus gave increased yield responses (Tables 21). Highest yields were obtained where a combination of 100 pounds of nitrogen and 200 pounds of P_2O_5 were applied as a side-dressed application shortly after emergence. Plots that received no fertilizer yielded only about one-half as much as the fertilized plots. Observations showed that nitrogen delayed seed maturity and that irrigation tended to prolong the normal flowering period.

Threshing of radish is very difficult because of the tendency for the seeds and the pithy pod to stick together in the threshing process. Also, the seed cracks readily and the pods blow over easily while threshing. Special threshing equipment is desirable if large acreages are involved. When using the ordinary combine or stationary thresher, it is necessary to reduce the cylinder speed to 500 to 600 RPM, remove most of the concaves, and reduce the wind blast. Even then it usually pays to rerun the threshed material once or twice in order to remove the seed from the pods which pass intact over the screens on the first run.

Table 21. SEED YIELDS OF COMET RADISH USING VARIOUS FERTILIZER TREATMENTS.

(Irrigated Chehalis sandy loam, 1950)

Treatment	Amount of fertilizer per acre: Nitrogen	Amount of fertilizer per acre: P_2O_5	Seed yield per acre*
	Pounds	*Pounds*	*Pounds*
Treatment 1	None	None	809
Treatment 2	50	......	1,202
Treatment 3	100	......	1,453
Treatment 4	150	......	1,430
Treatment 5	......	200	1,351
Treatment 6	100	200	1,573

* Difference for significance at the 5 per cent level = 185.

Lettuce

Nearly all of the lettuce grown for seed purposes in Oregon is produced in the Malheur irrigated area (Figure 29). Some growers in the Willamette Valley have produced satisfactory crops of the earlier maturing varieties, although proper maturity is often a problem especially during seasons when fall rains come early. Warmer temperatures are required for lettuce seed production than for the production of marketable heads. Most varieties require temperatures of 70° F. or higher for proper seed stalk formation (7).

Lettuce for seed is handled as an annual, being planted in early spring as soon as soil conditions permit and harvested in late summer when the seeds have swelled and turned yellow in color.

Soils selected for growing lettuce seed should be fertile and well supplied with organic matter. Because of the lettuce plant's demand for a plentiful supply of moisture during the growing season,

Figure 29. Lettuce, a self-pollinated crop, in bloom in the Malheur irrigated area. The alley in the middle of the field separates one variety from another in order to avoid mechanical mixture during harvesting operations.

heavy silt and clay loam soils are preferred. Soils known to harbor *Sclerotinia* should be avoided. Preparation of the soil and bed structure are generally the same as for market lettuce (Figure 30).

The seed should be planted thinly, at the rate of 1 to 1½ pounds per acre. Several weeks after planting, the seedlings are thinned in the row, the large heading types to 10" to 12" and the smaller growing types to 6" to 8" apart.

When the plants begin to head, off-type heads should be discarded. For some of the harder heading lettuce types, such as Great Lakes and Cornell 456, it may be necessary to split or pull the head leaves apart to allow the seed stalk to emerge. Proper timing of this operation is important since if done too early the plant will continue to head and if delayed too long seed stalk injury is inevitable. The use of hormone sprays, which prevent heading and permit the release of the seed stalk of the difficult bolters, may eliminate the expensive method of slashing. Although not yet perfected, definite progress is reported by the Parma, Idaho, Branch Experiment Station.

Since lettuce responds to careful cultivation, close attention from seeding time to maturity is required in growing the seed crop. One

Figure 30. Lettuce field prior to bolting in the irrigated Malheur section. Note that lettuce is planted in beds, the same as for commercial lettuce production.

of the most serious weeds is wild lettuce, being very difficult to separate from commercial lettuce in seed cleaning operations.

Exact fertilizer requirements for lettuce are unknown for Oregon conditions. Growers commonly side-dress with light applications of nitrogen fertilizer during critical periods of growth. Arizona producers have found that nitrogen applied at the time of bolting, for example, increases seed yields (5).

Lettuce ripens unevenly. If allowed to go to full maturity, shattering losses may be quite severe. The highest yields are obtained by hand harvesting methods. If fields are small, trained workers should go through the fields and shake the flower heads into picking sacks when one-third to one-half of the seed is firm and dry. Successive pickings will yield nearly all the seed, thus reducing the danger of wind shattering. The most popular method of harvest for larger fields, however, is to swath the crop when the majority of the seeds are yellowish in color, let dry, and then run through a combine which has some of the teeth removed.

Seed yields of 400 to 500 pounds per acre are considered good and can be attained easily by growers who give attention to the cultural demands and needs of the crop.

Cucumber

Cucumbers, like other vine seed crops, are characteristically warm-season crops, being intolerant of frost. Cucumber, squash, and muskmelon grow well where mean temperatures of 65° to 80° F. prevail (1).

Generally speaking, the production of vine seed crops is quite similar to growing for the fresh market, cannery, etc. They can be planted in two ways—either drilled in in rows or planted in hills. The tendency has been to drill in the smaller seeded vine crops such as cucumbers and to plant in hills the larger seeded crops such as squash and pumpkins. Good yields have been reported with both methods. The hill method, however, has the extra advantage of the prospect of cross cultivation if weeds are a serious problem.

In recent years several commercial seedsmen have transferred considerable of their cucumber seed production activities from eastern Oregon and other parts of the United States to the Willamette Valley. Experience here has shown that high seed yields are possible. Insect and disease difficulties are not serious.

Planting

Cucumbers should be planted on well prepared, weed-free land, from May 10 to June 10. Results of a date of planting experiment with 16 varieties of cucumbers on a Willamette clay loam soil showed that there were no significant yield differences between plantings made on May 7, May 18, or June 2 (Table 22). Earlier experiments on a Chehalis sandy loam soil, however, indicated that May plantings were slightly superior to those made in June. July plantings usually fail to mature seed. All seed should be treated prior to planting in order to lessen stand reductions caused by damping off organisms. Damping off losses are usually most serious on the earlier plantings when soil temperatures are still low.

If cucumbers are sown with a drill the rows are usually spaced about 3 feet apart with the plants from 4 to 12 inches apart in the row. If checked, the seed is placed in hills spaced 3 to 3½ feet apart. Seeding rates vary from 3 to 4 pounds per acre, depending on the spacing.

Growing the seed crop

Cucumbers are extremely responsive to good soil and sound fertilizer and water management practices. Irrigation should be aimed at keeping the plants in an active and vigorous condition throughout the growing season.

Table 22. SEED YIELDS FOR SIXTEEN VARIETIES OF CUCUMBERS PLANTED AT THREE DIFFERENT DATES.

(Irrigated Chehalis clay loam, 1949)

Variety	Seed yield per acre for various dates of planting*			
	May 7	May 18	June 2	Average, all dates
	Pounds	*Pounds*	*Pounds*	*Pounds*
A and C	977	1,147	988	1,037
Black Diamond	1,006	1,105	962	1,024
Boston Pickling	1,190	1,348	1,226	1,255
Chicago Pickling	1,234	1,408	1,181	1,274
Cubit	581	708	670	653
Davis Perfect	898	1,093	1,037	1,009
Early Cluster	1,153	1,288	1,162	1,201
Early Fortune	1,077	920	1,059	1,019
Early Russian	1,133	1,256	1,063	1,150
Highmoor	705	798	898	800
Improved Long Green	1,129	1,227	1,048	1,135
Longfellow	917	1,065	836	939
Marketeer	635	714	774	708
Stays Green	622	759	869	750
Straight Eight	725	883	819	809
White Wonder	1,099	1,144	1,235	1,160
Average, all varieties	943	1,054	989	995

* Difference for significance at the 5 per cent level for varieties = 133. Differences for the various dates are not significant at the 5 per cent level.

Table 23. EFFECT OF SIDE-DRESSED APPLICATIONS OF NITROGEN, PHOSPHORUS, AND POTASSIUM ON THE SEED YIELD OF BOSTON PICKLING CUCUMBERS.

(Irrigated Chehalis sandy loam, 1948.)

Experiment and treatment	Fertilizer per acre*			Seed yield per acre†
	Nitrogen	P_2O_5	K_2O	
	Pounds	*Pounds*	*Pounds*	*Pounds*
Experiment 1				
Treatment 1	0	0	0	1,001
Treatment 2	60	0	0	1,213
Treatment 3	120	0	0	1,259
Treatment 4	180	0	0	1,438
Experiment 2				
Treatment 1	120	0	0	1,259
Treatment 2	120	200	0	1,408
Treatment 3	120	200	100	1,286

* Boron was applied uniformly, at 30 pounds per acre, to all plots. All other fertilizers applied at time of planting.

† Experiment 1: Difference for significance at the 5 per cent level = 139. Experiment 2: Differences not significant at the 5 per cent level.

Present cucumber seed growers usually apply from 300 to 400 pounds of 16-20-0, or its equivalent, to produce a seed crop. Three years of experimental results with Boston Pickling cucumbers on a Chehalis soil type have shown that nitrogen is the main element influencing seed yields (Tables 23 to 27 and Figure 31). Phosphorus,

Figure 31. Comparison of nitrogen and phosphorus fertilizers on Boston Pickling cucumbers. Plot on left was side-dressed with 150 pounds of nitrogen per acre; plot on right received 150 pounds of P_2O_5 per acre. Nitrogen is the key to cucumber seed production in Oregon.

potassium, sulfur, and boron have failed to give measurable seed increases (Tables 23, 24). Results for specific rates of nitrogen have been somewhat erratic, but, nevertheless, point to the fact that rates used commonly may be insufficient for optimum seed yields. Significant increases in yield were noted in 1948 on Chehalis sandy loam soil, formerly in alfalfa, with up to 180 pounds of elemental nitrogen per acre (Table 23). In 1949, on a similar soil type of average fertility, the 150-pound level gave the best yields (Table 25). The same year, however, on Chehalis clay loam soil one year away from alfalfa, the yields were a trifle higher for the nitrogen plots but differences were statistically insignificant (Table 26). The 120-pound level gave the best yield in 1950, where smaller increments of nitro-

Table 24. EFFECT OF BORON AND SULFUR ON SEED YIELDS OF BOSTON PICKLING CUCUMBERS.

(Irrigated Chehalis sandy loam, 1948)

Treatment	Fertilizer per acre					Seed yield per acre†
	Nitrogen	P_2O_5	K_2O	Boron	Sulfur*	
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Treatment 1	None	None	None	None	None	868
Treatment 2	120	200	100	......	......	1,286
Treatment 3	120	200	100	30	......	1,325
Treatment 4	120	200	100	......	30	1,322
Treatment 5	120	200	100	30	30	1,276

* $(NH_4)_2SO_4$ provided source of sulfur.
† Differences not significant at 5 per cent level for treatments 2, 3, 4, and 5.

Table 25. EFFECT OF NITROGEN AND PHOSPHORUS ON SEED YIELDS FOR BOSTON PICKLING CUCUMBERS.

(Irrigated Chehalis sandy loam soil, 1949)

Phosphorus per acre	Seed yields per acre for various amounts of nitrogen*				
	No nitrogen	75 pounds nitrogen	150 pounds nitrogen	225 pounds nitrogen	Average, all rates nitrogen
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*
None	966	1,275	1,492	1,375	1,277
75 pounds	828	1,216	1,435	1,222	1,175
150 pounds	917	1,304	1,198	1,255	1,168
225 pounds	876	1,276	1,272	1,322	1,187
Average	897	1,268	1,349	1,293	1,202

* Difference for significance at the 5 per cent level for nitrogen means = 173.

gen were tested (Table 27). It is apparent, therefore, that on soils of average fertility, where the crop is well supplied with moisture throughout the growing season, that rates of nitrogen up to 120 to 150 pounds per acre can be used profitably for cucumber seed production.

Preliminary experimental results indicate that there is no difference in the method of application of fertilizer, whether broadcast before seeding or side-dressed at time of planting. Likewise, split applications of nitrogen have failed to give significant increases in yield over single applications (Table 28).

Table 26. EFFECT OF REMOVAL OF PICKLES AND RATE OF NITROGEN ON SEED YIELD OF BOSTON PICKLING CUCUMBERS FOLLOWING ALFALFA.

(Irrigated Chehalis clay loam, 1949)

Nitrogen per acre	Seed yield per acre for picked and nonpicked plots*			
	Not picked	Picked once	Picked twice	Average, all plots
	Pounds	*Pounds*	*Pounds*	*Pounds*
None	1,200	995	987	1,060
100 pounds	1,341	1,063	1,067	1,157
200 pounds	1,424	1,159	1,017	1,200
300 pounds	1,154	1,050	1,047	1,084
100 pounds (plus 200 pounds P_2O_5 and 100 pounds K_2O)	1,114	1,064	1,069	1,082
Average, all treatments	1,247	1,066	1,037	1,117

* Mean values of nonpicked plots are significantly higher than picked plots.

—*Courtesy of James Gardens*

Figure 32. Harvesting cucumbers with a special-built cucumber thresher in the Willamette Valley. The cucumber seed is separated from the rind and a portion of the pulpy material inside the fruits during the threshing process.

Table 27. Effect of Various Rates of Nitrogen on Seed Yields of Boston Pickling Cucumbers.

(Irrigated Chehalis sandy loam, 1950)

Nitrogen per acre	Yield per acre*
	Pounds
None	873
40 pounds	873
80 pounds	996
120 pounds	1,053
160 pounds	945
200 pounds	1,040

* Differences not significant at the 5 per cent level.

Table 28. Effect of Rate of Nitrogen and Time of Application on Seed Yields of Boston Pickling Cucumbers.

(Irrigated Chehalis sandy loam, 1950)

Total nitrogen per acre	Time of application and amount per acre		Seed yield per acre‡
	May 30*	June 30†	
Single application			*Pounds*
None	......	......	1,037
100 pounds	100	......	1,139
150 pounds	150	......	1,011
200 pounds	200	......	1,059
Split application			
100 pounds	50	50	1,102
150 pounds	75	75	1,116
200 pounds	100	100	1,084

* Side-dressed at time of emergence.
† Broadcast and watered in.
‡ Differences not significant at the 5 per cent level.

Harvesting and threshing

Cucumbers usually are ready for harvest in the Willamette Valley during the first part of October. The seeds are considered mature when they are no longer fastened to the rind and when the fruits have taken on a characteristic ripened color. The black-spined varieties are yellow to deep orange at maturity, whereas white-spined types are light green to almost white in color.

The practice of removing pickle crops prior to the time of harvesting the seed reduces seed yields (Table 26).

Special harvesting machines are needed to crush the fruits and separate the rind and part of the pulp from the seed (Figure 32).

The seed is sacked from the machine and allowed to remain in the field from one to two weeks in order to allow for partial decomposition of the pulpy material by natural fermentation processes. Over-fermentation should be avoided as this tends to result in discolored and lower quality seed. After field fermentation the seed is then hauled to washers where the pulp is washed free from the seed. After the washing process, the clean seed is placed in trays or in revolving drums for drying purposes. In both instances, adequate provision should be made for forced air movement in order to speed up the drying process. With tray drying it is necessary to stir the seed occasionally in order to obtain uniform drying and to prevent caking of the seed. During the first part of the drying process when the seed is still wet, temperatures should not go over 100° F. Temperatures throughout the remainder of the drying period should not exceed 110° F.

Varieties vary considerably in yielding ability. Pickling varieties are superior to slicing varieties. Yields from 800 to 1,000 pounds of seed per acre can be obtained with pickling varieties whereas 500- to 600-pound yields are more characteristic of the slicing types. Boston Pickling, Early Russian, Early Cluster and White Wonder have been consistently high yielders (Table 22). Marketeer, Palmetto, and Highmoor, on the other hand, have been low in seed-yielding ability, producing only about one-half that of the pickling types.

Squash and Pumpkin

There are two main types of squash: the summer or bush type, and the winter or vining type. From a seed production standpoint, both types are easy to grow, but they differ somewhat in their cultural and handling requirements.

Summer squash, typified by such varieties as White Bush Scallop and Black Zucchini, requires better soils, is more responsive to fertilizer, and is generally higher yielding than winter squash. Summer varieties should be planted in rows or in checked hills 3 to 4 feet apart (Figure 33). Winter varieties, such as Table Queen and Buttercup, are spaced further apart, with 6 to 8 feet between hills being most common. Spacing experiments with Mammoth Table Queen and Warted Blue Hubbard indicated that various spacings, both between and within rows, had very little effect on seed yields. The trend, however, was for somewhat higher seed yields with the narrower spacings (Table 29).

Figure 33. Summer squash being grown for seed purposes in the Willamette Valley. Although fields are usually planted in hills as shown above, they soon assume a uniform appearance because of a vigorous vine growth. Summer squash is threshed in much the same manner as cucumbers.

Both types of squash should be planted between May 1 and June 1 and at the rate of 3 to 5 pounds per acre, depending upon the spacing used.

Results of various fertility experiments are inconclusive for the larger vine seed crops. The common practice is to side-dress, if planted in rows, or to place the fertilizer in bands around hills. Commercial seedsmen usually recommend that 200 to 400 pounds of 16-20-0 fertilizer, or its equivalent, be used, the exact rate depending upon the soil fertility level. Light applications of nitrate fertilizers are often applied through the sprinkler system during the growing season.

Squash seed should be harvested after the first frost, when the fruits have taken on their characteristic matured color and when the seeds inside of the shell break away readily from the pulp. If the seed is immature, the pulp will adhere to the seed.

Summer squash can be threshed with a cucumber thresher. Winter squash, with the thickened and tough shells, is usually split open and the seeds scooped out by hand (Figure 34). After threshing

—Courtesy of James Gardens

Figure 34. Winter squash following harvest. Because of the hard outer shell, seed is scooped out by hand instead of being threshed mechanically.

summer squash the seed should be washed within 48 hours in order to prevent heating. Undue fermentation at this stage can materially injure and darken the appearance of the seed. The need for handling winter squash immediately after threshing is not quite as critical as summer squash although it should be processed within 3 or 4 days following removal of the seed from the fruits. After washing, the seed is placed on trays for drying. Drying temperatures are similar to those for cucumbers.

Seed yields vary greatly according to variety for both the summer and winter squashes. Yields from 600 to 800 pounds of seed per acre are commonly obtained with summer squash varieties, whereas, yields ranging from 400 to 500 pounds are more or less typical of the winter squash varieties.

Pumpkins are similar to winter squash in their growing requirements and general threshing and processing procedures. Irrigation should not be as heavy as for summer squash because of the danger of too much vine growth and delay of maturity of the fruits. Pumpkin seed yields have been somewhat variable although yields from 400 to 600 pounds are often attained under irrigated conditions.

Table 29. EFFECT OF SPACING OF TWO VARIETIES OF WINTER SQUASH.

(Chehalis sandy loam, 1948)

Plant spacing within rows	Seed yield per acre*	
	Mammoth Table Queen	Warted Blue Hubbard
	Pounds	*Pounds*
3-foot rows		
Drilled	1,353	540
2 feet	912	900
4 feet	990	978
6 feet	995	989
Average, 3-foot rows	1,062	852
4½-foot rows		
Drilled	730	373
2 feet	769	491
4 feet	704	872
6 feet	645	449
Average, 4½-foot rows	712	546
6-foot rows		
Drilled	741	421
2 feet	683	399
4 feet	655	554
6 feet	548	625
Average, 6-foot rows	656	500

* Mean differences not significant at the 5 per cent level.

Muskmelon and Watermelon

Neither muskmelon nor watermelon were being contracted for seed production purposes in Oregon in 1951. High-quality seed of these crops can be produced, however, in areas favored with a long growing season and with fairly high mean temperatures. Muskmelons usually need a little warmer temperature than cucumbers and for this reason are not as well adapted to western Oregon conditions as are the cucumbers and squash. Watermelons require a long season for maturity and thrive where mean temperatures are above 70°

F. They can be grown successfully along the Snake River in eastern Oregon and in the irrigated Hermiston area of Umatilla County.

In the past, growers usually have realized a greater financial return from the sale of melons than from the seed. It is doubtful if Oregon will ever be able to compete effectively with the Arkansas Valley in Colorado in muskmelon seed production, or with California and Florida in watermelon seed production.

Muskmelons are similar to cucumbers in their cultural and fertility requirements. The harvest process differs somewhat, however, because of the fact that muskmelons do not mature uniformly and must be threshed several times during the season. Since muskmelon pulp deteriorates rapidly, care must be taken so as not to allow excessive fermentation after threshing. The washing process should be done just at the time when the pulpy material is beginning to "break down." Seed yields of muskmelons in the Malheur area have averaged around 300 pounds per acre with 500 pounds being considered a high yield.

Watermelons require sandier soils and tolerate less fertility than most of the other vegetable seed crops. The preferred time of planting is from May 15 to June 10. Spacing between hills varies from 8 to 10 feet. Seed is mature and ready for harvest a little beyond the eating stage. The thresher commonly used for cucumbers is adaptable for threshing watermelons. Watermelon seed, unless washed and dried soon after threshing, will ferment rapidly, thus causing a poor color and a reduction in the sale value of the seed. Seed yields for the most part are similar to those of muskmelons.

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