Sugar Beet Seed PRODUCTION IN OREGON

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SUMMARY

The relatively long winter season with a mean temperature of 35° to 45° F. in western Oregon, provides an almost optimum condition for stimulating seed stalk formation of sugar beets.

Soils of the Willamette Valley best suited for sugar beet seed production are Chehalis, Newberg, Willamette, Hillsboro, and better grades of Amity; for the Medford area they are Medford, Neal, Columbia, and Sams.

Beets for seed should be fertilized in the fall with about 100 to 200 pounds per acre of ammonium sulphate. They should be side-dressed in the spring with 400 to 1,000 pounds per acre of nitrogen-carrying fertilizer, one-half of which should be ammonium sulphate. Mixtures of ammonium sulphate and sodium nitrate for the spring side dressing have given 100 pounds per acre more seed than ammonium sulphate alone. If both forms are to be used in the spring, they should either be mixed or the ammonium sulphate applied first. Ammonium phosphate may be substituted in part for the ammonium sulphate. Every effort should be made to increase the organic matter content of the soils.

All Willamette Valley fields should have from 125 to 150 pounds gypsum and 25 to 30 pounds of borax per acre broadcast before planting. In the Medford area elemental sulphur should be broadcast at the rate of about 90 pounds per acre.

Neither the Willamette Valley nor Medford soils have shown any consistent response to phosphorus or potash. A few spring treatments of phosphorus have produced small increases in yields.

Beet seed may be successfully grown in the Willamette Valley without irrigation by planting in early June. Supplemental irrigation, however, will generally be very profitable.

Experiment Station trials at Corvallis showed better yields from unirrigated beets planted in June than from irrigated beets planted in late August. The advantage of the irrigation did not overcome the disadvantage of the late planting.

Stands of from 4 to 10 beets per foot of row in 24-inch row widths have been most satisfactory.

Weeds should be eradicated before planting insofar as possible. A cultivation as late in the fall as possible and as early in the spring as conditions will permit will go far toward elimination of the necessity of hoeing.

Operations which in any manner tend to remove the early spring leaves should be avoided. This includes pasturing with livestock, springtoothing, cross cultivation or other like treatments.

Proper consideration should be given to isolation from crops related to beets, such as garden beets, mangels, and chard.

Retaining old roots for a second seed crop is not recommended.

Resistant varieties are being developed to minimize damage from leaf spots, mildew, rust, and other minor diseases in western Oregon.

Illustration on cover—

Figure 1. Very heavy crop of sugar beet seed grown at the Southern Oregon Branch Experiment Station, Talent, Oregon.

Sugar Beet Seed Production in Oregon*

by

Ray A. Pendleton, H. E. Finnell, and F. C. Reimer†

INTRODUCTION

The American beet sugar industry has become wholly dependent on domestic production of sugar beet seed in recent years. Ample supplies of adapted varieties must be available to meet the demand. Western Oregon is well-suited for the production of most of these varieties.

Practically all of the sugar beet seed produced in this country is by the method of overwintering in the field, a practice that fits in well with western Oregon agriculture. The first successful demonstration in Oregon for this method of growing sugar beet seed was at the Southern Oregon Branch Experiment Station at Talent in 1936-37. The following season successful experimental plantings were made on the Experiment Station at Corvallis and several other points in the Willamette and Rogue River valleys, and one was made at Klamath Falls. These early successful trials included varieties that had not satisfactorily produced seed in previously established seed growing areas. Following these experiments, the industry expanded to 300 acres harvested in 1939 and 1,470 acres in 1941. The acreage has declined somewhat during the war years.

Varieties resistant to bolting‡ are in demand for fall and winter planting in California where growers of beets for sugar wish to avoid seed stalk development in the first, or vegetative, year of growth. Such varieties will produce seed satisfactorily in western Oregon.

CLIMATIC RELATIONS

Reproductive processes in beets, when overwintered in the field, are dependent on winter temperatures cold enough to retard growth, yet not so cold as to cause complete dormancy or serious frost injury.

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‡ Production of seed stalks.

Temperature

The relation of temperature to flowering in sugar beets has been studied by Owen and others. (*4*)* Temperatures ranging from 35° to 50° F. for a 4- to 5-month period have been found very favorable for this purpose. In the Willamette Valley and Medford areas the period from October to April has a mean temperature within this favorable range as shown by Figure 2. Varieties of sugar beets have been developed mainly by mass selections for desirable characteristics and are not pure lines. It is important, therefore, to have every plant produce seed in order to reproduce all these varietal characteristics.

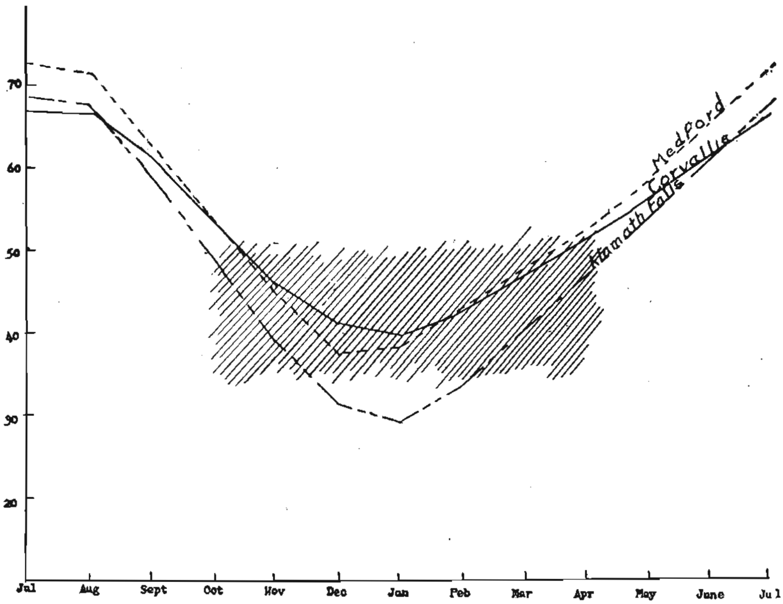

Figure 2. Average monthly temperatures for Oregon beet seed growing areas. Shaded portion represents temperature zone favorable for starting reproductive processes.

Klamath Falls has a mean temperature during October, November, February, and March that lies within this favorable range. The area, however, has a hazardous period during December and January when temperatures may drop as low as —25° F. and, frequently, drop below the safety point with respect to beet root injury.

Rainfall

The annual rainfall of the Willamette Valley averages about 40 inches which is considerably more than in the other seed growing

* Italic numbers in parentheses refer to LITERATURE CITED on page 23.

areas. Medford has about 17 inches and Klamath Falls about 12 inches. The higher rainfall of the Willamette Valley has both advantages and disadvantages. Less irrigation is required than in drier areas. In fact, it has been demonstrated that beet seed can be grown successfully without irrigation. Disadvantages of the higher rainfall are that it favors the development of certain fungus diseases on beets and may interfere with cultural operations.

Environmental

Another favorable factor in western Oregon arising from climatic conditions is that the environment is unfavorable for the beet leaf-hopper, the insect that carries the virus of curly top. Because of this, varieties susceptible to curly top can be grown in this area with practically no injury from the disease. Such varieties have sometimes been heavily damaged by curly top in other seed growing areas.

SOIL REQUIREMENTS

Because the sugar beet is a deep rooted plant, a deep mellow soil is preferable. Plow soles, hard pans, or other similar physical

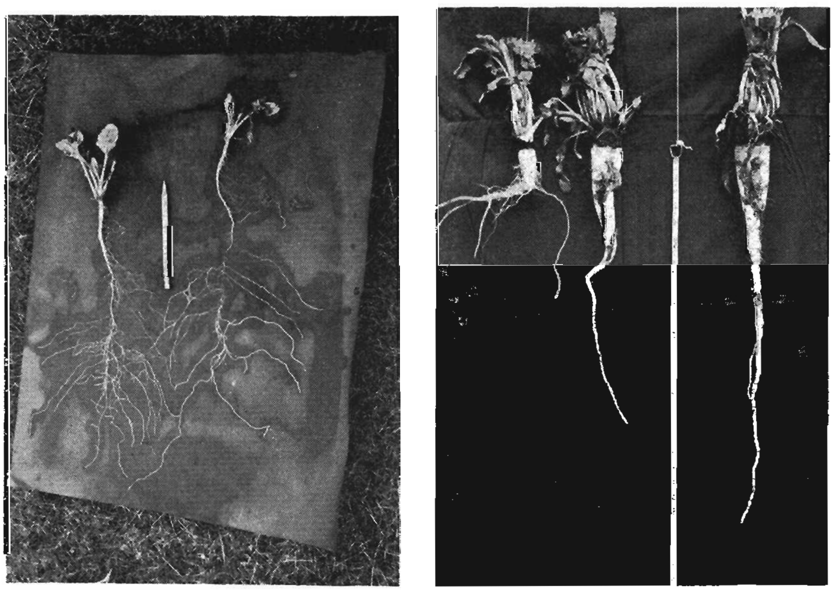

Figure 3. Root system of sugar beet plants as grown in seed fields: (A) Seedling plants on sandy loam soil, unrestricted penetration. (B) Overwintered plants. Penetration of the soil in the case of the two plants at the left was restricted by poor physical condition of the soil. The plant at the right shows growth of the root when penetration in the soil was unrestricted.

features of the soil, which occur near the surface, may seriously interfere with the root development and subsequent general growth (Figure 3). Good aeration, high fertility, and high water-holding capacity are important characteristics.

Chehalis and Newberg soils are used most extensively in the Willamette Valley; of these, Chehalis is more desirable because of its better general fertility. These are recent alluvial soils adjacent to streams and are subject to overflow. Chehalis soils have a medium-brown to rich-brown surface with a similar textured subsoil to a depth of 3 or more feet. The surface of Newberg soils is similar to that of Chehalis; but they have lighter, more sandy subsoils, and are not as retentive of soil moisture.

Good beet growth has also been produced on the older alluvial bench land soils not subject to overflow, including Willamette, Hillsboro, and the better grades of Amity. Soils of the Willamette series are typically brown in color but are somewhat more compact in the subsoil than Chehalis tending to impede root penetration. The better grades of Amity are somewhat like Willamette except for still greater compactness in the subsoil. Soils of the Hillsboro series, which occur only in limited areas, resemble Willamette but have more open subsoils.

In the Medford area the principal acreage is on soils of the Medford series. These soils are usually well-drained, brown to dark-brown to a depth of 12 to 16 inches, and carry varying quantities of angular granitic particles. The heavier types are darker in color and have more restricted drainage. Other soils of the Medford area suitable for beet growth include Neal, Sams, and Columbia.

FERTILITY PROBLEMS

Relatively few field crops make as much vegetative growth as a heavy crop of beet seed. Yields of 5,000 pounds of seed per acre have been produced in southern Oregon and up to 4,000 pounds in the Willamette Valley, although average yields are much less. Consequently, the demand on plant food material is large. Even in very fertile soils some supplemental fertilization is required. On the less fertile fields relatively large amounts of commercial fertilizer are needed to produce satisfactory crops.

Where large amounts of fertilizers are used, it is important from an economic standpoint that proper consideration be given to type, amount, time of application, and placement of them. Failure in any phase may partially or completely nullify the results.

Nitrogen

If any one plant food material can be classed as being more necessary than others, probably nitrogen should be given that distinction. Nitrogen deficiency results in chlorotic stunted growth with low unprofitable yields. Growers should strive to develop and maintain a good supply of soil organic matter since this constitutes the main storage form of nitrogen in the soil. Additional nitrogen, which will be needed in the form of commercial fertilizers, is available in several forms, the most common of which are as follows:

Ammonium sulphate	20	per cent nitrogen
Ammonium nitrate	32	per cent nitrogen
Sodium nitrate	16	per cent nitrogen
Calcium nitrate	15.5	per cent nitrogen
Urea	45	per cent nitrogen
Cyanamide	21	per cent nitrogen

In addition to these straight nitrogen carriers, other commercial products such as Ammonium phosphate, Ammo-Phos, and Conaphos contain 10 to 16 per cent nitrogen in addition to phosphoric acid. Nitrogen is supplied in varying amounts from mixed fertilizers also.

Growers should be guided by the percentage of nitrogen in the material, the cost, and the contemplated use. Nitrate fertilizers are subject to leaching and should not be used for fall applications. When a quick response is desired, they are more effective than the ammonia forms. Sodium nitrate, calcium nitrate, and cyanamide leave slightly alkaline residues in the soil and are more desirable on acid soils. Ammonia or urea forms of nitrogenous fertilizers leave acid residues and are therefore more desirable on alkaline soils. Cyanamide has a toxic stage in its decomposition and transformation that may be injurious to plants. It should be applied two weeks in advance of seeding time to avoid injury to germination.

Fall Nitrogen Fertilization

Where beets are to be grown on soil of only average fertility, or are to follow early spring crops, or when they are planted late, some fall nitrogen should be applied. For these conditions the use of 100 to 200 pounds per acre of either ammonium sulphate, 16-20-0 Ammo-Phos, or a similar material is suggested. Nitrate fertilizers are not recommended for fall use. Experiments at the Corvallis Station in 1940-41 showed an increased seed yield of 450 pounds per acre from fall nitrogen when the beet crop followed a spring barley crop, but no increase on summer fallow land. Under most conditions in western Oregon a fall application of nitrogen is desirable.

Spring Nitrogen Fertilization

The major supply of nitrogen fertilizer should be applied in the spring. A total of from 400 to 1,000 pounds of fertilizer per acre (the equivalent of from 75 to 200 pounds of nitrogen) will be needed during the spring season. This may be applied in one, two, or three applications depending on the circumstances and total amount used. Where beets are grown without irrigation, a side dressing with 200 pounds about April 1st and an additional 200 pounds about May 1st, or the application of the full amount during the early part of April are good practices. Where beets are grown with irrigation, the suggested fertilizer program is to side dress with about 200 pounds per acre April 1st, 200 pounds the early part of May, and 200 pounds more with the first irrigation. The above figures are for average conditions of the areas where beets have been grown and are based on a percentage composition of the fertilizer of 20 per cent nitrogen. If materials of other composition are used, the rate should be adjusted accordingly. That is, use about two-thirds of this amount of ammonium nitrate containing 32 per cent nitrogen and one-fourth more of materials containing only 16 per cent nitrogen. Spring fertilization has shown increases in yields of varying amounts, some of which are listed in Table 1.

Table 1. EFFECTS OF DIFFERENT RATES OF NITROGEN ON THE YIELD OF SUGAR BEET SEED ON SEVERAL SOIL TYPES.

Treatment	Rate[1] of nitrogen per acre	Yield of seed per acre					
		Chehalis loam	Newberg loam	Willamette clay loam	Newberg sandy loam	Medford fine sandy loam	
		1941	1941	1944	1944	1940[2]	1941
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Untreated	None	790	1,692	....	....	1,221	748
Nitrogen fertilizer	50	....	....	1,300	1,002	....	....
Nitrogen fertilizer	100	1,712	2,521	1,500	1,276	....	1,425
Nitrogen fertilizer	200	1,976	2,833	....	....	4,155	....

[1]The amount of fertilizer required to furnish this amount of nitrogen can be calculated from the formula:

$$\text{Amount} = \frac{\text{pounds nitrogen} \times 100}{\text{per cent nitrogen in fertilizer}}$$

[2]These 1940 plots had 5 tons stable manure per acre.

For this spring fertilization from one-third to one-half should be ammonium sulphate since this is necessary to insure an adequate sulphur supply. The remainder may be sodium, calcium, or ammonium nitrate. In 4 years' results at the Corvallis Experiment Station, mixtures of one-half ammonium sulphate and one-half sodium nitrate have given average seed yields of 100 pounds per acre more than straight ammonium sulphate. This mixture has an advantage from the standpoint of permanent soil fertility in the Willamette Valley since it has no tendency to increase soil acidity. Willamette Valley soils are already somewhat unfavorably acid for sugar beets. If ammonium sulphate alone is to be used in this area, 110 pounds of lime should be applied for every 100 pounds of fertilizer used. Some results of source of nitrogen and the sulphur relation are shown in Table 2.

Where irrigation is practiced, about 200 pounds per acre of a nitrate fertilizer should be applied with the first irrigation. A nitrate form is preferable for this method of application because of its better soil penetration and quicker action.

Table 2. EFFECTS OF SOME COMBINATIONS OF NITROGEN AND SULPHUR ON YIELDS AND GERMINATION OF SUGAR BEET SEED.

Treatment[1]	Chehalis loam soil	
	Yield per acre	Germination
	Pounds	*Per cent*
Sodium nitrate	885	73.2
Sodium nitrate plus gypsum at 150 pounds	1,614	82.7
Sodium nitrate plus potassium sulphate at 100 pounds	1,719	89.5
Sodium nitrate plus ammonium sulphate	1,984	87.5
Ammonium sulphate	1,783	89.5

[1]The total amount of nitrogen was held uniform at 100 pounds per acre for all plots.

Similar nitrogen-sulphur relations are shown for the Medford area, as indicated by results listed in Table 3. Although yields varied rather widely in the 2 years, the results clearly show that calcium nitrate alone is not satisfactory as a source of nitrogen for beets. Some improvement was obtained when sulphur was included with the calcium nitrate, but this did not appear to supply sulphur in sufficient quantity to satisfy the needs of the plants since ammonium sulphate in equivalent quantity of nitrogen was markedly better both seasons. No mixtures of the 2 forms of fertilizer were tried, such as are cited previously for the Willamette Valley.

On these Medford soils there was a slight benefit indicated for treble superphosphate, and a more substantial benefit suggested from the inclusion of potassium chloride in the fertilizer mixture. More experimental work will be necessary to establish these effects.

Sulphur

Nearly all Willamette Valley and Medford area soils suitable for beet seed production are deficient in sulphur. Sulphur deficiency for certain other crops on these soils was noted by Reimer (7) and

Powers (*5*), and striking need of sulphur by sugar beets in the Willamette Valley was observed and discussed by Tolman and Stoker (*9*). Consequently, in no case should the growth of beets be attempted without applying sulphur in some form. Deficiency of sulphur results in a yellowish green foliage, sometimes bushy seed stalk branches, usually stunted growth, and lowered yields of poor quality seed. Beets grown under such conditions are also more susceptible to *Ramularia* leaf spot (Figure 4).

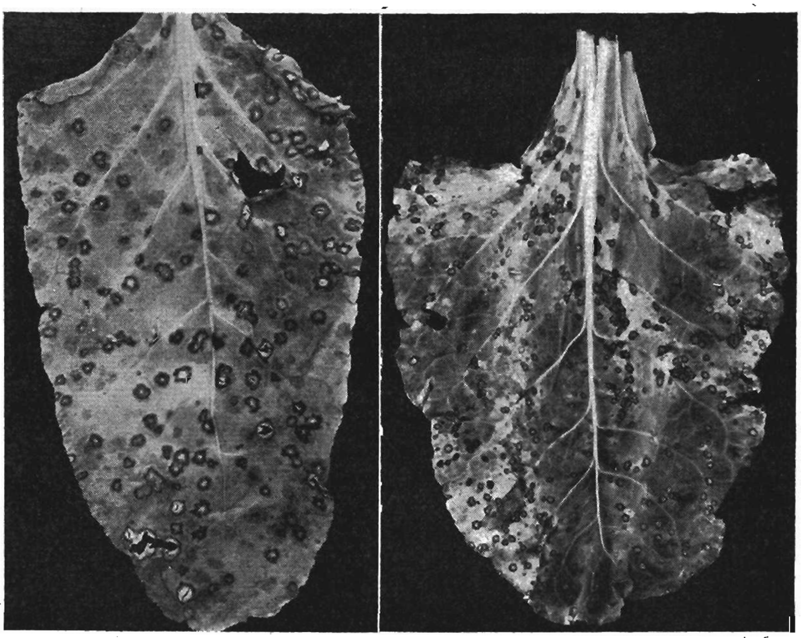

Figure 4. Leaf-spot diseases occurring in sugar beets grown for seed sometimes cause serious defoliation: (A) Leaf spot caused by *Cercospora beticola;* (B) leaf spot caused by *Ramularia beticola. Photograph by Eubanks Carsner.*

Sulphur is available from several sources. Gypsum contains about 16 per cent; ammonium sulphate, 25 per cent; 16-20-0 Ammo-Phos, 12 per cent; superphosphate, 9 per cent; and potassium sulphate, 18 per cent. Sulphur is available also in pure form as elemental sulphur. For Willamette Valley soils 125-150 pounds of gypsum per acre should be broadcast before planting and a similar quantity of elemental sulphur for the Medford area. Sugar beet plants grown for seed, however, do not always obtain sulphur from these materials in sufficient quantity for their needs. Consequently plants heavily fertilized with nitrogen may need other sources of sulphur. Further additions can be supplied from other fertilizers such as ammonium sulphate. Elemental sulphur is not recommended for general use in the Willamette Valley as it increases soil acidity. Soils of the Medford area are neutral to slightly alkaline and for them elemental sulphur is entirely satisfactory. Yield responses from sulphur have varied greatly, depending on the soil and previous treatment.

Table 3. RESULTS OF FERTILIZER STUDIES ON MEDFORD FINE SANDY LOAM.

Treatment	Rate per acre and time of nitrogen application		Seed yield per acre
	Fall	Spring	
	Pounds	*Pounds*	*Pounds*
Season 1939-40			
Calcium nitrate	500	250	1,989
Calcium nitrate	500	500	2,743
Ammonium sulphate	500	250	3,852
Ammonium sulphate	500	500	3,869
Ammonium sulphate plus stable manure at 5 tons	500	250	3,847
Ammonium sulphate plus stable manure at 5 tons	500	500	4,155
Stable manure at 5 tons	......	......	1,221
Ammonium sulphate	200	......	2,308
Season 1940-41			
Unfertilized	......	......	748
Calcium nitrate	500	500	1,134
Calcium nitrate plus sulphur at 180 pounds	500	500	1,372
Ammonium sulphate	375	375	1,426
Ammonium sulphate plus treble superphosphate at 250 pounds	375	375	1,747
Ammonium sulphate plus treble superphosphate at 250 pounds plus muriate of potash at 250 pounds	375	375	1,696
Blood and bone meal	750	750	1.264

Boron

Most Willamette Valley soils used for beets are deficient in boron. The effect of boron deficiency for garden beets was noted by Powers and Bouquet (*6*) in 1940. Stoker and Tolman (*8*) discussed the effects of boron deficiency on sugar beets for seed. A deficiency of boron in the soil may result in heart rot, winter killing, death of the terminal shoot, or in weak side branches. These side branches, in addition to being weak seed producers, frequently break off with subsequent complete loss when the seed gets heavy. Other types of deformed growth resulting from a shortage of boron have been noted by Cox (*1*). The degree of boron deficiency in soils naturally varies greatly among different soils or fields depending on previous management. Where any possibilities of such deficiency exist, it is best to apply 25 to 30 pounds of borax per acre. This should be broadcast prior to planting either as a separate operation or mixed with gypsum. Experiment Station results have shown that this amount of borax increased seed yields about 150 pounds per acre. Beets grown on boron deficient soils are often susceptible to winter killing and loss of yield may be very extensive.

Phosphorus

Although it has been customary for beet seed growers to apply 16-20-0 commercial fertilizer in the fall, there is very little experimental evidence to indicate that the phosphorus part of this material improves the yield or quality of seed produced. Table 4 gives some results of trials with and without phosphorus in fall and spring applications in the Willamette Valley and Medford districts. As can be observed from the data, results have not been conclusive.

As plants assimilate a large portion of their phosphorus reserves relatively early in their growing period, it is generally assumed that phosphorus should be applied in the seedling stage; or if a marked deficiency exists in the soil, some must be applied with the seed. However, with a biennial crop such as sugar beet seed, reserves of phosphorus taken up in the fall and stored in the leaves may be mainly lost to use since most of the fall leaf growth is usually lost during the winter and spring. The major amount of vegetative growth takes place during the second season. Consequently, it is during this season that the major supply of phosphorus is needed. Phosphorus fertilizer, if applied in the fall, tends to revert to a form only slowly available to the plants by the following season. In view of this, it seems that the most efficient use of phosphorus could be obtained by applying it as a side dressing early in the spring of the second season's growth. Further investigation is in progress on this question.

Where phosphorus is to be used, sufficient material should be applied to supply 60 to 90 pounds of phosphoric acid (P_2O_5) per acre. Since large amounts of nitrogen are necessary, it is preferable to add the phosphorus in combination with a nitrogen fertilizer;

Table 4. EFFECTS OF PHOSPHORUS ON SUGAR BEET SEED YIELDS ON THREE SOIL TYPES.

Treatment[1]	Yields of seed per acre			
	Chehalis loam	Chehalis loam	Medford gravelly clay loam	Medford fine sandy loam
	1941	1943	1939	1941
	Pounds	*Pounds*	*Pounds*	*Pounds*
No phosphorus	1,919	1,668	4,718	1,425
Fall phosphorus	....	1,817	4,490	1,474
Spring phosphorus	2,436	2,061	....	....

[1]All comparable plots had a uniform supply of nitrogen. Phosphorus was all supplied at about 40 pounds phosphoric acid per acre, some of which was from superphosphate, some from triple superphosphate, and some from Ammo-Phos.

16-20-0 or 11-48-0 grades of ammonium-phosphate or ammoniated superphosphate are entirely satisfactory. Superphosphate and treble superphosphate are also satisfactory sources of phosphorus, but they do not contain nitrogen.

Table 5. EFFECTS OF POTASH ON SUGAR BEET SEED YIELDS ON THREE SOILS.

Treatment[1]	Yields of seeds per acre		
	Chehalis loam	Chehalis fine sandy loam	Medford fine sandy loam
	1941	1943	1941
	Pounds	*Pounds*	*Pounds*
No potash	1,919	1,970	1,474
Muriate of potash at 100 pounds per acre	2,287	1,931	1,695

[1]All plots had a uniform supply of nitrogen and sulphur.

No definite information is available at this time regarding the need for phosphorus on Klamath Falls soils; but certain other crops in that area require phosphorus and until such time as more definite recommendations can be made, it is advisable to apply phosphorus fertilizer there.

Potassium

As with phosphorus, the results obtained from the use of potash on western Oregon soils have not been conclusive. Some fields show trends toward a response and others show none. The general use of potash fertilizer is of questionable value, and further studies on it are in progress. Table 5 shows the results obtained in a few experimental trials.

COVER CROPS AND MANURE

Too little attention has been given to maintaining the organic matter supply of our soils. Beet seed culture provides an excellent opportunity to utilize green manure cover crops. Late spring or summer plantings offer plenty of time for not only good cover crop growth, but also for turning-under and partial decomposition.

Barnyard manure has a high fertilizing value as well as a value for the organic matter it provides. It has been variously estimated to be worth from $2 to $5 per ton when used on other crops. Care should be taken to see that it is either well-composted, or turned-under early in the spring, so that as much of the weed seed as possible will be eliminated. If some such precaution is not taken, the nuisance effect of the weeds may offset the fertilizing value.

ROTATION AND SUMMER FALLOW

All sound agricultural programs call for an established crop rotation practice. Beets for seed should be easy to fit into a satisfactory plan. A rotation consisting of small grain, clover, and beets is suggested for irrigated conditions. In this case, the second-year clover should be turned under as a green manure crop. When alfalfa is included in the rotation, the beets should follow alfalfa, turning under the fourth-year alfalfa as a green manure crop.

Although beets can be grown following spring crops, such as early potatoes, crimson clover, and some other seed crops, it is sometimes difficult to harvest such crops in time for early August planting. Summer fallowing can be started sufficiently late in the spring to permit turning under a green manure cover crop thus replenishing the soil organic matter supply. It effectively eliminates many noxious weeds, also, thereby greatly reducing hoeing costs. Summer fallow land tends to be replenished in available nitrogen supply which reduces the amounts of commercial fertilizer required for fall growth. This replenishment is at the expense of organic matter in the soil that, in turn, should be renewed.

Time for Planting

Trials at the Experiment Station at Corvallis show no decided difference in performance of sugar beets planted from the middle of June to the early part of August. Plantings in the latter part of August have been definitely inferior to those in early August. Although beet seed may be grown from plantings in late August or September, yields and germination quality of the seed will suffer proportionally to the delay in planting time. Similarly, May plantings have been inferior to June plantings.

Planting in June has an advantage in that moisture remaining from spring rains is usually adequate for germination. Ordinarily on summer fallow land such moisture will be adequate until about June 20 on Chehalis soil and until about June 10 on Willamette soil. However, this will vary with the season. July or August plantings usually require an irrigation prior to planting.

Rate of Planting

As with all row crops, the stand of beets should be so adjusted that the plants utilize all the space to the best advantage. This involves consideration of the soil fertility, exposure of leaves to light, irrigation or soil moisture supply, time of planting, and amount of applied fertilizers. In past seasons, the stands of many commercial fields have been too thick. Very thick stands (more than 10 to 12 beets per foot of row) may have a substantial portion of plants that do not produce seed. Vegetative growth at the expense of seed production is obviously not desirable as it results in uneconomical use of moisture and fertility. At the other extreme, too thin a stand does not utilize all the soil and light space and likewise permits greater competition from weeds. The plant population should not be less than 4 plants per foot of row, or more than 10. With a well prepared seed bed, 7 to 10 pounds of good quality seed per acre will provide a good stand.

Row Spacing

Row spacing may vary depending upon the type of cultivation equipment on the farm. Growers should adjust the row spacing to suit their specific conditions. Twenty-four inches between rows is most common, but row spacings of 20 inches to 30 inches have been satisfactory. The best utilization of soil space is accomplished with the most uniform distribution of plants consistent with cultural operations. Less space between rows and greater spacing of plants within the row best accomplish this purpose. Rows spaced less than 20 inches are difficult to cultivate.

Cross Blocking

Variations in stand obtained by cross blocking or hill planting have been tried under a number of conditions both in the Willamette Valley and at Medford. Results of these trials as given in Table 6 show no significant effect on seed yield. Under some circumstances cross blocking may facilitate weed eradication. If cross blocking is contemplated, it should be done early in the growth of the plants so that those remaining can take advantage of the additional space allotment. Cross blocking in the spring is not recommended.

Cultivation

Timely cultivation of beets to keep weeds under control is extremely important. Every effort should be made to avoid hoeing or other expensive methods of weed eradication. Consequently growers should avail themselves of suitable cultivation equipment adapted to the row spacing of the planter. The first cultivation should be done as soon as the beets are large enough that the rows are clearly marked. A fall cultivation as late as the soil can be worked, and a spring cultivation as early as the soil is suitable for working, will do much to reduce weeding costs. Cultivation should be continued in the spring as long as the height of seed stalks will permit. The cultivator should be equipped with a fertilizer attachment so that the fertilization and cultivation can be done at one operation.

Table 6. YIELDS OF SUGAR BEET SEED WITH CONTINUOUS STAND VERSUS 12 INCH AND 24 INCH BLOCKING ON TWO SOIL TYPES.

Spacing treatment	Yields of seed per acre: Chehalis loam 1941	Chehalis loam 1944	Neal silty clay loam 1941
	Pounds	*Pounds*	*Pounds*
Continuous rows	1,934	1,612	2,408
12-inch blocks	2,264	1,625	2,535
24-inch blocks	2,101[1]	1,421	2,321

[1]20-inch blocks.

Some growers have used a spring tooth weeder crosswise of the rows for the first spring cultivation. Preliminary experimental trials do not support this practice. Any removal of leaves or beets after spring growth has started resulted in loss of seed yield.

Irrigation

Irrigation is necessary for beet seed in areas of very low rainfall such as Klamath Falls or Medford. In the Willamette Valley supplemental irrigation is usually profitable though results of several years' trial have shown that beet seed can be grown on Chehalis or Willamette soils without such irrigation. Returns from irrigation vary widely according to rainfall, soil conditions, and other considerations. In preliminary trials of the value of supplemental irrigation in the Willamette Valley, returns have varied from none to as much as 1,400 pounds seed per acre increase. The uneven topography of most Chehalis or Newberg soils, and much of Willamette, necessitates the sprinkling method of irrigation. In this area 2 irrigations of about 3 inches each will be sufficient for nearly any season and frequently 1 irrigation will be adequate. About 4 hours per set with 16-gallon sprinkler heads will supply 3 inches of water. Most soils will not absorb over 3 inches of water in 1 irrigation period. Because of the difficulties of moving sprinkler equipment through a beet field after the seed stalks are high, some growers are inclined to overwater at each set thereby wasting water and leaching out valuable plant food.

Time or number of irrigations must be gauged by the condition of the soil and crop, and the grower had best seek the advice of an experienced irrigator until he becomes familiar with such operations.

The last irrigation should be timed so that the surface of the soil will have dried before harvest.

Harvesting and Threshing

Beet seed does not ripen uniformly, and a time to harvest must be selected when the major portion of the seed is ready. If the seed is permitted to become too ripe, severe shattering will result. If cut too green, there is a serious shrinkage and loss of yield. The seed is ready to harvest when it is in the hard-dough stage. This time can be determined by cutting and examining a number of seed balls from representative plants. Color of the seed stalks is not a good measure since late application of nitrogen will frequently maintain a fairly green stalk color even after the seed is ready to harvest. On the other hand, if a crop is short of nitrogen and moisture, it may appear ripe even before the seed is mature.

Harvesting the crop under average to large field conditions is best accomplished with some type of large windrow cutter with an attachment for catching shattered seed. (Figure 5A.) Smaller fields may be mowed; in which case, extra labor is necessary to bunch the seed stalks and carry them out of the path of the machine. A corn binder has been used with good success where the seed stalks are not too badly tangled and down. This method has an advantage for stationary threshers in that the bundles can be bound and are more easily handled. Where no device is available for catching shattered seed, cutting is better done when the dew is on to decrease shattering.

Threshing has been most satisfactory where special built machines have been used. (Figure 5B.) These may be either stationary or pick-up type. Ordinary combine or stationary threshing machines can be used, but they leave more trash with the seed.

ISOLATION

Beet seed fields need to be well-separated from seed fields of other related crops such as mangels, table beets, and chard to prevent cross pollination. As more of these related crops are grown, the problem of isolation will become more critical. Under ordinary circumstances seed-producing fields of these related crops should be separated by at least 1 mile. Different varieties of sugar beets also require the same degree of isolation to prevent cross pollination.

HOLD-OVER BEETS

Sometimes it is possible to retain sugar beet roots in the field for another crop of seed the following year. The crop is grown both from the hold-over plants and volunteer plants that start from shattered seed. In general, the practice cannot be recommended although it might be used for some special seed lots. There are several disadvantages in the practice. It is very uncertain since winter killing may eliminate a stand that looked good in the fall. Hold-over plants are also objectionable in that they may harbor insect pests and dis-

Figure 5. (A) Swathing sugar beets in the Willamette Valley. (B) Threshing sugar beet seed with special beet equipment. *Photographs by West Coast Beet Seed Company.*

eases that, in turn, may start insect infestations or disease epidemics in the new seedlings. In such fields up to 50 per cent of the stand is frequently lost which may depreciate the variety type. In a few instances where observations of comparative performances are possible, carry-over fields yielded only about 50 per cent as much as new seedlings.

Any lower cost of production under this practice would not compensate for the disadvantages involved in it.

DISEASES

Western Oregon is fortunate in that plant diseases have not as yet very seriously affected the seed crop. The leaf spots are probably the most important diseases of sugar beets in the seed-growing districts. (Figure 4.) Two are known to occur. *Ramularia* leaf spot (*Ramularia beticola* Fautr. and Lamb.) is prevalent in winter and under cool conditions in early spring. *Cercospora* leaf spot (*Cercospora beticola* Sacc.) has been less abundant and is favored by warmer weather. Some progress is being made in breeding for resistance to these two diseases.

In some seasons considerable damage has resulted from a seed-stalk blight caused by *Phoma betae* (Oud.) Frank, a fungus that occasionally causes damping-off of seedlings and under some conditions causes a leaf spot. Factors conducive to severe stalk blight are not well-known.

These diseases have been more prevalent in the Willamette Valley than at Medford. Some varieties of sugar beets are more susceptible than others to the leaf spots and to stalk blight. Varieties resistant to *Cercospora* leaf spot also show resistance to both *Ramularia* leaf spot and to stalk blight. Thus far, these diseases have not appeared sufficiently serious to warrant control measures; although in some sugar beet areas, some degree of control of leaf spots is secured by spraying or dusting with copper fungicides. Crop rotation and careful destruction of volunteer beets and residues from a previous sugar beet seed crop are helpful sanitary measures. New plantings of sugar beets in fields directly adjacent to recently harvested seed fields have shown increased disease in the portions nearest to the old fields.

Downy mildew (*Peronospora schactii* Fckl.) (Figure 6) occasionally causes considerable damage which may be severe in late fall-planted beets. This disease is most active in the moist weather of late fall or early spring. Injury to the heart leaves and the seed stalk is produced resulting in the development of weak side branches. Often these weak side branches break off before harvest and become a total loss. Some loss of stand may be caused by heavy infestations. Sometimes the fungus attacks the seed head sufficiently to cause deformation.

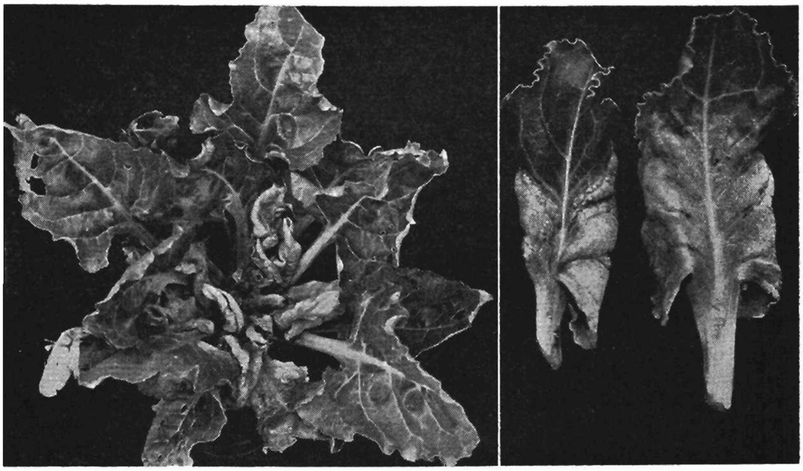

Figure 6. Downy Mildew (*Peronospora schactii*) on sugar beet plants which may result in crown injury and other deformations: (A) The dwarfing effect of the fungus upon the central whorls of leaves. (B) Individual, partly expanded, leaves showing effects of fungus invasion. *Photograph by Eubanks Carsner.*

Seedling diseases cause relatively minor reductions in stands. Fungi causing damping-off or "black root" may be either seed or soilborne. They can be controlled, to a large extent, by seed treatment. Since the company contracting for sugar beet seed in this area customarily treats all stock seed with a fungicidal dust, growers need not concern themselves regarding details of treatment.

Black streak, probably *Pseudomonas aptata* (Brown and Jamieson) Stapp, a bacterial disease, is common in western Oregon; but so far, it has caused relatively little damage. This trouble has been more marked at Klamath Falls where a high percentage of infection occurred in a few fields. (Figure 7.)

Beet rust, *Uromyces betae* (Pers.) Lev., is abundant in the Willamette Valley at times but has not been of any great economic importance.

INSECTS

Lygus bugs (*Lygus* spp.) are probably the most injurious insects attacking beet seed in western Oregon. Up to the present time, they have been considerably more abundant in the Medford and

Klamath Falls areas than in the Willamette Valley. Low germination is caused by their feeding on the immature seed. Hills (*3*) in 1942 effectively controlled Lygus at Klamath Falls with pyrethrin-sulphur dust. Two applications, each at the rate of 25 pounds of dust per acre, were made in July with a power duster. The first application was at the early bloom stage and the second about two weeks later. Germination of the seed was improved from 49.5 per cent to 70.8 per cent. In 1945, when Lygus populations at Klamath Falls were very high in early July, Hills* was able to effect an almost complete kill with 5 per cent DDT dust applied by airplane at about 30 pounds per acre. However, other factors seemed to contribute to low germination seed that season.

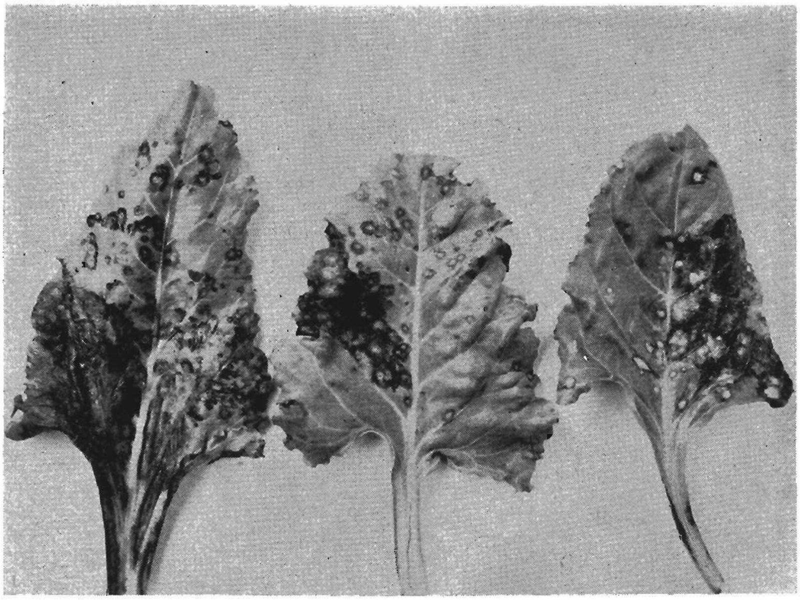

Figure 7. *Black Streak* on sugar beet plants. This disease has been more prevalent at Klamath Falls than in the Willamette Valley. It may cause appreciable defoliation.

Black aphids (*Aphis rumicis*) occasionally appear on the seed stalks in late June and early July. These have been somewhat more abundant at Medford than in the Willamette Valley. They usually appear first on scattered individual plants near the edge of the fields and spread from these infection points. Diligence in controlling these first infected plants may save extensive later treatment.

* Oral communication.

Spittle bugs (*Philaenus leucophthalinus*) are usually present in seed beet fields and may do appreciable damage. The extent has not been evaluated. Presence of the insect is readily detected by the spittle masses. Damage results in a certain amount of dwarfing of the seed stalks with brushy top growth.

The spotted cucumber beetle (*Diabrotica* spp.) something damages young seedlings by feeding on the cotyledon leaves. However, under most field conditions, the seedling loss from this insect has not been serious enough to justify control measures.

Root aphids (*Pemyhigus betae*) have made their appearance in some fields of June-planted beets. Presence of this insect is first suggested by obvious wilting of beets in small, irregular or circular shaped spots and can be verified by digging up some of the roots within the affected area. It appears as a white wooly aphid that feeds on the plant roots. They occasionally are sufficiently numerous to cause appreciable damage. Later plantings may avoid the trouble. No serious damage has been reported from August-planted beets.

If it appears desirable to apply control measures for any of the insects described above, the Experiment Station entomologists should be consulted for recommended practices.

RODENTS

Pocket gophers (*Thomomys* spp.) can cause considerable damage to local areas in fields by feeding on the roots. If these rodents make their appearance, measures should be taken to eliminate them by trapping or poisoning. Gophers accustomed to feeding on beet roots can be readily exterminated by placing poison-coated beet roots in the runways.

Moles (*Scapanus townsendi*) usually do not feed on beet roots but may injure young seedlings by pushing them out of the ground. In addition, their runways are utilized by field mice in obtaining access to plant roots. Trapping has been to date the most successful method of controlling moles. Field mice (*Microtus* spp.) sometimes cause appreciable losses of stand by eating the roots and crowns during the winter months. They are usually more numerous in fields adjacent to meadows or weed patches. Poisoned grain placed in their runways provides effective control.

Control of these rodents has been more fully discussed by Gabrielson (*2*).

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