FACTORS AFFECTING VEGETABLE SEED PRODUCTION IN THE WILLAMETTE VALLEY, OREGON

by

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FACTORS AFFECTING VEGETABLE SEED PRODUCTION IN THE WILLAMETTE VALLEY, OREGON

INTRODUCTION

Every American should be vitally concerned with vegetable seed production. Without seed it would be impossible to grow the common vegetables which constitute such an important part of the American diet today. Since time immortal, man has depended on vegetables to maintain his health and physical condition.

Recent studies by the National Research Council (14, p.46) have shown the American diet to be relatively deficient in nutrients. Home Economists have recommended a fifty per cent increase in the use of vegetables to overcome this deficiency (52, p.211). According to nutritionists, vegetables are important in our diet because they supply energy, protein, and an abundance of minerals and vitamins. Considering the need for, and the value of, vegetables in the diet of our peoples it is important that we place vegetable seed production on a high plane and give it full recognition in our present day agricultural planning programs.

Because agricultural leaders foresaw the possibilities of a new and promising vegetable seed industry for the farmers of Oregon, the Farm Crops Department of the Oregon Agricultural Experiment Station, in 1942, in cooperation with the United States Department of Agriculture, Bureau of Plant Industry, Soils and Agricultural Engineering, initiated a vegetable seed research program. The research objectives were aimed primarily at solving production problems that were confronting producers of these specialty crops. This cooperative arrangement operated until 1945, after which time the research program became the sole responsibility of the Farm Crops Department and continued until 1950.

It was the writer's privilege to have had the opportunity to serve as leader of this project from 1947 to 1949, inclusive. The information presented is based mainly on the knowledge and experience obtained in the conduct of three years of experimental work and in association with seed company representatives and producers in the Willamette Valley during that period of time.

The primary purpose of this study was to analyze the various factors affecting vegetable seed production in the Willamette Valley. Because of the complexity of the industry, it was necessary to study the interrelated problems in order to properly evaluate the factors which must be considered in relation to each other. The analysis was made with the purpose in mind of emphasizing principles and making certain suggestions and recommendations which are applicable to vegetable seed production in the Willamette Valley.

EXPERIMENTS WITH VEGETABLE SEED CROPS

As previously pointed out the background for this study was based mainly on three years of experimental work with vegetable seed crops in the Willamette Valley. Experimental data from vegetable seed experiments carried on at Corvallis are presented. Only a small portion of the vegetable seed research data is included, and that presented is limited to those experiments which illustrate certain points discussed under the section "Analysis of Production Factors Affecting Vegetable Seed Production." Summary tables of the data are shown along with the statistical analyses for each experiment. The raw data for all of the experiments included can be found in the Experiment Station Annual Reports of the Vegetable Seed Project for 1948, 1949, and 1950.

SCOPE AND NATURE OF EXPERIMENTS

During the years 1948 to 1950 inclusive, a total of 60 experiments were initiated. Fifty-two of these were carried through to completion. Thirteen experiments were conducted with cabbage, ten with cucumbers, nine with onions, five for table beets, four each for mustard and turnip, three for squash, two for spinach and one each for radish and pumpkin. In these experiments slightly over 1800 plots were planted, cared for, harvested, and processed. Yield and other pertinent data were obtained therefrom.

Most of the experiments conducted were either fertility or cultural experiments since these general problems were of primary concern to seedsmen and growers. The main objectives in the fertility experiments were to determine the response of the various crops to the major fertilizer elements and to different rates and times of application. The majority of the cultural experiments were studies on date of planting, spacing requirements, and varietal performance for the various crops.

LOCATION OF EXPERIMENTS

All the vegetable seed research was carried on at three Central Agricultural Experiment Station farms—the East farm, the Lewis-Brown farm, and the Hyslop Agronomy farm.

The East farm, as shown in Figure 1, is a highly productive river-bottom soil, mostly of the Chehalis sandy loam type but quite variable in its soil characteristics. Sprinkler irrigation facilities were available on this farm and were used throughout the conduct of the experiments. Experiments on this farm consisted primarily of the spring planted crops since previous experience had shown that the flood hazard rendered this farm unsatisfactory for precise trials with field, over-wintered crops.

The Lewis-Brown farm is characterized by a somewhat heavier soil than the East farm and is predominately a Chehalis clay loam type. This area, although subject to flooding, is a little higher in elevation than the East farm and, therefore, is less hazardous for over-wintering crops such as cabbage and onions. Irrigation facilities were also available on this farm and used whenever needed.

Fig. 1. General view of vegetable seed experimental plots at the East Experimental Farm, July 20, 1949. The plots shown represent only a portion of vegetable seed experimental work that was carried out that year.

Fig. 2. Seeding cabbage in plant-bed in July with Planet-Junior drill. Note firm, finely worked seedbed condition and sprinkler irrigation system. Both are essential for good plant emergence.

The vegetable seed experiments at the Hyslop Agronomy farm were located on a Willamette silt loam soil. Supplemental irrigation facilities were not available for the onion seed experiments in 1949 but were temporarily installed in 1950 and used for the extensive experiments carried on during that year.

EXPERIMENTAL TECHNIQUES AND METHODS

Because of the extremely limited amount of vegetable seed research reported in the United States in the past, there was a dire lack of information relative to techniques useful for research in this field. As a result the techniques and methods had to be worked out for many of the crops as the experiments progressed.

Plot Size and Shape. Plot size and shape varied with the crop and conditions of the experiment but, in general, long, narrow, and relatively small-sized plots were used.

The usual plot length ranged from 20 feet for the closely-spaced crops such as cucumber, radish, spinach, turnip, and mustard to 25 feet for the more widely spaced crops such as cabbage, parsnip, table beet, squash, and pumpkin. During the first year of experimental work longer plot lengths were used but experience soon showed that it was necessary to reduce the length of plot to that which was better adapted to the type of small-plot equipment available and which could be handled efficiently on a small-plot basis.

Row width and spacing of the plants in the row varied according to the crop and approximated those in general use by vegetable seed growers throughout the Willamette Valley. Three-row plots were used wherever land area permitted, with only the middle row being harvested for seed yield. A three-foot row width was used for cucumber, onion, spinach, Chinese cabbage, and table beet whereas two-foot row widths were employed for mustard, turnip, radish, and spinach. Summer squash was planted in rows spaced three and one-half feet apart while winter squash types were planted in rows spaced five to six feet apart. Cabbage was transplanted in rows five feet apart.

Plots were always planted to a distance at least one foot beyond both ends of the plots and the border plants were removed immediately before harvest.

Seeding and Transplanting. Method of seeding and transplanting varied according to kind of crop and equipment available. Seeding was always made shallowly on a well-prepared, firm, moist, weed-free seedbed.

The small-seeded crucifer crops and spinach were seeded with a Planet-Junior drill as shown in Figure 2. Where large experiments with one variety were involved, a conventional four-row Planet-Junior drill pulled with a tractor was used advantageously. One outside unit was dismantled in order to facilitate uniform spacing of rows on a three-row plot basis.

Seeds of crops like cucumber and table beet were weighed out for each plot and seeded with a nursery V-belt planter as shown in Figures 3 and 4 or were planted with an ordinary grain drill as illustrated in Figure 5. For variety experiments where seed size varied, seeds were

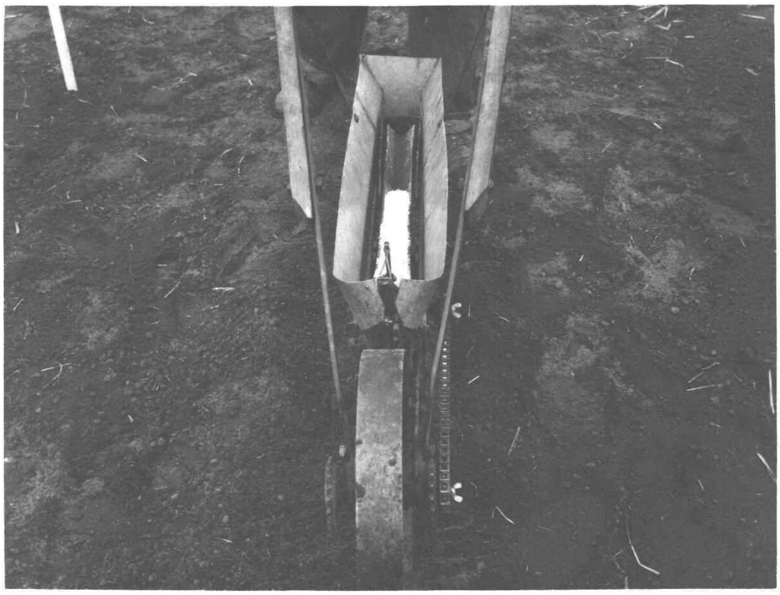

Fig. 3. The V-belt nursery planter being used to apply weighed out amounts of fertilizer to individual rows. This implement is also useful for seeding crops where it is desired to plant a certain quantity of seeds in a given row length.

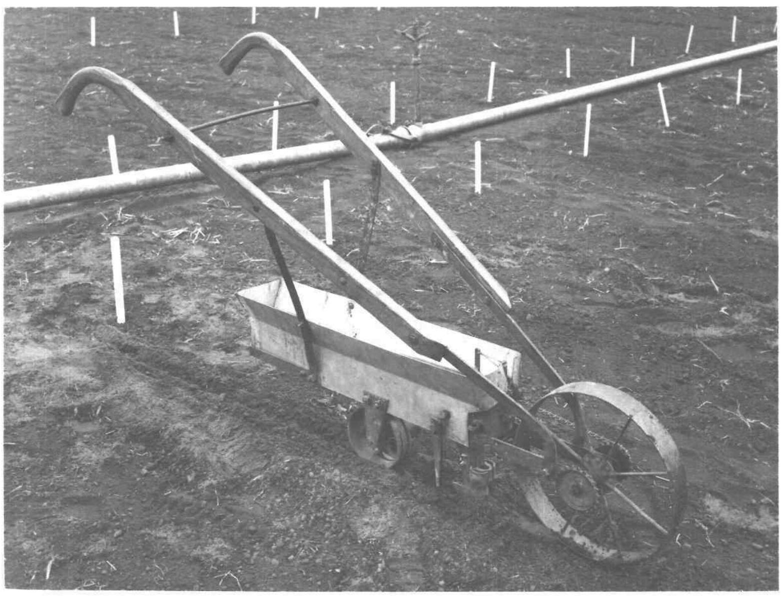

Fig. 4. Side view of the V-belt planter used in this case for side-dressing table beets. Beets have already been transplanted but have not yet emerged.

Fig. 5. Seeding cucumbers with a grain drill, an ideal implement for planting this crop for experimental purposes. Three-row plots can be seeded by plugging all seed outlets except those at three-foot intervals. Note small stakes in background which aid the driver in making straight rows.

Fig. 6. Transplanting technique used with cabbage. Note markers on string which are necessary to obtain uniform spacing within each row.

counted out for each plot and planted with the V-belt planter. Squash and pumpkin were planted in hills and shortly after emergence were thinned to a uniform stand of three plants per hill. Cucumbers were likewise thinned but to a spacing of three or four inches between plants in the row.

At transplanting time plants of crops like cabbage were lifted carefully from the plant-bed so as to injure the root system as little as possible and were then transplanted as shown in Figure 6. Exposed roots were kept moist and when temperature conditions were above normal, one-half of the top growth was removed in order to reduce transpiration losses. Supplemental irrigation was used to provide moisture to the plants immediately following transplanting in order to insure the best possible plant survival. Onion bulbs were transplanted as shown in Figures 7 and 8. Table beet roots were transplanted into a deeply-worked soil similar to cabbage with care being taken to set the root crown even with the ground level. Off-type, diseased, and otherwise non-uniform bulbs or roots were discarded before planting.

Fertilization. Method of application of the various fertilizers used in the experiments differed with the kind of fertilizer, season of the year and whether or not irrigation facilities were available.

When fertilizer materials were applied as a uniform application for all the plots in a given experiment they were usually broadcast uniformly over the entire area and worked into the soil during the final seed-bed or plant-bed preparation operations.

Fig. 7. Hand-planting of onion bulbs for seed production purposes. Rows are three feet wide and bulbs are spaced six inches apart in the row. Note marker string, an aid to uniform spacing.

Fig. 8. Covering onion bulbs so that tops of bulbs are near soil surface. Following this, the plots were side-dressed with the various fertilizer treatments.

Wherever phosphorus, potassium, or sulfur were the variable fertilizer nutrients, these materials were side-dressed on in bands with a V-belt nursery planter three to four inches to the side of the row and to the same depth (Figures 3,4). Nitrogen was applied in the same manner except during early spring when soil conditions would not permit the use of equipment and when rainfall could be depended upon to leach soluble nitrates into the root zone. Under these conditions nitrogen was broadcast in bands beside the rows as shown in Figure 9. The same procedure was followed for summer applications of nitrogen where irrigation facilities were available.

When calcium or boron were the nutrient elements being tested, the carriers of these elements were broadcast evenly over the plot soil surface and then rotatilled in to a uniform depth.

The source of each of the plant nutrients for all the fertility experiments was as follows:

Nitrogen	--- Ammonium nitrate, sodium nitrate, ammonium sulfate[1]
Phosphorus	--- Treble superphosphate
Potassium	--- Potassium chloride
Lime	--- Ground limestone
Sulfur	--- Gypsum
Boron	--- Borax

[1]Ammonium sulfate was never used when testing the effect of nitrogen alone. This material was used only when a uniform application of nitrogen and sulfur was needed for all plots.

Fig. 9. Broadcasting fertilizer in bands on a cabbage spacing experiment in early February. Soil was still too wet to use conventional side-dressing equipment. Note good survival of somewhat undersized plants.

Fig. 10. Technique used to reduce shattering losses for turnip and mustard. All of the crucifer crops shatter badly and burlap or similar material should be placed underneath harvested crop to reduce this source of error. Bundles need to be anchored so that sudden gusts of wind do not scatter them over field.

Harvesting and Processing. Harvest and processing methods varied according to crop as did other techniques previously discussed.

Crucifer crops, table beet, and spinach were cut by hand before appreciable seed shattering had taken place and were placed on burlaps as shown in Figure 10. This was done in order to save seed that would likely shatter in the curing and threshing operations. As soon as the various crops were sufficiently dry, they were threshed with a small-plot stationery thresher. Cylinder speed was reduced to 500 to 1000 rpm and several rows of concaves were removed so as not to crack or otherwise injure the seed. Radish plots had to be run several times in order to obtain a thorough separation of the seed from the pithy seed-pod material.

Seed-heads of onions were cut by hand as soon as the black seeds were exposed in the middle of the seed-head. Several successive cuttings were necessary in order to obtain seed in the proper stage of maturity. After removal of the seed-heads they were placed in loosely woven sacks and hung in a position so that air could circulate freely around the sack. When dry they were threshed in a special-built onion seed plot thresher equipped with rubber beater blades.

Vine seed crops upon maturity were separated into their respective hills or rows as shown in Figure 11. Squash and pumpkin seeds were scooped out of the fruits by hand after which they were run through a small, special-built washer and then placed on trays and dried artificially at 110 F. Cucumber seeds on the other hand, were threshed mechanically by a small-plot macerator which crushed the

Fig. 11. Cucumber variety and date-of-planting experiment near harvest time. Note how vines and fruits have been separated for each row prior to picking. This technique speeds up harvest operations. Single-row plots were used where a large number of varieties were being compared.

fruits and separated most of the pulp from the seed. After a one- to two-week fermenting period the seeds were run through a washer and then dried in a manner similar to that described for pumpkin and squash.

After the threshing and drying operations all lots of seed were cleaned on an individual plot basis with conventional seed cleaning equipment. Plot yields were calculated on the basis of clean seed per acre. The data were then summarized and treated statistically by the analysis of variance.

HISTORY OF THE VEGETABLE SEED INDUSTRY

The vegetable seed industry, a highly specialized and intensified business, is a relatively recent addition to American agriculture and to the Willamette Valley. What was once a mere matter of collecting vegetable seeds by hand at harvest and then cleaning and packaging them, has now become a complicated and technical industry, employing scientific research and skills and specialized mechanical equipment, both in the field and in the warehouse.

DEVELOPMENT OF SEED TRADE

In pioneer times seeds were either home-saved and exchanged by neighbors or were imported. Most of the early imports came from England with smaller quantities coming from Holland. These seeds went to the Dutch settlement at New Amsterdam, New York while smaller quantities of imported seeds from Sweden were used by the immigrants established along the Delaware River (22, p.72).

Prior to 1850 America was largely rural and self-sufficient and the seed trade which is recognized today as a vital part of our agricultural economy was of minor importance. Early seed merchants' sales were limited principally to new farms and to certain townspeople who wanted to grow gardens. Once provided with the seed, however, the majority of these people would save from year to year what seed they expected to use in their future plantings.

In 1820 a certain Philadelphia seed merchant received from

England 300 bushels of garden peas and over 400 pounds of onion seed and with his advertising indicated that he had "received this ample supply and was prepared to fill all orders" (90, p.273). Today this amount would not meet the needs of many of our larger truck farmers who require hundreds of pounds of seed yearly.

Records before 1862 showed that there were only 45 firms in business primarily as seed merchants. However, as cities grew and railroads spread, as agriculture expanded and population increased, the commercial distribution of seed became increasingly important. By 1908, the number of firms whose sole business was growing and handling seed, had increased to over 800 (90, 273). Forty-four years later, in 1952, an estimated 2000 seed firms were in business in the United States.[2]

DEVELOPMENT OF PRODUCTION

Just as the retail seed trade had its beginning in the northeastern states, so also was seed production first undertaken there. In early times most of the garden seed produced in America was grown by the seed merchants themselves, either on their own farms or on lands in their immediate vicinity and under their personal supervision. Seed growing as a business distinct from that of the seed merchandising was unknown. With the development of the domestic pea seed industry and certain other seed crops which could be grown easily,

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[2] Estimate by H. A. Schoth, Senior Agronomist, United States Department of Agriculture, Bureau of Plant Industry, Division of Cereal Crops and Diseases. Corvallis, Oregon.

people soon began to demand home-grown seeds. As the demand increased, the seed merchant's business increased until he was no longer able to supervise personally the seed growing operations. At first the supervision of the seed growing work was handed over to one of the merchant's employees--then, to a capable neighboring farmer who would handle both his own and his neighbor's crops. This was done at first under the direction and control of the seedsman. Finally, as business pressure mounted, the responsibility for growing the seed crop was passed on directly to the producer. It was in this manner that the business of the seed grower became established as separate and distinct from that of the seed merchant (90, p.274).

WESTWARD EXPANSION

As agriculture expanded westward, seedsmen gradually moved the bulk of their vegetable seed acreage in this same direction. They soon learned that the Pacific coast region and the arid Intermountain states of the west, being rain-free at harvest time, produced disease-free and higher quality seed than the eastern sections of the country where there was great danger of disease and rain damage to the seed crops.

It was not until World War I, however, that vegetable seed production received its first great impetus. (115) Previously, most of the vegetable seeds planted in the United States were imported from Great Britain and the western European countries. With imports cut off because of the war, United States seedsmen and producers met the challenge and produced enough seed so that it was possible to export in large quantities. In 1916 European countries placed large contracts with commercial seed growers in the United States for the production of many crops which in the past had not been grown here on a commercial scale. Sizeable acreages were planted in old, proved localities and new areas of production were sought. It was during this era that many new crops were tried for the first time in Oregon and many other western states. Those grown in the Willamette Valley during World War I period were: mangel, bean, pea, onion, turnip, radish, sweet corn, cabbage, spinach, pumpkin, squash and carrots (115, p.200-205). No acreage or production data are available however, which would indicate the extent of the development of the vegetable seed industry in the Willamette Valley during this era.

With the drop in prices following World War I, acreage declined for many of the crops and the United States once again began to depend upon foreign countries for many of its garden seeds. Production of vegetable seed in the United States, however, remained at a higher level than before the war. Experience gained in growing vegetable seed during World War I and the years following set the stage for a phenomenal development of the industry during World War II. Record production in nearly all kinds of vegetable seeds was attained between 1940 and 1945. Production of certain crops increased from two to five times while several crops, formerly grown hardly at all in the United States, were produced on a fairly large scale. With the termination of the war, however, acreage and production were reduced to near the pre-war figure.

In a hundred years time, therefore, there developed a vegetable seed industry in the United States, which during periods of national emergency, was fully capable of supplying our nation's domestic requirements of garden seeds.

SPECIALIZED AREAS OF PRODUCTION

As a result of the evolution of the vegetable seed industry, there have developed certain areas in the United States which, because of climatic reasons and/or other production advantages, have specialized in the growing of certain kinds of seeds (9, p.48).

Most of the vegetable seed production as previously indicated is now centered in the Pacific Northwest states and California. Cabbage seed, for example, is grown for the most part in the general vicinity of Puget Sound in Washington. Other crucifers, like cauliflower and broccoli, are also grown in this area. Spinach and table beets are likewise well adpated to this area and other sections west of the Cascade mountains. Cauliflower, celery, and heading broccoli seeds are grown mainly in California. Considerable amounts of the seeds of the umbelliferous crops are grown there also. Within the last decade extensive vegetable seed-growing operations have been developed in Idaho. Idaho now produces most of the nation's sweet corn, carrot, and onion seed (116, p.46). Bean, parsnip, turnip, and lettuce seeds are also grown there extensively. Most of the nation's supply of seed beans and peas is grown in Montana, Idaho, Washington, California, Colorado, and Wyoming.

Seeds that are recovered from fleshy fruits are produced more extensively in the more humid parts of the country. Vine seed crops like cucumber, muskmelon, pumpkin, and squash are grown largely in California, Colorado, Kansas, and the middle western states and to some extent in the northeastern states. Watermelon seed is produced chiefly in the warm parts of the United States--in southern California and Florida, although some farms in the Middle West produce considerable quantities. Tomato and pepper seeds are usually produced in the greatest amounts in areas where the commercial crops of these plants are grown for canning. Most of such seed is produced in the middle Atlantic states and in California. Tomato seed is produced also in the cornbelt states.

Many other areas, other than those mentioned, produce seeds of several of the crops, but in less spectacular quantities. Efforts have been made to grow some of the cool season crops in the Northeast but with less success than in the West.

THE WILLAMETTE VALLEY AS A VEGETABLE SEED PRODUCTION AREA

The Willamette Valley, a highly diversified agricultural area, has long been recognized by many agronomists and seedsmen as a favorable section for the growing of field seed crops. Although numerous persons like the late Professor Hyslop[3] foresaw opportunities several decades ago for the development of a vegetable seed industry in the Willamette Valley, it was not until World War II that the possibilities were put to a real test. During that time it was demonstrated that many vegetable crops were well adapted here for seed production purposes. As a result the Willamette Valley became Oregon's leading vegetable seed producing area and since then has retained its position as leader in the production of vegetable seeds in the state of Oregon.

KIND OF SEED CROPS GROWN

Seed production of vegetables can be classified into two main groups: (1) annuals, which produce seed during one growing season and (2) biennials, which require two seasons or portions thereof for the production of seed.

In statistical literature another classification is sometimes made on the basis of size of seed. Large-seeded vegetable crops consist of sweet corn, beans, and peas. All other vegetables are classed as small seeds or non-edible vegetable seeds. It is the latter group

[3]Head of Farm Crops Department, Oregon State College, 1912-1943.

which is of most significance in the Willamette Valley.

Many different kinds and varieties of vegetable seed crops have been grown successfully in the Willamette Valley in the past. Before the war most of the vegetable seed acreage consisted of peas and beans as shown in Table 1. During the war years, however, Willamette Valley farmers shifted from the production of these large seeds to small seeds and after 1948 produced no peas, beans, or sweet corn. The most important and consistently grown biennial crops in recent years have been turnip, cabbage, table beet, onion, parsnip, and rutabaga. The main spring-sown annual crops have been mustard, spinach, and the vine seed crops, especially cucumber and squash. Crops of lesser importance are radish, pea, bean, tomato, cauliflower, brussels sprout, broccoli, chard, collard, Chinese cabbage, lettuce, mangel, kale, and pumpkin.

CLIMATE

Although numerous reasons account for the possible successful growing of vegetable seeds in the Willamette Valley, the one that over-shadows all others in importance is climate. The long-time weather records presented in Figure 12 show the Willamette Valley climate to be relatively uniform and equable throughout the year. Climatologists have designated the climate as a mild sub-coastal type, characterized by moist open winters, dry summer periods and with a growing season of approximately 200 days duration (69, p.2).

Winter temperatures throughout the Valley are mild enough to allow biennial crops like cabbage, turnip, and rutabaga to over-winter

Table 1. Acreage of different kinds of vegetable crops for Oregon and the Willamette Valley by years, 1939 to 1951 inclusive. 1/

Area and kind of crop	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952
State of Oregon														
Beans*	1239	440	150	1000	425	300	200	175	250	250	200	104	105	75
Peas*	1250	3000	1900	3700	6700	6600	4700	13000	17000	8000	-	-	6100	6300
Spinach	-	40	330	1350	1850	1200	300	270	100	-	20	-	50	25
Onion	320	250	365	650	1800	2000	1200	600	550	500	250	152	65	115
Turnip	400	340	230	250	525	1100	900	700	500	480	480	470	310	380
Mustard	-	2300	6200	1500	100	2200	915	625	230	75	20	40	50	20
Other	340	465	625	892	2660	5400	3000	2550	2400	2500	1955	1104	425	493
Total large	2489	3440	2050	4700	7125	6900	4900	13175	17250	8250	200	104	6205	6375
Total small	1060	3395	7750	4642	6935	11900	6315	4745	3780	3555	2725	1766	900	1033
Grand total	3549	6835	9800	9342	14060	18800	11215	17920	21030	11805	2925	1870	7105	7408
Willamette Valley														
Beans*	1000	340	60	35	35	100	15	10	-	-	-	-	-	-
Peas*	10	50	40	50	-	-	25	-	15	50	-	-	-	-
Spinach	-	40	320	1220	1560	1090	300	255	-	-	-	-	5	15
Onion	295	225	340	335	1035	1290	865	270	225	180	145	48	64	65
Turnip	395	290	241	230	270	875	730	580	380	330	430	420	310	304
Mustard	-	-	-	-	-	50	65	25	30	25	-	20	50	20
Other	140	260	400	301	1437	3231	2272	2015	1650	1750	1375	594	425	443
Total large	1010	390	100	85	35	100	40	10	15	50	0	0	0	0
Total small	830	815	1301	2086	4302	6536	4232	3145	2285	2285	1950	1082	854	847
Grand total	1840	1205	1401	2171	4337	6636	4272	3155	2300	2335	1950	1082	854	847

1/ Data courtesy of Oregon State College Fxtension Service, Department of Agricultural Fconomics. Not for publication without permission from that Department.

* Large seeds; all others are considered as small seeds.

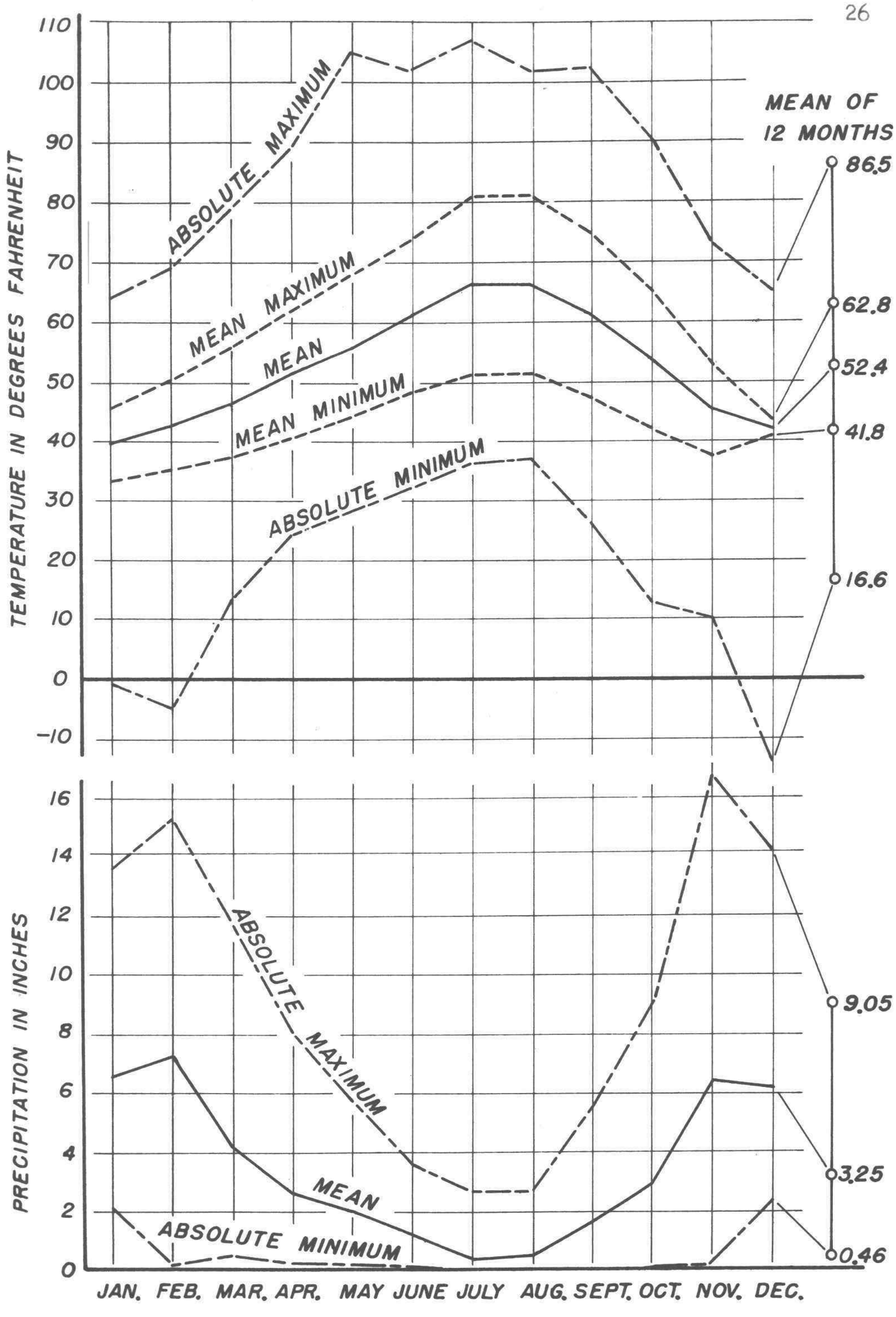

FIG. 12 CLIMATE AT CORVALLIS, OREGON FOR 60 YEARS, 1889 TO 1950 (AGRICULTURAL EXPERIMENT STATION, OREGON STATE COLLEGE, CORVALLIS, CIRCULAR OF INFORMATION 487, AUGUST 1950)

in the field with only occasional loss of stands. In some years, however, when minimum temperatures drop below 0 F for a prolonged period of time, considerable losses of over-wintering crops can occur. The lowest temperatures occur in January, with an average minimum of 32.9 F.

Average temperatures during the summer months are not excessive and usually range from 70 F to 80 F. Hot spells are of very short duration and even if daytime temperatures are high, night temperatures are usually quite cool. In Corvallis where the climate is similar to the leading vegetable seed producing counties of Linn, Marion, and Lane, the average maximum temperature is 78.4 F for the summer months with August being the highest, 81.3 F. The average minimum temperature for the summer months is 50.2 F, all three months being nearly equal. For the spring months, March, April, and May, the average minimum temperature is 10 F less and the average maximum temperature is 16 F less than during summer months.

The pattern of annual distribution of precipitation fits in with seed production practices admirably well. Although the Willamette Valley receives approximately 40 inches of rainfall a year, less than five per cent of this total comes during the three summer months as shwon in Figure 12. This lack of moisture during the summer makes for dry soil conditions, especially on the lighter textured soils, and necessitates supplemental irrigation for those crops which extend their growth late into the summer. Seed-borne diseases are seldom a factor of concern as a result of the dry summers. Harvest conditions are near to being ideal because of the lack of rains and showery weather during this period. Throughout the summer months sunshine is plentiful and hail storms are a rare occurrence. Humidities are generally quite low and high winds are uncommon with average velocities ranging from five to six miles per hour. This unusual combination of environmental conditions favors the production and harvest of high quality seed crops.

ANALYSIS OF ECONOMIC FACTORS AFFECTING VEGETABLE SEED PRODUCTION

Two main groups of factors, economic and production, have in the past and will in the future, determine the position that the vegetable seed industry holds in the Willamette Valley's agricultural economy. Economic factors are those forces that determine how farmers allocate their resources of land, capital, and labor. These forces are far reaching and involve world-wide and nation-wide considerations of supply, demand, and economic alternatives.

It is largely economic factors which first generate interest and enthusiasm among seedsmen and producers as to the possibilities of growing a new crop in their particular area. When price and cost-of-production relationships for a new crop become more favorable than for other crops produced in their area, and it appears that this relationship will hold over a period of several years, farmers are willing to allocate a portion of their land, capital, and labor for the production of the new crop. As production experience is gained and efficiency improves, acreage will continue to expand as long as an economic advantage can be realized for that particular crop. If an economic advantage can no longer be maintained and/or production problems cannot be resolved, production of the crop will be reduced in favor of crops or other enterprises which offer greater economic opportunity.

DEMAND

It is the interaction of demand and supply which largely determines the price that Willamette Valley vegetable seed producers obtain for their product. Both domestic use and exports constitute demand.

Domestic Use. During World War II domestic use of garden seeds expanded tremendously in response to war-time conditions. Publicity on victory gardens by various public agencies, seedsmen, magazines and newspapers brought forth a greater demand for vegetable seeds than had ever heretofore been experienced. In response to the patriotic movement millions of home gardeners, whether city or country, planted gardens, thereby adding their bit to the war effort. Commercial truck gardeners used hundreds of pounds more seed when called upon to meet huge production goals. As a result, domestic consumption of vegetable seed increased nearly 50 per cent during the war years as shown in Figure 13 and Appendix Table I. Following the war domestic use of garden seeds rapidly returned to levels approximating pre-war conditions with slightly more seed being used in recent years than prior to 1941.

During the war per capita consumption of fresh, canned, and frozen vegetables increased considerably. Within the last three-year period, consumption of these classes of foods has averaged approximately ten per cent higher than during the 1935 to 1939 period as indicated in Table 2. Most of the increase has been in the fresh vegetable class with snap beans, lettuce, tomato, cauliflower and onion showing the greatest increase whereas fresh peas and spinach have decreased in use. Of the canned vegetables which constitute only 16 per cent of the total vegetables consumed, corn, peas, snapped beans, processed tomato, beet, and carrot have increased markedly whereas canned whole tomatoes have decreased. Although per capita consumption of frozen vegetables has

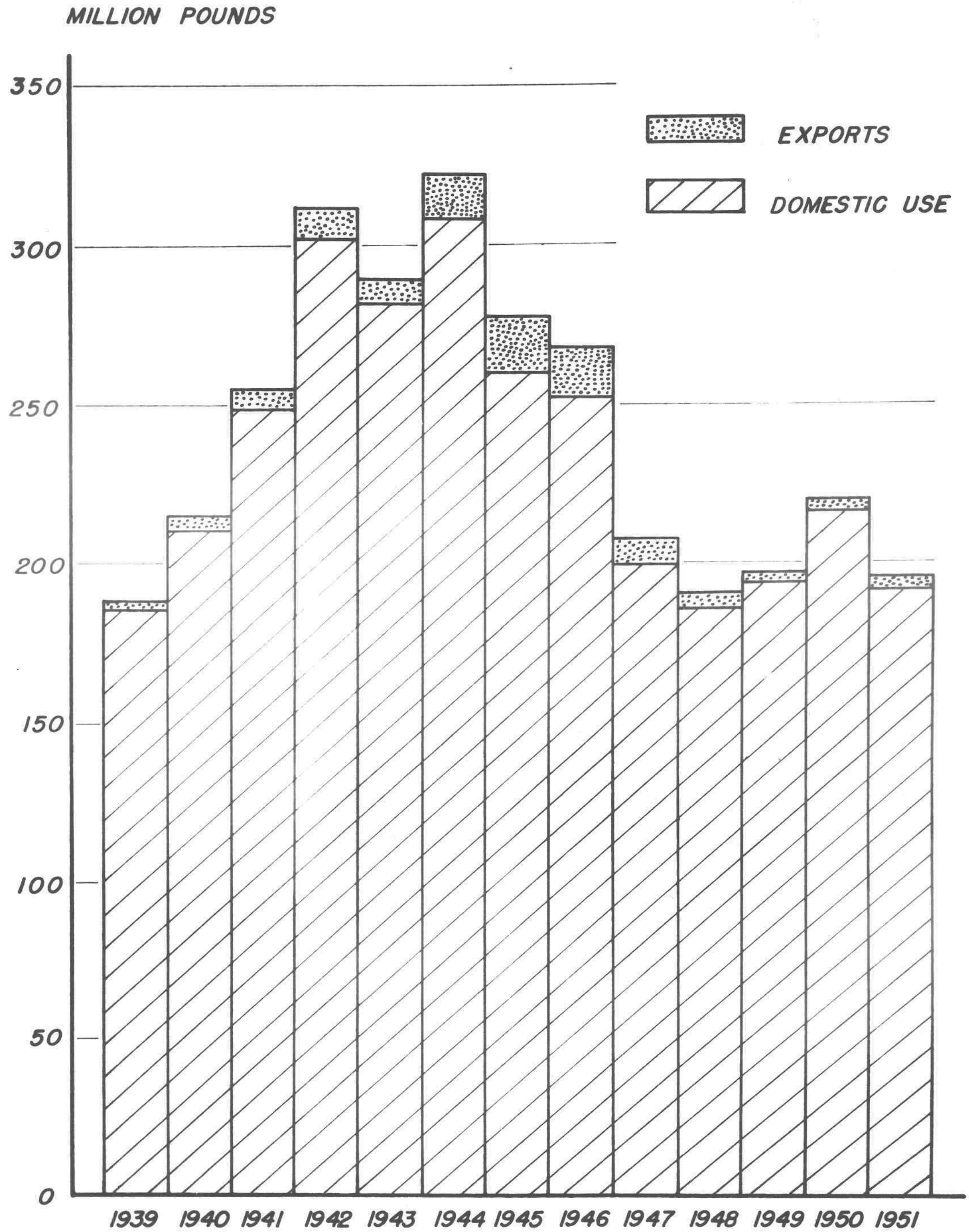

FIG. 13 USE OF VEGETABLE SEEDS IN THE UNITED STATES FROM 1939 TO 1951

Table 2. Apparent per capita civilian consumption of vegetables in various forms. United States, indicated years. 1/

Class of vegetables	Average 1935-39	1950	1951	1952
	Pounds	Pounds	Pounds	Pounds
Fresh 2/	235.0	252.0	254.0	241.0
Canned	29.9	41.8	41.4	41.2
Frozen	0.4 3/	3.3	4.1	4.2
Dry edible beans	8.8	8.6	8.4	8.5
Dry edible peas	0.6	0.8	0.7	0.7

1/ Data from 1953 Outlook Issue, the National Food Situation. Bureau of Agricultural Economics, United States Department of Agriculture. October - December. 1952.

2/ Does not include potatoes.

3/ Average 1937-39. Data prior to 1937 are not available.

increased tenfold since 1935-39, this class accounts for less than two per cent of the total vegetables consumed. Most of the increase in frozen vegetables has been with peas, corn, and snapped and lima beans. The per capita use of dry edible beans and peas has remained relatively stable throughout the last 15-year period (91, p.80-81-91-115; 92, p. 7-8-9).

Even though domestic consumption of vegetables has increased since pre-war years, it should be pointed out that it takes a considerable shift in consumption of vegetables to effect much of a change in acreage of vegetable seeds. One acre of seed cabbage, for example, could be expected to yield 500 pounds of seed. Based on normal cabbage seeding rates and yields per acre, this amount of seed would produce 10,000 tons of cabbage, enough to supply 100,000 people for five and one-half years at the present rate of per capita consumption. Table beet could be expected to produce at least 1200 pounds of seed per acre under Willamette Valley conditions. Twelve hundred tons of roots could be produced from this seed which would be sufficient to supply 100,000 people for four years at the present rate of consumption.

Exports. With the occupation of Holland and other western European countries and the dislocation of British agriculture, the opportunity arose for the United States to expand its foreign markets. Evidence of this is shown in Figure 13. Starting in 1944 and continuing through 1946, the United States exported substantial amounts of large seeds, especially to Australia and Great Britain, to help meet their needs. Large amounts of seeds, both field and vegetable, were purchased by the Federal Surplus Commodities Corporation for export under the Lend-Lease Program (114, p.18-19). Since that time, with the recovery of Holland, Denmark and England, war-time gains in exports have been reduced to an amount which is no longer of any great significance to the producers of the Willamette Valley.

Possible Future Demand. The future domestic demand for vegetable seeds of the kinds produced in the Willamette Valley depends upon many factors (13, p.1-7).

With the increasing population more total food will be needed to supply our peoples' nutritional requirements whether it be vegetables of the type for which the Willamette Valley farmers produce seed or some other kind. The amount of vegetables that will be consumed by each person, however, depends to a large extent upon the consumer level of income. With high levels of income consumers tend to shift from high-calorie foods such as the cereal and potato products, to those that contain less carbohydrates and more proteins, minerals and vitamins. This has been amply illustrated in recent years with the increased per capita consumption of most vegetables.

Another factor which could influence the future vegetable consumption is the educational program of nutritionists and others which is being directed toward acquainting the public with the need for more vegetables in their diet. Unless these efforts are greatly increased, however, it is doubtful if this factor will exert much influence on the peoples' eating habits in the future.

Granted that total domestic demand of vegetables will in all probability increase in the future, the effect that this will have on demand for seeds produced by the Willamette Valley farmers may be of little consequence because of the increased efficiency in the use of garden seeds as a result of improved cultural procedures and better varieties. Likewise improved marketing and handling methods for vegetable products should reduce the amount of waste and thereby decrease the need for seed.

With the current shortage of dollar exchange in the hands of other nations plus the fact that certain European countries are strongly seeking markets for their garden seeds, it does not appear that exports are destined for any great increase in the future.

In view of these considerations it is doubtful if there will be an appreciable increase in demand for vegetable seeds in the immediate future. In the event of another national emergency, however, demand could be expected to increase sharply for seeds of all types, such as was the case during World War II. If high tariffs should be imposed so as to restrict foreign imports of small seeds, that too would result in an entirely different situation than exists at present and should bring about a sharp increase in demand for garden seeds produced by the Willamette Valley farmers.

SUPPLY

Supply factors are important to the Willamette Valley farmer since they have an effect on the price offered the seed grower.

Production. It has been pointed out that the demand for vegetable seeds received a tremendous stimulus as a result of World War II. This was immediately reflected in an increased domestic production both in the Willamette Valley and the nation as a whole. Evidence of this is shown in Table 1 and Figure 14.

In the United States production of garden seeds increased from slightly over 100 million pounds in 1939 to over 350 million pounds in 1943. Production was maintained at a high level until 1948 after which time a sharp reduction occurred for both large and small seeds. In recent years the average production of large seeds has been maintained at a level approximately 50 per cent greater than that of 1939. The production of small seeds, on the other hand, is slightly below that for the pre-war period.

Most of the production in the United States has been of the large seeded kinds, i.e., peas, beans, and corn. In only one year, 1944, did small seeds ever comprise more than one per cent of the total seeds produced.

Figures on vegetable seed production are unavailable for Oregon. Acreage statistics in Table 1 for the Willamette Valley, however, show that before the war an average of 1500 acres of vegetable seed were grown each year. During 1944, the peak production year, 6636 acres of vegetable seed were produced, of which all but a hundred acres were of the small-seeded kinds. This expansion of vegetable seed acreage in the Willamette Valley exceeded the percentage increase in seed poundage produced in the United States as shown in Appendix Table I. This

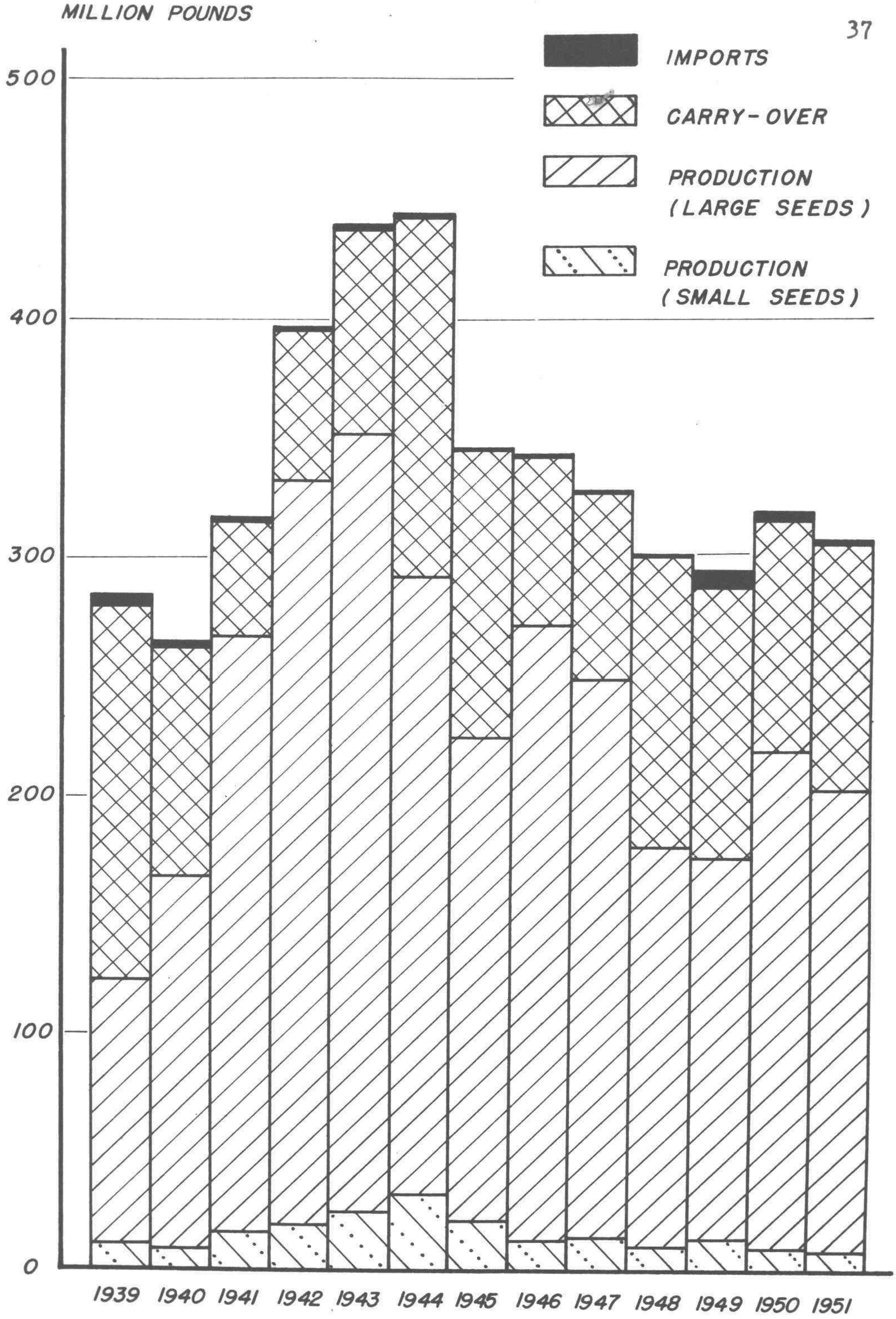

FIG. 14 SUPPLY OF VEGETABLE SEEDS FOR THE UNITED STATES FROM 1939 TO 1951

suggests that the Willamette Valley was a more favorable place to increase vegetable seed production than many other areas in the United States. Since 1944 acreage has declined steadily, the same as in other vegetable seed-producing areas in the United States. In 1951 and 1952 less than 1000 acres were planted in vegetable seeds. This amount is slightly below that of the pre-war period but follows closely the production pattern for the entire nation.

Carry-Over Stocks. The vegetable seed industry is characterized by sizeable carry-over stocks from year to year as shown in Figure 14 and the data in Appendix Table I. Whenever production greatly exceeds the demand, carry-over stocks are large. In the year 1944, for example, following the record vegetable seed production year, these stocks amounted to more than one-half a full year's domestic production. Seed houses must necessarily give due consideration to these fluctuating carry-over stocks in determining the acreage to be contracted and the price to be offered. The influence of these stocks on price to the Willamette Valley seed producer cannot be determined since a detailed break-down of the kinds of seed making up the carry-over are unavailable. It may be a factor of considerable significance, however.

Imports. The data shown in Figures 14 and 15 indicate that imports of large seeds have never been of much significance in comparison with total domestic production of these kinds of seeds. Imports of small seeds before World War II, however, were equivalent to approximately one-half the annual production of the United States as shown in Appendix Table I. These imports approached the vanishing point during

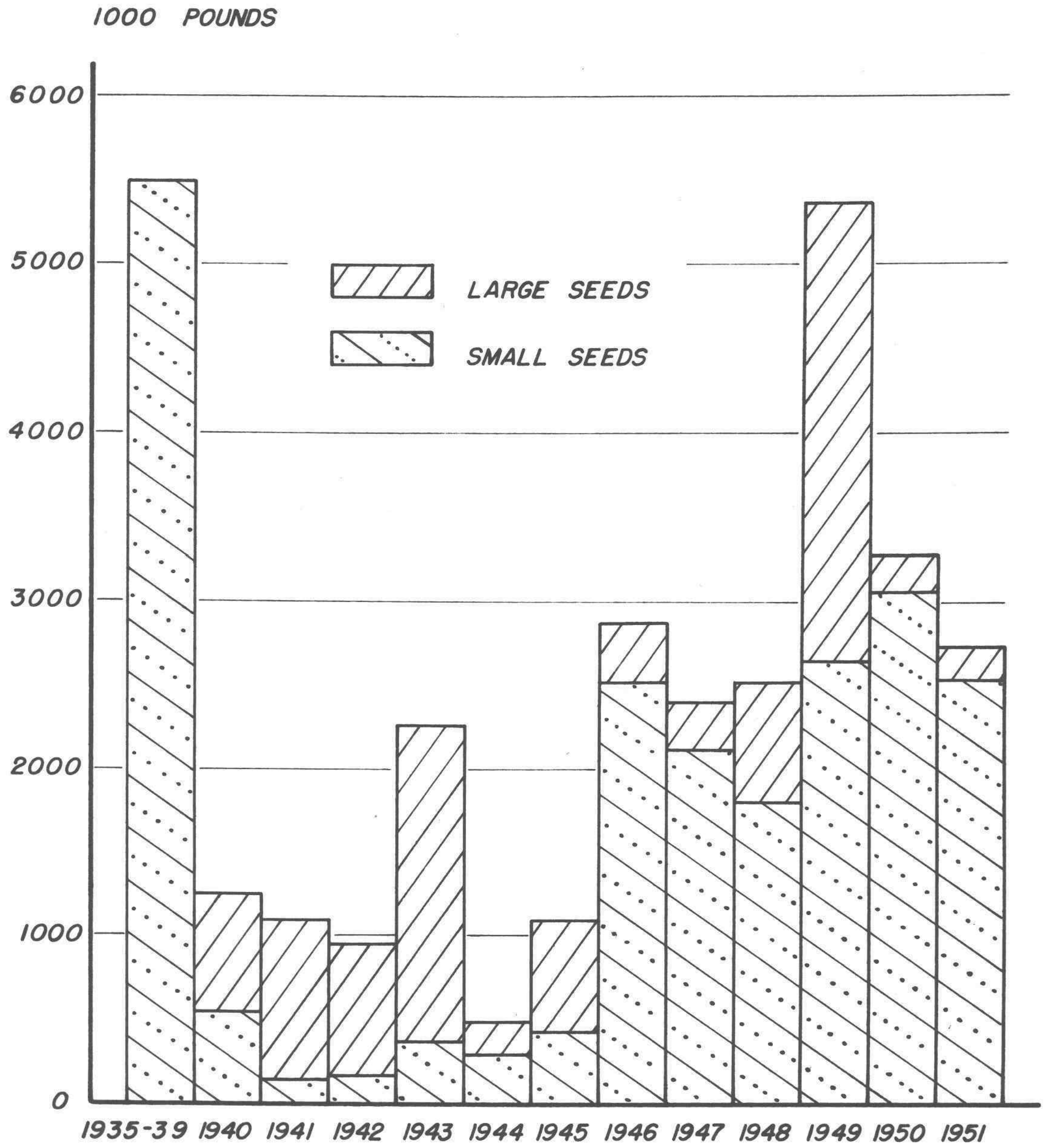

FIG. 15 TOTAL IMPORTS OF VARIOUS KINDS OF VEGETABLE SEEDS FOR THE UNITED STATES FROM 1935 TO 1951

the war years when seeds of garden beet, cabbage, turnip, spinach, rutabaga, and radish no longer came in from western European countries to meet the nation's domestic needs (Appendix Table II). In 1946, however, a sharp recovery of trade became apparent with the imports of small seeds again being shipped in from our former suppliers. The amount of seed which was imported approximated one-half that of the 1935-39 average. Since then this position has been maintained at about the same level. These data indicate that the foreign seedsmen have been forced to sacrifice a substantial portion of their United States market.

It was previously pointed out that the national production of small seeds is slightly below that of its pre-war position. In view of this and decreased imports it is apparent that with the overall per capita increase in vegetable consumption and the expanding population there has been achieved a measurable degree of increased efficiency in the use of small seeds. This can be explained for the most part on the basis of improved precision planting equipment, better farming practices associated with the commercial vegetable growing industry, and improved, higher-producing vegetable varieties.

Production Potentials. The vegetable seed industry in the Willamette Valley is characterized by a high degree of flexibility as determined by its land, capital, and labor requirements. These resources relate directly to the supply of vegetable seeds.

1. Land. Considerable land is available for vegetable seed production purposes in the Willamette Valley. As discussed in later

paragraphs (pages 80 and 82), river-bottom soils are most suitable for vegetable seed culture and constitute most of the acreage. The total acreage of Class I land suited to intensive crop production is 273,316 acres (78, footnote on map). Assuming that 80 per cent of the vegetable seed acreage is located on this land, less than one-half of one per cent of the total land was devoted to vegetable seed production in 1952. Even in the peak production year of 1944, when vegetable seed acreage reached 6636 acres, only about two and one-half per cent of the land resource was devoted to this use. Consequently, there is tremendous room for expansion, limited only to the extent that it is necessary to conform to isolation requirements for cross-pollinated crops.

2. Capital. While certain specialized equipment and facilities are required for the production of some of the vegetable seed crops, fixed capital outlay for the Willamette Valley farmer is not especially large as compared with many other forms of intensive agricultural enterprises such as hop and bean growing, dairying, and similar enterprises. Most of the buildings, machinery and equipment necessary for seed-growing operations, can be used for other enterprises carried on in conjunction with vegetable seed production. Whenever shed room is needed, buildings designed primarily for other farm uses can be readily remodeled and utilized to good advantage. Most of the row-crop machinery and other equipment used for ordinary cultivated crops, can be used interchangeably for vegetable seed farming, with little or no modification. Irrigation equipment, used on more than one-half the vegetable seed crops, can be utilized for other crops as well. The need

for an irrigation system, however, entails a substantial portion of the investment of the seed grower. Whenever specialized and expensive equipment such as transplanting machines, precision drills for small seeds, and threshers is needed, contracting seed companies usually furnish these to the grower at a nominal rental, thus saving the farmer a heavy investment cost.

Operating capital required to produce vegetable seed crops is relatively large compared with other seed-growing enterprises, such as grasses and legumes. Tractor and machine use is high because of the necessity to keep the crops cleanly cultivated and well fertilized throughout the growing season. Fertilizer requirements for vegetable seed crops are high in comparison with other field crops which results in increased costs for the fertilizer and its application. Operating costs are increased further because of the necessity for frequent spraying and dusting for insect and/or disease control.

3. Labor. Many of the vegetable seed crops, especially biennials, are notoriously high in their labor requirements, since so many hand operations are involved. Some of the various hand operations for certain crops are illustrated in Figures 16, 17, 18, and 19.

An example of a vegetable seed crop with a high labor requirement is cabbage. The following steps are usually taken in order to produce seed: (99). First, a small plant bed is prepared and seeded in the early summer months. This is carefully cared for—irrigated, fertilized, insects and weeds controlled. In late summer or early fall the plants are dug by hand, hauled into the field and transplanted into a finely-worked, weed-free soil as shown in Figure 18. Transplanting is a

Fig. 16. Winter squash following harvest. This is another example of a crop with a high labor requirement. Because of the hard outer shell, seed is scooped out by hand instead of threshed mechanically.

Fig. 17. Experimental field of cabbage showing common staking practice used for supporting plants. This practice requires much labor and is quite widely used. Research has shown that unstaked fields yield as much as those that are staked.

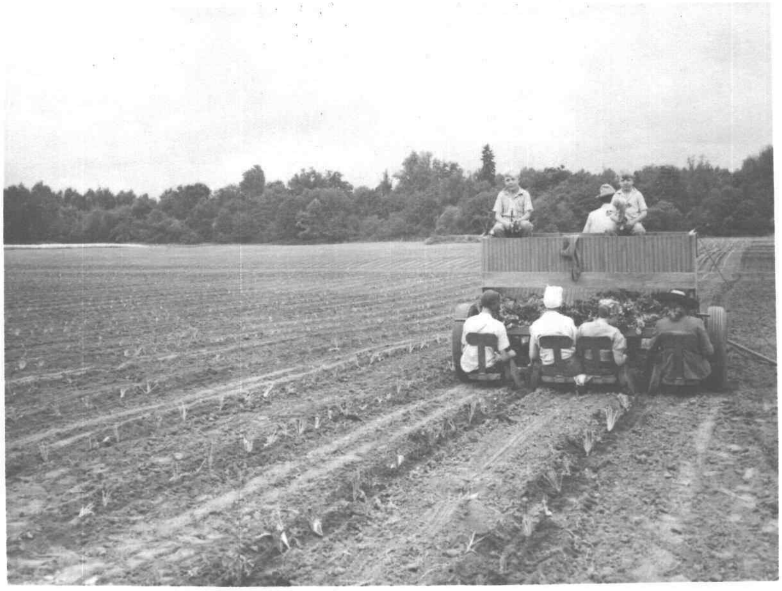

Fig. 18. Transplanting cabbage on typical Willamette Valley river-bottom land in early September. Note the firm, weed-free seedbed. Labor-saving machines such as the one shown greatly reduce labor costs.

Fig. 19. Harvesting onions for seed by hand. Workers cut off only the ripened heads and drop them into picking sacks supported at the waist.

hand-setting operation, aided considerably by special machines used only in relatively recent years in the Willamette Valley. At this time fertilization and irrigation are usually required to get the plants off to a good start. Early the next spring brings the problem of weed control and the need for fertilization. The encroachment by insects must be constantly guarded against and control measures applied when and as often as are necessary. Prior to blooming, plants are often staked and strung by hand in order to support them in an upright position. In addition, conscientious growers, who are interested in producing the highest quality seed, make it a practice to go over their fields two to three times a season to rogue for off-type plants. In July comes the harvest, which is another hand operation. The plants are cut, laid in windrows for curing and after a two to three weeks curing period, are pitched into a combine or are hauled to a stationary machine for threshing.

Fortunately not all the vegetable seed crops have such a high labor requirement but the example given points out the tremendously high labor requirement for certain crops. While the development of specialized machinery has reduced labor requirements for many crops in recent years, the fact still remains that there are a large number of crops for which a great amount of hand labor is required.

Labor is one of the most significant costs of vegetable seed production, particularly in view of the fact that farm labor wages as shown in Table 3 have advanced at a faster rate than have most other costs of production. This points to the advisability of developing

Table 3. Index numbers of prices paid by farmers for production items and hired labor wage rates. United States, indicated years. 1/

(1910-14 = 100)

Year	Production items price index	Hired labor wage rate index
1939	121	127
1940	123	129
1941	130	151
1942	148	197
1943	164	262
1944	173	318
1945	176	359
1946	191	387
1947	224	419
1948	250	442
1949	238	430
1950	246	425
1951	273	470
1952	274	503

1/ Data from United States Department of Agriculture, Bureau of Agricultural Economics, Crop Reporting Board, Washington, D.C.

companion enterprises whose seasonal peak demands for labor do not coincide with those for the vegetable seed crop. In this way it is possible to make the maximum use of the labor resource and to utilize it the most efficiently. This principle is especially important for small operators who perform most of the labor themselves.

When total operating capital and labor are combined, this results in a high proportion of the total cost being variable. It has been previously pointed out that the non-transferable fixed costs are a relatively minor item. As a result of this relation, with changing prices, considerable fluctuation in the number of growers and in the acreage involved in seed production would be expected. Evidence of this is shown in Table 1.

Alternative Opportunities. The existence of alternative enterprise opportunities greatly influences the supply of vegetable seeds that are or will be grown in the Willamette Valley. Whenever the resources of land, labor and capital are transferred to some enterprise in order to obtain a greater economic advantage this directly affects the amount of vegetable seed acreage and total production. It has been pointed out that much of the equipment, machinery, and facilities could be readily transferred for use into other enterprises. The soil, being the most productive type in the state, also has a wide range of alternative uses. With the relatively favorable price level for certain grass and legume seed crops in recent years many of these crops have been substituted advantageously for some of the low value, more extensive type of vegetable seed crops like mustard, turnip, and radish. For the more intensive vegetable seed crops, however, there are but few other enterprises which allow a grower who operates a small total acreage to market his own labor to so great an advantage.

No data are available on the size of units on which vegetable seeds are produced or on income and cost-of-production relationships for vegetable seed crops and competitive enterprises. Without these data it is impossible to accurately assess the degree of competition from alternative enterprises.

PRICE

It has been pointed out that supply and demand conditions affect the price of vegetable seeds in relation to the price of other agricultural commodities. Price-making forces are not limited to Willamette Valley conditions since the production and markets here are generally competitive with other producing areas.

The price data presented in Table 4 were obtained from three seed companies and represent contract prices paid to Willamette Valley farmers for 16 various vegetable seed crops during the last 13-year period.

Several significant points are apparent in these data. The first concerns itself with the pattern of price changes for vegetable seeds. As demand increased the prices of vegetable seeds rose rapidly from 1940 on and reached their peak in 1944, which was twice that of the 1940 price level. As a result acreage of vegetable seeds increased and closely paralleled the changing price patterns as shown in Figure 20.

Table 4. Prices paid to farmers by three contracting companies for 16 kinds of vegetable seeds in the Willamette Valley. 1939 to 1952 inclusive 1/

Kind of crop	Company	Year													
		1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952
Beet, table	A	- 2/	-	-	15	24	25	25	20	20	-	20	-	-	-
	B	-	-	-	40	40	40	40	30	25	25	25	25	25	30
	C	-	12	14	20	30	30	30	26	25	-	25	-	-	-
Cabbage, white	A	-	-	-	40	85	1.00	75	50	50	50	50	50	33	45
	B	75	75	75	1.00	1.00	1.00	85	80	75	70	65	60	75	75
	C	-	-	-	-	1.00-1.25	1.00-1.25	60-75	60-75	60	60	60	60	-	-
Carrot	A	-	-	17	30	40	50	-	-	-	-	-	-	-	-
	B	-	-	75	75	-	-	-	-	-	-	-	-	-	-
	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chinese cabbage	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	B	-	-	100	100	100	60	60	-	-	-	-	75	80	85
	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cucumber	A	-	-	-	-	-	50	45	45	55	50	-	25	40	45
	B	Always paid 45¢ for pickle varieties and slicers average 60¢													
	C	-	-	-	-	-	-	-	-	-	50-60	-	-	-	-
Kale	A	-	-	-	16	16	30	25	30	30	-	30	20	17	20
	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	C	-	12	15	25	35	35	25	20	20	20	20	-	-	-
Mangel	A	-	-	13	13	20	20	18	16	16	16	-	-	-	-
	B	-	-	During war about same as beet, around 40¢ per pound. Exact records lost.											
	C	-	10	12	18	25	28	28	20	16	-	-	-	-	-
Mustard	A	-	-	-	-	-	15	-	-	-	-	-	-	15	15
	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	C	-	10	12	15	15	15	12	12	15	-	15	15	15	-
Onion	A	-	35	35	47½	85	85	65	50	50	50	50	50	50	50
	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Parsnip	A	-	15	18	18	18	22	25	18	18	18	16	17	15	17
	B	-	-	-	-	25	25	25	20	20	20	20	20	20	22
	C	-	-	-	15	18	18	15	12½	-	-	15	15	-	-
Radish	A	-	-	-	17	19	25	20	-	-	25	25	15	25	25
	B	25	25	25	25	-	-	-	-	-	-	-	-	-	-
	C	-	10	15	18	18	19	15	15	15	-	-	-	15	-
Spinach	A	-	-	10	17	20	20	15	-	-	-	15	9	13	15
	B	20	20	20	25	20	20	20	20	27	-	-	-	-	-
	C	-	10	15	15	18	18	15	12	12	-	-	-	-	-
Squash, winter	A	-	-	-	31	55	55	30-45	30	40	-	30	25	40	45
	B	-	-	-	-	45	50	50	45	45	45	45	45	45	50
	C	-	-	20	25	50	55	45	45	-	-	-	-	-	48
Squash, summer	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	B	25	25	25	25	25	25	25	25	25	25	25	25	25	40
	C	-	-	-	-	-	70	70	-	-	-	-	-	-	-
Swiss chard	A	-	-	-	15	20	20	-	-	16	-	-	-	-	-
	B	-	-	-	-	-	30	30	20	20	20	20	20	20	-
	C	-	10	12	18	25	25	18	-	-	-	-	-	-	-
Turnip	A	-	-	9	9	12	15	12	09	10	10	12	12	10	13
	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	C	-	10	12	15	15	15	12	12	12	12	12	12	14	14

1/ Data courtesy of three well-established seed companies in the Willamette Valley.

2/ Missing price data indicates that company did not contract for that particular kind of seed in given year.

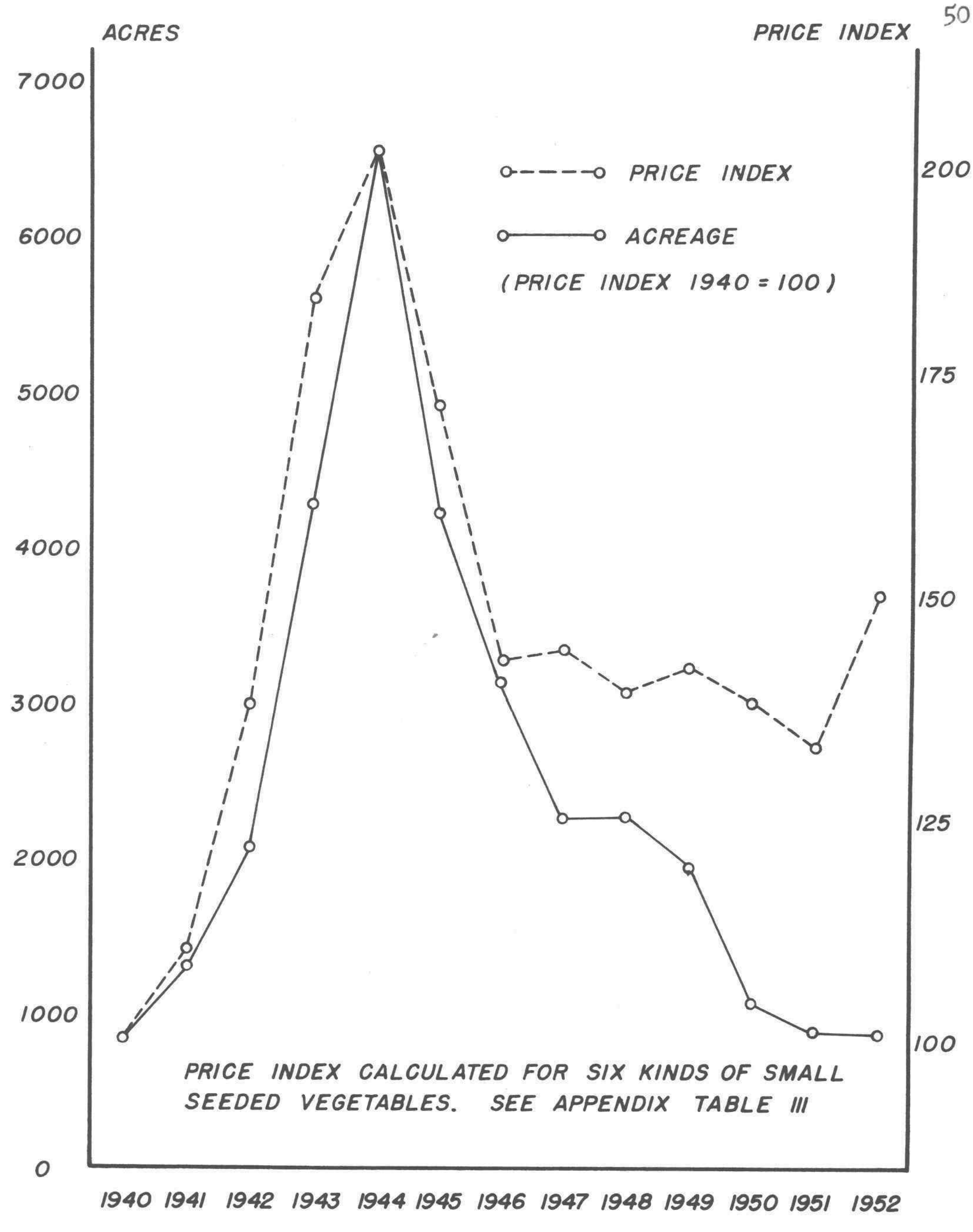

FIG. 20 ACREAGE AND PRICE RELATIONSHIPS OF SMALL SEEDS FOR THE WILLAMETTE VALLEY FROM 1940 TO 1952

After 1944 vegetable seed prices declined sharply and leveled off from 1946 on at approximately one and one-half times that prior to the war. The prices of other Oregon farm commodities, on the other hand, continued to increase as the data in Table 5 indicate. This changing relationship of prices for vegetable seeds and other farm commodities is responsible for much of the shift out of vegetable seed production. It has already been noted that the acreage devoted to vegetable seed crops in the Willamette Valley is now below the 1940 level.

Another striking feature of the price data is the widely differing prices which various companies contract a given kind of seed in a given year. For example, in 1951 Company A contracted cabbage for 33 cents a pound whereas Company B contracted the same crop for 75 cents. It is possible that this was due to a price differential established for different varieties but in 1944 both Companies A and B were contracting cabbage for $1.00 per pound while Company C was contracting for this same kind of seed at $1.00 to $1.25. Another discrepancy between companies is noted in the case of table beets where Company B contracted at 15 cents in 1942, 24 cents in 1943, and 25 cents in 1944 and 1945. Company C in these same years was contracting this crop for 20 cents, 30 cents, 30 cents, and 30 cents, respectively.

In most cases seed companies contract with growers within a reasonable distance from their warehouses and there are but few places where two or more companies have warehouses in the same locality. This tends to result in a delineation of the area of competition and, except for sporadic attempts at expansion or entry into the market by new

Table 5. Comparison of price indexes for vegetable seed crops and other Oregon farm commodities.
(1940 = 100)

Year	Oregon farm price index 1/	Vegetable seed price index 2/
1940	100	100
1941	117	110
1942	156	138
1943	185	184
1944	185	202
1945	198	172
1946	222	143
1947	266	144
1948	283	139
1949	244	142
1950	249	138
1951	285p	133
1952	285p	150

1/ Source of data: Oregon Extension Bulletin 722. November 1951. p. 4.

2/ Based on contract prices for six kinds of vegetable seeds. See Appendix table III.

p = Preliminary

companies, limits the bargaining opportunities of farmers wishing to produce seed. Evidence of this monopolistic characteristic has been indicated by widely differing prices paid by seed firms for the same kind of seed and is further shown by the unchanging price offered for certain seeds throughout a series of years. Company B, for example, contracted summer squash for 25 cents a pound from 1939 to 1951. In 1944 to 1945, Company C contracted the same kind of seed at a price of 70 cents. Company A did not contract for this crop at any time. Of the three companies listed, only one contracted for onion seed and since 1946 paid a fixed price of 50 cents a pound to the growers.

It has been pointed out previously that with present prices, the vegetable seed industry is at a relative disadvantage in comparison with many other alternative enterprises in the Willamette Valley. On the basis of the present supply and demand situation for vegetable seeds, it is not likely that any significant price rise will be forthcoming in the immediate future. Until such time as economic forces act as to increase vegetable seed prices at a much faster rate than other farm commodities, it is not logical to expect any marked or rapid expansion of this industry in the Willamette Valley.

ANALYSIS OF PRODUCTION FACTORS AFFECTING VEGETABLE SEED PRODUCTION

Production factors are those that a grower must take into full consideration when producing the crop. These determine largely whether the seed-growing operation will be a success or failure, since many factors of production are limiting and deserve full recognition and understanding on the part of the grower if he is to cope with the various problems involved. Production factors are for the most part localized for the specific area under consideration--in this case the Willamette Valley.

The factors of production could be classified logically into two main groups: indirect and direct. The indirect group of factors is characteristically non-physical and includes such things as personal qualifications of the seed grower, seed marketing contract and isolation requirements of the various vegetable seed crops. All these factors must be considered fully before launching a vegetable seed production program.

The direct group of factors are those that deal primarily with the growing and handling of the crop. These factors, to a large extent, determine the efficiency of production and the yield and quality of the seed produced.

PERSONAL QUALIFICATIONS OF SEED GROWERS

Personal qualifications of seed growers are a vital factor which may determine success or failure in the vegetable seed growing business.

Because of the complex characteristics of vegetable seed growing, farmers who possess special qualifications are often needed to handle these crops.

Vegetable seed production is quite specialized compared with the production of other seed crops (93, p.4). The problems presented by the culture of vegetable seed crops are generally more difficult and exacting than those encountered with the growing of many forage seed crops or with grain production. This is especially true for the biennial crops which must be handled during two seasons or portions thereof. These specialty crops for the most part are more subject to insect hazards and other risks than are ordinary farm crops. They require intelligent and diligent care and oftentimes above-average skill on the part of the producer. On the whole they require more hand labor and a greater amount of attention and untiring application to details from the time the crop is planted until it is harvested. Much of the success of vegetable seed growing depends upon the growers' willingness to cope with these problems, the amount of personal attention they are willing to give the crop, and their ability to meet new situations when they arise.

Seed companies who contract with farmers for the production of vegetable seed are fully cognizant of the necessity for good personal qualifications of growers and weigh these heavily before offering a seed-growing contract. In the earlier years of vegetable seed contracting in the Willamette Valley, many contracts were made with growers without giving full consideration to their personal qualifications.

This procedure resulted in losses in many cases both to the seed company and to the farmer. Based on this experience seed companies have found that they must select growers who are willing to do a good job of farming and who agree to handle the crop in such a manner as to secure optimum yields of high quality seed. Full-time farmers have usually proven more satisfactory than part-time farmers for this purpose.

SEED MARKETING CONTRACT

A vegetable seed contract is an essential part of the seed-growing operation. It assures the grower of a market for his seed and in addition provides the grower an opportunity to avail himself of the services of a technically-trained seed company field representative who can give helpful suggestions with respect to growing the crop.

In the Willamette Valley as in other vegetable seed growing areas, nearly 100 per cent of the crops are grown under contract between farmers and commercial seed firms. This unique feature is one of the principal ways in which the vegetable seed industry differs from other seed-growing ventures. Growers who produce vegetable seeds without a contract often find that they have no market for their crop. The reasons for this are twofold: First, is the likelihood of over-production. It takes only a very small acreage of most of the vegetable crops to produce enough seed to supply the national need. Less than 2000 acres of cabbage seed, for example, are needed to supply our nation with one year's seed requirements. Consequently seed produced over and above the required amount would likely find no market.

Secondly, seed companies, which are the only outlet, like to promote their own varieties and prefer to make the necessary arrangements for growing their variety under specific field conditions.

Two examples of typical seed growing contracts used in the Willamette Valley are shown in Appendix Figures 1 and 2. These contracts usually provide 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, care for, harvest, 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 seedsmen on or before a certain date. Also they usually state that the seed will not be accepted unless it meets certain germination requirements. The seedsmen ordinarily agree to furnish the stock seed and to pay an agreed price for all the seed in excess of the amount furnished for planting. Provisions are made in most contracts 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 seedsmen or both.

ISOLATION REQUIREMENTS

Isolation requirements must be carefully considered before planting a vegetable crop for seed purposes in the Willamette Valley. If this is ignored, genetical deterioration of cross-pollinated crops may occur because of promiscuous crossing with other varieties or kinds of tame or wild species which happen to be growing nearby. Seedsmen and growers must continually guard against this danger in order to safeguard the genetic purity of seeds. Users of vegetable seeds are entitled to demand a minimum of contamination since this directly affects the quality of their product and oftentimes lowers the efficiency of their production. In many cases, vegetables as a result of crossing, acquire undesirable characteristics such as roughness, multiple crowns, and pronginess besides losing their proper type. For example, where rutabaga crosses with turnip or bird rape, *Brassica campestris*, the progeny invariably shows wart-like lumps similar to those found on roots affected with club root. Other wild forms which may cause serious trouble to their related cultivated crops are wild carrot, wild radish, wild parsnip, and salsify (103, p.3).

Methods of Handling Isolation Problems. Bateman (6, p.752-753) pointed out that the maximum permissible contamination varies with the crop and the use for which the seed is intended. The tolerance limit of contamination can be higher for commercial seed that is used by the commercial or home gardener than for stock seed which furnishes the source of planting material for seed growers. Isolation must be nearly perfect if elite or breeder seed is being produced although it is unnecessary to attempt to reduce the contamination below a level equivalent to the natural variability of the variety.

Haskell (34, p.591) working on vegetable seed crop isolation requirements in Great Britain, stated that two methods could be used to handle this problem: (1) by zoning, in which certain areas are designated for the production of certain varieties or strains of seed crops and (2) by spatial isolation, i.e., the spacing of crops at specified distances from each other.

The first method applies more generally to highly intensified areas of production where it has become necessary because of the large number of varieties and kinds of crops, to regulate their spacing relative to one another. In Noord-Holland, the leading vegetable seed producing province in Holland, for example, over 100 zones were mapped out during World War II and applied to a wide range of crops including beet, swiss chard, Brassicas, carrot, radish, mangel, onion, broad bean, and runner bean (62, p.532-533). Regulations were also established to decide the priority of crops growing on the borders between two zones. Zoning schemes were also used in the Essex seed growing area of Great Britain for seed production of sugar beets, garden beets, mangels, and the Brassicas (27, p.13-14). In the United States, in the Mt. Vernon, Washington, area it became necessary during the war to set up a zoning system to accommodate the large number of Brassicas grown there (118, p.5).

Where zoning rules and regulations have not been promulgated it is essential that seedsmen take the necessary precautions in separating crops that are likely to cross with other kinds or varieties.

Isolation Requirements for Different Crops. Mode of pollination must be known before isolation requirements can be determined for any crop. Vegetable seed crops are either (1) self-pollinated, (2) wind-pollinated, or (3) insect-pollinated.

1. Self-pollinated Crops: Barrons (4), Swenson and Miravalle (84), Thompson (87), and Jones (43) working with beans, peas, lettuce, and tomatoes respectively, showed that these crops were self-pollinated and that very little attention needed to be given to separating varieties within each group. Pea varieties should be separated by at least 15 feet and the other crops by approximately 10 rods, however, in order to avoid mechanical mixing and occasional crossing which does occur within each self-pollinated group (103, p.16; 60, p.54).

2. Wind-pollinated Crops: Isolation distances for the cross-pollinated crops, especially those that are wind-pollinated, must be great in order to keep varieties genetically pure.

Pendleton, Finnell, and Reimer (65, p.19) stated that seed-producing fields of the beet group (table beet, mangel, sugar beet, and swiss chard) should be separated by a distance of at least one mile. The British, however, reported that wind will carry beet pollen a distance of over two miles (34, p.592).

Very little is known about the correct isolation distance for the spinach group which is also wind-pollinated but Canadian and English growers allow at least one-fourth mile between spinach varieties (107, p.1).

Care should be taken to avoid placing wind-pollinated crops and their varieties within the same group in direct line with prevailing winds. High hedges or windbreaks are helpful in reducing the amount of crossing that occurs between fields (34, p.592).

3. Insect-pollinated Crops: Morrison (60, p.58) stated that insect-pollinated seed crops should be isolated from one another one-

half mile or so, preferably a mile or more for the Brassicas, and with due regard to location of colonies of domestic or wild bees.

Vegetables that depend mainly upon bees for pollination and whose varieties are interfertile are the cabbage group (cabbage, cauliflower, broccoli, kale, collard, kohlrabi), radish, carrot, celery, asparagus, Chinese cabbage, leek, onion, pepper, parsley, parsnip, rutabaga, mustard, turnip, eggplant, cucumber, the muskmelon group (muskmelon, cantaloupe, honeydew, casaba), watermelon, squash, and pumpkin. All of the types and varieties within each group should be isolated from one another. There is no danger of crossing between groups with the exception of the squash and pumpkin groups. Cabbage and mustard or onion and leek, for example, can be grown safely side by side. The three main species of squash and pumpkin are Cucurbita moschata, C. pepo, and C. maxima, neither of which will cross with the other (21, p.372). It is essential that the seedsman know the species he is dealing with since varieties within each species usually are interfertile and must be separated in order to maintain pure seed supplies.

The experimental evidence on isolation requirements of insect-pollinated crops indicates that distances normally recommended for field plantings are on the safe side with respect to minimizing the deleterious effect of pollen contamination. Studies by Crane and Mather (15, p.301) showed that only one per cent inter-crossing occurred for varieties of radish planted 15 feet apart. Tedin (85, p. 454) working on turnip in Sweden, obtained only one per cent contamination at a distance of 27 yards. Bateman (6, p.755) of Great Britain, found that isolation distances more than 200 feet produced no detectable reduction in contamination for turnip, radish, beet, and corn. In all cases contamination decreased rapidly at first and then gradually lowered to approximately one per cent. Haskell (34, p.592) found that cucumber varieties when planted side by side in the field underwent 65 to 70 per cent natural cross-pollination. He recommended that varieties be separated by at least 40 rods or more.

Investigations on crossing between strains and varieties among members of the Umbelliferae have not been undertaken. Although it is customary to allow one-half mile between different varieties of carrot, there is no experimental evidence to substantiate the adequacy of this field practice. Parsnip varieties are usually isolated from each other although there is lack of agreement as to their mode of pollination (34, p.592; 105, p.1).

Very little information is available concerning the amount of crossing between varieties within the squash and pumpkin species. The same is true for onion, although it is definitely known that onion varieties are pollinated by both insects and wind (34, p.592).

Need for Beneficial Insects for Cross-Pollination. Many types of insects are involved in cross-pollination but the bee is by far the most important kind in any vegetable seed producing area. It is essential to have an adequate population of bees, whether native wild species or the domestic honey bee, in order to insure a good seed set of insect-pollinated crops. Edgecombe (18) reported on several studies in which honey bees contributed significantly to increased vegetable seed production. He pointed out that yields of many seed crops could be increased by placing additional colonies of honey bees near the seed field.

Very little is known about the behavior of bees on vegetable seed crops in the Willamette Valley. It is the opinion of bee experts, however, that an insufficiency of bees may occasionally limit seed production in this area. Ordinarily native bees are numerous enough to furnish the necessary pollination for fields surrounded by untilled land. As the surrounding land is brought under cultivation, however, and there is less untilled land for the propagation of these insects, their numbers diminish and inadequate pollination results. Hence, the older a seed-producing area becomes the greater is the need for honey bees.

Fundamental research work on bees in relation to vegetable seed production is badly needed for the Willamette Valley. Until such time as this information is available no definite recommendations can be made as to the number and type of bees that are necessary to effect good pollination of the various seed crops. Suffice to say, seedsmen and farmers should recognize the basic importance of beneficial insects to their industry and supply these insects whenever they suspect that their numbers are inadequate.

Suggested Isolation Requirements for the Willamette Valley. The exact isolation requirements for vegetable seed crops have not been determined experimentally for the Willamette Valley. Until such time as this information is made available, field isolation standards should conform with those found necessary in old, established vegetable-seed producing areas and which through experience have proven satisfactory in this area.

The isolation problem is seldom a serious one in the Willamette Valley because of the large land area involved and the relatively small acreage of vegetable seeds. Occasionally, however, local problems arise in areas where several seed companies are contracting for seed crops. These situations need to be worked out cooperatively by the seed company representatives and farmers if high quality seed is to be grown. It is important in such cases that minimum isolation distances be known for the different crops. Suggested minimum isolation requirements for commercial seed production are shown in Table 6. Distances should be increased one and one-half to two times over those indicated if stock seed is being produced.

FACILITIES AND EQUIPMENT FOR GROWING AND HANDLING THE CROP

Practices for growing and handling vegetable seed crops in the Willamette Valley are almost as diverse as the crops themselves. Some crops are very simple and easy to grow, harvest, and process whereas others are extremely difficult because of the complexity of the operations involved. It is the latter group of crops that often require specialized facilities and equipment.

During World War II, because of the labor shortage, there developed the need to mechanize the vegetable seed industry wherever possible. It was largely the American farmers' mechanical ingenuity, the Willamette Valley farmers included, that made it possible for the United States to grow enough garden seeds to supply our nation's domestic

Table 6. Suggested minimum isolation requirements for commercial seed production of vegetable seed crops in the Willamette Valley.

Crop	Isolation distance in miles	Authority
Table beet Swiss chard	1 mile	Pendleton et. al. (1 mile)
Mangel	½ mile	Canadian Seed Growers Assoc. (¼ mile) Haskell (1000 yards)
<u>Brassica oleraceae var.</u>		
Cabbage Kale Kohlrabi Brussel sprouts Cauliflower	1 mile	National Institute of Agricultural Botany (2 miles) Haskell (1 mile) Canadian Seed Growers Assoc. (¼ mile)
Turnip Rutabaga Mustard	½ mile	Haskell (½ mile) Canadian Seed Growers Assoc. (¼ mile)
Radish Spinach	¼ mile	Haskell (1/8 mile) Canadian Seed Growers Assoc. (¼ mile)
Cucumber	¼ mile	Haskell (¼ mile) Canadian Seed Growers Assoc. (¼ mile)
Parsnip Pumpkin Muskmelon Squash Watermelon Parsley	¼ mile	Canadian Seed Growers Assoc. (¼ mile)
Leek	¼ mile	Haskell (250 yards) Canadian Seed Growers Assoc. (¼ mile)
Celery	¼ mile	Canadian Seed Growers Assoc. (1/8 mile)
Lettuce Tomato Pepper Egg plant Bean, dwarf	160 feet	Morrison (160 feet) Canadian Seed Growers Assoc. (150 feet)
Pea	25 feet	Canadian Seed Growers Assoc. (15 feet)

needs and other countries as well. Difficulties in obtaining machinery complicated this problem but certain growers, being adept and ingenious, developed specialized equipment to meet their particular needs. Where highly specialized and costly planting and harvesting equipment was required, contracting companies usually furnished these implements to growers with whom they were contracting vegetable seed acreage.

Cultural Equipment and Related Facilities. The implements used for planting and cultivating commercial cannery row-crops in the Willamette Valley can often be used interchangeably for vegetable seed crops.

The Planet-Junior drill is commonly used for planting small-seeded crops such as mustard, turnip, spinach, radish, and cabbage. The ordinary grain drill as illustrated in Figure 5 and the corn planter with special plates have been used successfully for seeding cucumbers. The hand method of planting still prevails for widely-spaced vine seed crops such as pumpkin and squash.

The farm plow, potato digger or similar implement can be used for digging onion bulbs or parsnip and table beet roots prior to transplanting or storage. When these crops and others like cabbage, broccoli or kale are transplanted, specialized transplanting machines like the one shown in Figure 18 can be used advantageously.

Storage facilities must often be provided for root or bulb crops where it is necessary to hold them over winter for planting the following spring. Storage temperatures and humidities must be maintained at optimum levels for certain bulb or root crops in order to avoid losses from destructive root-rot organisms.

Greenhouse facilities are sometimes necessary where highly specialized crops like cauliflower are being grown (101, p.2-3). In such cases plants must be started with controlled temperatures in order to obtain proper plant development before transplanting them into the field.

Harvesting. Techniques for harvesting vegetable seed crops range from the ancient flail method to complicated machines which cut and thresh in the field.

The combine as shown in Figure 21 and the stationary thresher are the common methods of harvest used by Willamette Valley seed growers. Necessary precautions should be taken in the adjustment of these machines if threshing is to be successful. Cabbage, for example, is easily cracked unless the cylinder speed of the threshing rig is set at 1000 rpm or less, with some of the concaves removed.

Seed crops that do not shatter badly and which ripen evenly can often be combined directly in the field. Spinach, radish, and occasionally mustard and turnip are harvested in this manner. Radish is very difficult to thresh because of the tendency of the pithy pod to adhere to the seed. Special-designed threshers are necessary in order to obtain maximum seed yields with this crop. Onion seed with its very thin seed coat, is easily injured if over-scarification results in the threshing process. Special threshers equipped with rubber beaters are needed to overcome this hazard.

Where shattering losses and proper curing of the seed following

Fig. 21. Threshing parsnip with an ordinary 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 the Willamette Valley.

Fig. 22. Turnip in windrows for drying prior to harvest. Windrowing is the most popular method for handling similar crops which are subject to shattering losses.

cutting are major considerations, the crops should be windrowed or shocked as shown in Figures 22 and 23. The combine or stationary thresher can be used after these crops have field cured. Table beet, lettuce, carrot, cabbage, swiss chard, broccoli, and turnip are usually harvested in this manner. Rank and tall-growing crops like parsnip can be harvested advantageously with a corn binder and stationary thresher combination.

Seed is obtained from fleshy-fruited crops like cucumbers and summer squash with special-built, mobile threshing machines as illustrated in Figure 24. These machines crush the fruits and separate the rind and pulp from the seed (110, p.5-6). The seed is sacked at the machine and, in the case of cucumbers, allowed to remain in the field from one to two weeks to allow for partial decomposition of the pulpy material which adheres to the seed. The seed is then hauled to the processing center and washed free from the pulp after which it is placed in trays or in revolving drums for drying purposes.

Not all crops can be harvested by mechanical means. Hand harvest still prevails for cabbage, cauliflower, table beet, broccoli, and various other crops which shatter badly. These crops must be cut by hand and placed in windrows or small shocks for curing purposes. Onion seed heads are also harvested by hand as shown in Figure 19. After the heads are picked, they are hauled from the field and transferred to curing sheds, drying crates or drying canvasses. Winter squash and pumpkins, with their thickened and tough shells, are usually split open and the seeds are scooped out by hand as shown in Figure 16. The seeds are then washed and dried in a manner similar to other vine

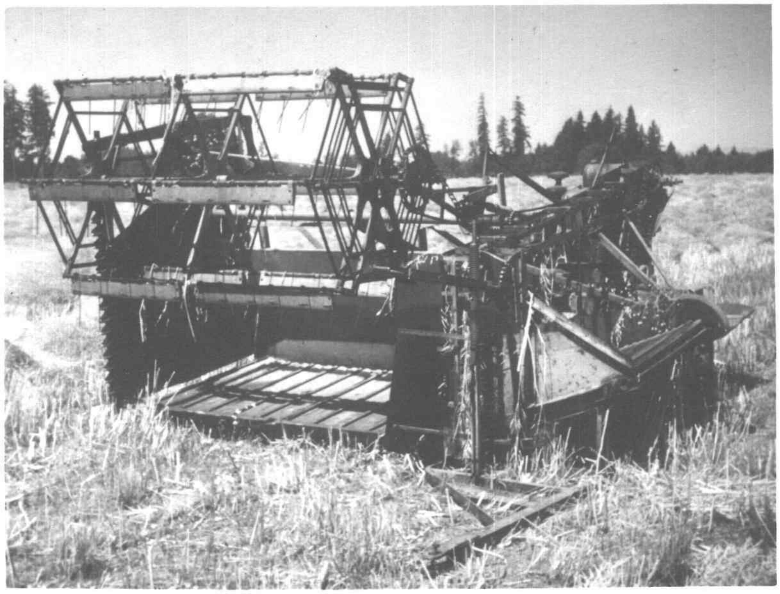

Fig. 23. Windrower, commonly used for sugar beet seed harvest, is well adapted for cutting and windrowing such crops as swiss chard, mangel, and other heavy crops which cannot be harvested standing.

Fig. 24. 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. Specialized machines such as this are furnished by the contracting seed company.

seed crops.

Processing. It is usually necessary to clean or process many of the different seeds with special equipment after harvest (108). Most of the seed is processed by seed companies who have special-designed cleaning and recleaning machinery. Some of the larger producers have their own cleaning facilities.

It has been pointed out that vine seed crops, in contrast to other crops, require special washing and drying facilities. Most of this equipment is beyond what the average Willamette Valley producer can afford unless he produces these seeds on a tremendously large scale. Seed firms that contract for vine seeds usually furnish these facilities or subcontract with some large grower who has the necessary washing and drying facilities to process seed for growers with whom they have seed growing contracts.

KIND AND VARIETY OF CROP

The choice of crop and variety is a highly significant production factor since it affects both the yield and the net return to the producer. Only those crops and varieties that are well adapted to the climatic and soil conditions of the Willamette Valley and which will yield a high economic return should be grown.

As early as 1645, Sir Richard Weston from England, on observing the farming practices of the Flemish farmers, made a definite statement of this cardinal principle of husbandry as follows: (112)

> It is a certain thing, that the chiefest and fundamentallest point in Husbandrie, is, to understand the nature and condition of the land that one would till, and to sow it with such Seed as it would produce, either Naturally, or by Art, that which may turn to a Man's greatest profit and advantage.

Kind of Crop. It has been previously pointed out that many kinds of vegetables are well adapted for seed production in the Willamette Valley. These, as well as those that are poorly adapted, are listed in Table 7. This classification is based on growers' experiences and on research findings to date and represents the general situation for the Willamette Valley.

The seeds best suited for seed production are divided into two qualitative groups—those that are consistent in yielding ability and those that are less consistent. Consistent yielders are those crops which have given good results throughout the years for the majority of producers. It is possible that some of the crops which are classified as being less consistent in seed production might prove to be stable seed producers under certain conditions, since so much of the success with any adapted seed crop depends upon the variety, the individual grower and his farming abilities.

The beet and spinach groups, crucifers, and certain members of the cucurbit group are especially well adapted for seed production in the Willamette Valley. These are cool-season crops which produce seed readily with relatively cool summer temperatures. Onion is listed as a consistent yielder but can qualify only under conditions where care is taken to locate the seed fields where air drainage is good, so as to discourage the downy mildew disease. Fall-sown turnip is more

Table 7. Adaptation of various vegetable seed crops to the Willamette Valley.

Yielding ability	Crops well adapted		Crops poorly adapted		Adaptation unknown
	Annuals	Biennials	Annuals	Biennials	
Most consistent yielders	Cucumber Squash Pumpkin Spinach Chinese cabbage Turnip Mustard	Swiss chard Mangel Table beet Parsnip Rutabaga Turnip Kale Onion Parsley Collard	Lettuce Watermelon Bean Sweet corn Pea	Carrot Cauliflower	Muskmelon Celery Chicory Egg plant Endive Leek Pepper Rhubarb Salsify Tomato Asparagus Okra
Less consistent yielders	Radish	Kohlrabi Broccoli Brussels sprouts Cabbage			

consistent in yielding ability than spring-sown turnip. Radish, as shown in Figure 25, and mustard have been low and somewhat inconsistent in their seed yielding ability. The crucifers which are listed as being inconsistent, mature seed easily but require extra care, usually beyond that which the average farmer or seedsman is willing to give.

Carrot is not adapted to the Willamette Valley because of the danger of crossing with a widely spread weed, wild carrot (*Daucus carota*). It also matures its seed late in the season, as does lettuce, which imposes a serious harvest problem. Peas for seed are poorly adapted to the Willamette Valley because of the aphid and disease problems. Watermelon, bean, and sweet corn are warm-weather crops which do not mature their seed in time to allow for harvest before the fall rains and frost.

Not all adapted crops will yield equally well. Seed yields of parsnip, swiss chard, table beet, and mangel range from 1000 to 2000 pounds per acre. Rutabaga, turnip, and kale do well to average one-third this amount. The amount of seed produced per acre, however, should never be used as a criterion as to the profitableness of a crop. Although contract prices broadly reflect yield and cost-of-production differences, net returns per acre differ widely for various crops.

Variety of Crop. Varieties of different kinds of vegetables are too numerous to mention. Recently, two of the larger and more progressive seed firms, listed in their seed catalogues, 675 and 500 vegetable varieties, respectively. Although many of the varieties listed are of minor value and in many cases very similar, nevertheless,

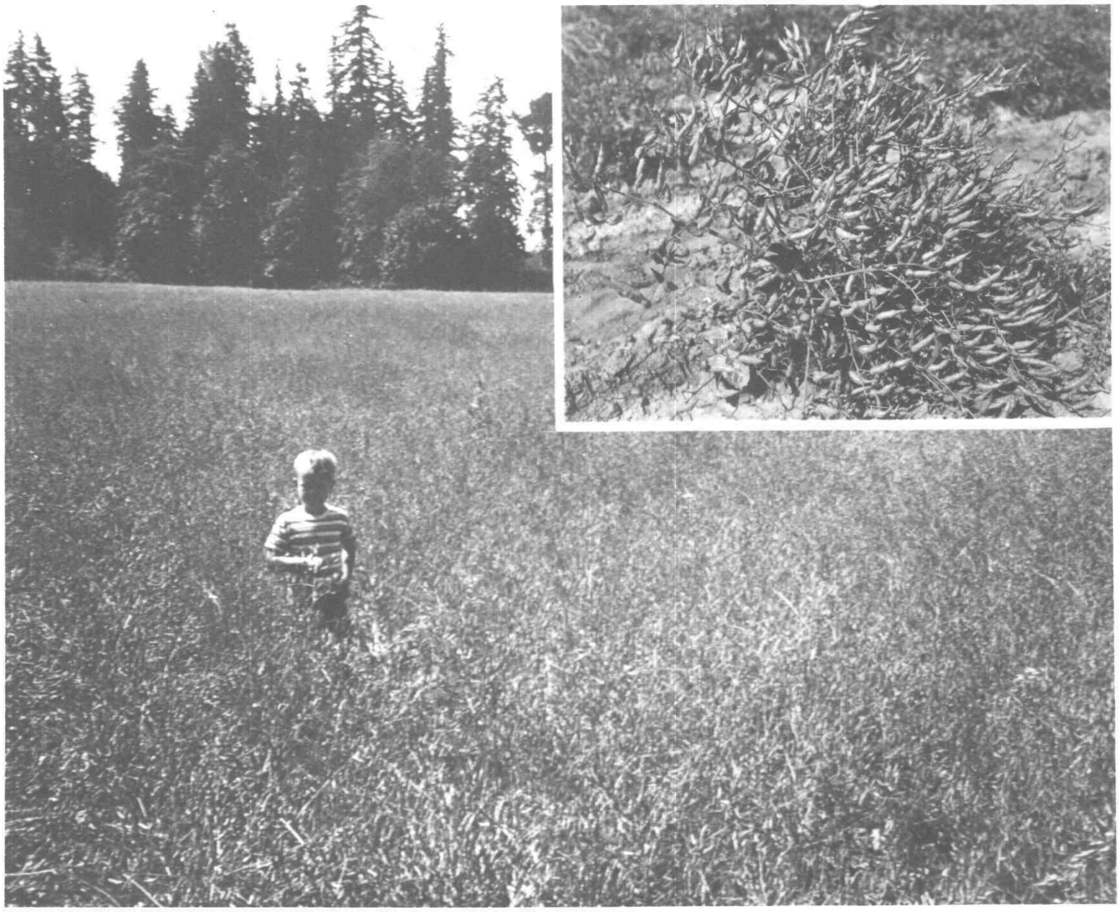

Fig. 25. Comet radish for seed in the Willamette Valley. Meshed appearance of the seed pods makes the rows almost indistinguishable. The heavy pod set as shown in the inset is not always indicative of high yields.

there is the problem of having to contend with a large number of varieties for each crop.

Varieties and strains differ widely in their yielding ability as illustrated in Figure 26 and Table 8 for cucumbers. Pickling varieties, like Chicago and Boston, produce nearly twice as much seed as certain slicer varieties, such as Cubit and Marketeer. Variations of this magnitude could be shown for other crops as well. Cabbage strains like Marion Market and Ferrys Round Dutch bolt easily and produce more seed under Willamette Valley conditions than do the Ball-head and All-Season strains as the data in Table 9 indicate. Squash varieties of the summer type average 600 to 800 pounds per acre whereas winter squash varieties average only 400 to 500 pounds per acre. Within each group there is considerable fluctuation in seed yields for the different varieties. Yields of Butternut, a summer squash, are very low while Table Queen and others are considerably higher yielding. Many other examples could be given which illustrate the wide difference in varietal seed producing ability in the Willamette Valley.

Seed companies in their contract pricing should take into account the variability in yield of varieties and pay the farmer accordingly.

SOIL TYPE AND MANAGEMENT

Soil, the medium in which plants grow, is one of the major environmental factors determining whether or not a vegetable seed crop can be grown successfully in the Willamette Valley. It must possess, either naturally or by human adjustment certain conditions favorable

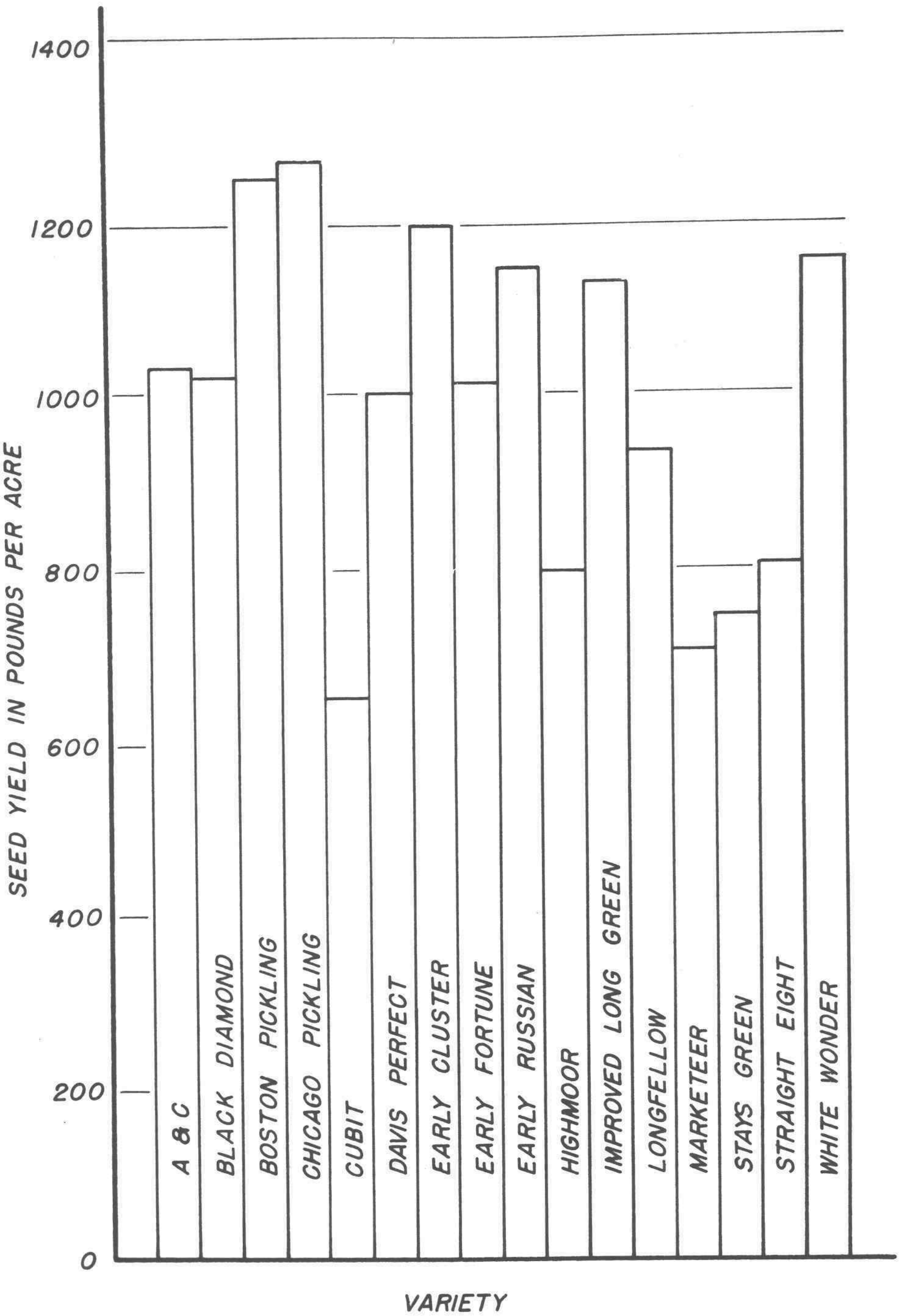

FIG. 26 SEED YIELD FOR SIXTEEN VARIETIES OF CUCUMBERS AT CORVALLIS, OREGON. AVERAGE OF THREE PLANTING DATES. IRRIGATED CHEHALIS CLAY LOAM, 1949

Table 8. Seed yields for sixteen varieties of cucumbers planted at three different dates. 1/

(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

1/ All plots were side-dressed with 100 pounds of nitrogen shortly after emergence.

* 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 8A. Analysis of variance for the effect of three dates of planting on the seed yield of sixteen varieties of cucumbers.

Source of variation	D/f	Sum of squares	Mean square	F value
Replication	2	375,783.3	187,891.65	
Dates	2	301,030.8	150,515.40	0.43
Error (a)	4	1,410,106.6	352,526.65	
Variety	15	5,376,911.0	358,460.73	17.73**
Interaction	30	507,252.6	16,908.42	0.84
Error (b)	90	1,819,978.7	20,221.99	
Total	143	9,791,063.0		

Table 9. Comparison of seed-to-seed method of production with transplant method for 15 varieties of cabbage.

(Irrigated Chehalis clay loam, 1947-48) 1/

Variety	Survival in percent				Bolting in percent				Seed yield in pounds per acre			
	Transplant 2/		Seed 3/	Ave.	Transplant		Seed	Ave.	Transplant		Seed	Ave.
	45 da	60da	-to-seed		45da	60da	-to-seed		45da	60da	-to-seed	
All-Head Early	92.3	94.9	87.2	91.5	83.3	73.4	97.0	84.6	178.0	127.5	309.0	205.2
Cheiftain Savoy	97.4	97.4	82.1	92.3	89.7	42.3	86.5	72.8	163.3	185.7	155.3	168.1
Copenhagen Market	74.4	70.4	64.4	69.7	100.0	100.0	100.0	100.0	144.7	211.7	111.0	155.8
Danish Red Ballhead	76.9	87.2	100.0	88.0	67.0	50.7	97.4	91.7	70.3	60.0	167.5	99.3
Ferry's Round Dutch	97.4	92.3	76.9	88.9	100.0	91.9	100.0	97.3	357.7	295.3	265.0	306.0
Golden Acre	87.2	97.4	46.2	76.9	97.0	100.0	100.0	99.0	199.7	189.7	121.3	170.2
Jersey Wakefield	87.2	97.4	84.6	89.7	93.7	92.3	94.5	93.5	182.0	124.7	175.7	160.8
Marion Market	94.9	94.9	89.8	93.2	100.0	97.2	100.0	99.1	297.0	260.0	365.5	307.5
Penn State Ballhead	97.4	94.9	92.3	94.8	94.5	47.2	95.2	79.0	374.7	156.0	365.0	298.6
Resistant Detroit	82.1	97.4	56.4	78.6	100.0	97.2	100.0	99.1	257.7	206.7	144.3	202.9
Savoy Perfection Drumhead	94.9	94.9	82.1	90.6	68.3	36.1	97.0	67.1	244.3	120.0	370.3	244.9
Stein's Flat Dutch	97.4	97.4	97.4	97.4	97.4	92.7	97.4	95.8	284.3	182.7	543.0	336.7
Wisconsin All-Season	71.8	97.4	43.6	70.9	100.0	68.1	93.3	87.2	158.0	127.0	90.7	125.2
Wisconsin Bugner	92.3	100.0	81.2	91.2	54.1	46.6	100.0	66.9	280.0	81.5	302.3	221.3
Wisconsin Hollander No. 8	100.0	97.4	97.4	98.3	82.0	44.6	100.0	75.6	269.7	64.5	436.0	256.7
Average	89.6	94.1	78.8	87.5	88.5	72.0	97.2	85.9	237.4	159.5	260.9	219.3

LSD .05 = 64.45 for method and date

LSD .05 = 141.88 for varieties

1/ All plots received fall application of 25 pounds of Borax, 150 pounds of gypsum and 500 pounds of 10-10-10 per acre. Spring fertilizers consisted of 100 pounds nitrogen, broadcast in bands beside rows.

2/ All varieties seeded in plant bed on July 18. The 45-day transplant made September 2, the 60-day transplant, September 17.

3/ Seed-to-seed plots seeded August 6.

Table 9A. Analysis of variance for two dates of transplanting and seed-to-seed production of 15 varieties of cabbage, 1947-48.

Source of variation	D/f	Sum of squares	Mean square	F value
Replication	2	10,290.17	5,145.085	
Method	2	249,028.57	124,514.285	5.77
Variety	14	650,812.44	46,486.603	2.15
Method x variety	28	604,750.32	21,598.226	
Error	80*	410,304.50	5,128.806	
Total	126*	1,925,186.00		

* 8 missing values.

for the particular plant being grown.

Productive soils for vegetable seed production must have good tilth, good aeration, good depth, plentiful organic matter, and available plant nutrients and be well supplied with moisture, either by irrigation or natural means.

Type of Soil Preferred. River-bottom soils as shown in Figures 27 and 28 are generally preferred to the upland soils in the Willamette Valley since they as a rule tend to be more productive. They are also lighter in texture and consequently better drained. Medium-textured soils such as sandy loams and loams offer a real advantage for crops like spinach, mustard, and turnip, as they can be worked and planted early in the spring.

The Chehalis and Newberg soil series are used most extensively for vegetable seed production in the Willamette Valley. These series are recent alluvial soils adjacent to streams and are generally subject to overflow (72, p.12). Chehalis is more desirable than the Newberg series because of its heavier sub-soil and higher level of fertility. Both soil series are near neutral in reaction, being well supplied with calcium.

Good seed crops have also been produced on the older alluvial bench-land soils of the main Valley floor, including the Willamette and the better grades of Amity. These soils are not subject to overflow and are not as easy to work as the river-bottom soils. They have a higher clay content in both surface and sub-soil horizons, are slightly acid, but are reasonably well supplied with plant nutrients

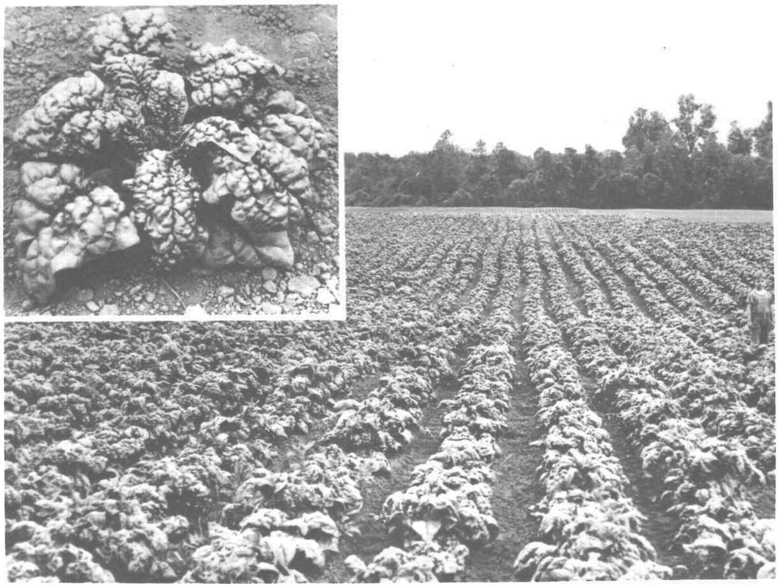

Fig. 27. Spinach being grown for seed purposes on productive river-bottom land. Spinach requires soils such as these, well-supplied with organic matter, in order to produce maximum yields. Note excellent vigor of the plants and the weed-free condition of the field.

Fig. 28. Transplanting table beets in early spring on river-bottom land. Well-drained soils of this type can be worked early in order to facilitate early planting. Note the fine and deeply worked condition of the rootbed. Press wheels pack the soil firmly around the roots.

(72, p.13). They have a higher moisture holding capacity than the river-bottom soils and will often produce crops without supplemental irrigation. Mustard, turnip, rutabaga, cabbage, and onion are crops which have been successfully grown on these heavier soil types.

Because of their extreme heaviness, the soil series Wapato, Cove, and Dayton are unsuited for vegetable seed production. The residual hill-land soils, the Olympic and Melbourne series, have not been used extensively for vegetable seed production because of their general lack of suitability for this particular class of crops.

Soil Management and Cropping Practices. It is important for Willamette Valley vegetable seed producers, if they are going to stay in production for a long period of time, to use good soil management practices and follow recommended cropping practices which allow for the frequent renewal of large quantities of organic matter in the soil. Soils having a greater content of humus are more productive than soils having less organic matter (61, p.938). This means, then, that it is wise to use rotations which include humus-forming sod crops. Stephenson (80, 8-12) points out that soils high in organic matter are better aerated, retain moisture better, are less subject to erosion, and require less water and commercial fertilizer than those that have a low level of this vital component. Also, when good crop rotations are followed, there is usually less trouble with weeds, diseases, and insects.

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

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 such as cucumbers, squash, and pumpkins, 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.

The erosion hazard is great for over-wintered row crops on overflow lands as shown in Figure 29. Provision should be made to hold the valuable top soil in place with a cover crop as illustrated in Figure 30. The planting of inter-row crops such as Abruzzi rye, winter barley, and winter oats has proved valuable for this purpose. The cover crop can be rotatilled into the soil in the early spring as soon as soil conditions permit, thus making a valuable addition of organic matter. This practice is somewhat questionable on heavy soil types where cultivation has to be delayed because of prolonged, wet soil conditions because the cover crop often grows so rank that it is difficult to handle and work into the soil. Another method for alleviating the erosion hazard and which can be practiced in conjunction with a cover-cropping program, is to plant the rows at right angles to the direction of water flow. This checks the eroding action of the water, especially with crops like turnip and rutabaga where the rows are

Fig. 29. Soil erosion is a hazard with field over-wintered biennial crops on overflow lands unless some protective measures are taken.

Fig. 30. 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.

spaced relatively close together.

SUPPLEMENTAL IRRIGATION

Many of the vegetable seed crops grown in the Willamette Valley, because of the shortage of summer rainfall, require supplemental irrigation in order to produce maximum seed yields. Although viable seed can be grown without the aid of irrigation, these facilities, if available, reduce the risk involved and ordinarily assure the grower a higher net return per acre.

Powers (70, p.3) pointed out that vegetable seed crops were well adapted for irrigation in the Willamette Valley and that sandy loams of Chehalis and Newberg soil series as well as the better-drained soils of the main valley floor, such as Willamette loam and silt loam, were well suited to irrigation. He further stated that the sprinkler type of irrigation was often preferred to surface irrigation because of its adaptability to soils with uneven surface topography.

In the semi-arid vegetable seed producing regions, Woodbury and Dietz (117) of Idaho, Hawthorne (35) of Utah, MacGillivray (51) of California, and Griffiths et al (30) in Arizona, stressed the necessity of irrigation for profitable seed production and discussed general irrigation requirements for some of the crops grown in their respective areas.

Where Needed. There are numerous instances when irrigation is a prime necessity for the Willamette Valley vegetable seed grower.

Supplemental irrigation as shown in Figure 31 is nearly always essential for establishing plant-beds during the warm summer months for such crops as cabbage, table beet, and parsnip. Irrigation is also needed when transplanting these crops in order to get the plants off to a good start. Biennial seed crops which are grown by the seed-to-seed method usually require irrigation in order to put the soil in a suitable condition for planting and to assure establishment of the young seedlings after their emergence. Seed yields of summer-growing crops which make maximum moisture demands after June 15 are greatly enhanced by supplemental irrigation. This is especially true for such crops as cucumber, squash, and pumpkin. Even for early spring-sown crops such as mustard and turnip, which mature relatively early in the season, outstandingly high yields have been obtained with good water and fertilizer management.

Practical Considerations. No specific rules can be formulated as to the exact amount, rate, and frequency of irrigation since this varies widely for different crops, different areas, different stages of growth, soil conditions, and weather conditions.

Good irrigation demands a sound, workable knowledge of crops and soils if a farmer is to be able to tell when to irrigate and the quantity of water to apply. Without this knowledge and experience to back it up, it is very unlikely that a crop can be brought to its maximum production of the highest quality seed.

Pendleton, Finnell, and Reimer (65, p.17) working with sugar beets for seed in the Willamette Valley, stated that supplemental irrigation

Fig. 31. Irrigating seedbed for table beets in the Willamette Valley. Seed sown in June is being "irrigated up" because of dry soil conditions. Irrigation facilities are a necessity for vegetable seed crops planted during the dry summer period.

was profitable and that two irrigations of about three inches each were sufficient most seasons for river-bottom soils. They indicated that irrigation should continue through the ripening period, allowing just enough time for the soil surface to dry before harvest. Woodbury and Dietz (117, p.11) stressed this same point for onions and concluded that it was not advisable to withhold water in order to mature seed.

Hawthorne (35, p.40), in Utah, presented data which showed that low soil moisture levels were more profitable than medium or high levels for all spacings of the deep-rooted carrot crop and for onions spaced more than 30 inches apart in rows. Heavier and more frequent irrigations were justified only when onions were grown in rows closer than 30 inches apart.

MacGillvray (51, p.11) of California showed that irrigation nearly doubled onion seed yields. He found that three or four irrigations were desirable for the northern Central Valley, with a minimum of ten inches of water being applied during the growing season.

Aside from the work referred to above, there has been very little experimental work on the determination of irrigation requirements for vegetable seed crops. Observations made during the conduct of the experimental work at Corvallis showed that most vegetable seed crops required more frequent and lighter irrigations than did most of the common farm crops grown on the same farm. This was very noticeable for the shallow-rooted cucurbits and many of the crucifers, especially turnip and mustard. Frequency of irrigation was governed largely by weather conditions, with high temperatures and low humidities necessitating more frequent irrigations in order to keep the plants in an active, vigorous growing condition.

FERTILIZER REQUIREMENT OF CROPS

The fertility of any soil is determined by several interdependent physical, chemical and biological factors whose combined effects can be expressed in the ability of that soil to meet the specific needs of crop plants (111, p.202-203). Careful selection of soil type and good soil management practices make it possible to maintain the physical and biological factors sufficiently well so that they do not become limiting factors for plant growth. Chemical condition of a soil, however, cannot always be handled so simply and must be considered carefully where specific needs of certain crops are being administered. Lack of plant nutrients is often a limiting factor in the Willamette Valley unless this deficiency is corrected. The aim of any good fertilizer program should be to supply adequate amounts of available nutrients for plants during all periods of growth, without permitting harmful concentrations of any constitutents (59, p.753).

Plant nutrient requirements vary according to the kind of crop, fertility level of the soil, amount of water available to the crop, and various other factors. Likewise, soils vary greatly in their inherent productivity and thereby affect the degree of response that can be obtained from the addition of commercial fertilizers.

Field experiments at Corvallis 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. The demand for plant food is usually quite large for crops which produce heavy vegetative growth like cabbage and swiss chard. Crops like onion and radish that make smaller vegetative growth require considerably less plant food. Large amounts of commercial fertilizer or the equivalent of barnyard manure are usually needed to produce satisfactory crops on fields where the level of fertility is low. Even on soils known to have a high fertility level, relatively large amounts are often needed to produce maximum seed yields, provided that moisture or some other factor does not limit production.

Importance of Nitrogen. The data summarized in Tables 10, 11, 12, 13, 14, and 16 show that nitrogen is the key to vegetable seed production in the Willamette Valley. Figures 32 to 41 inclusive further substantiate this statement. The data indicate that seed producers with irrigation facilities would be justified in using larger amounts of nitrogen than they do at the present time. Amounts up to 150 pounds of elemental nitrogen have given significant yield responses for irrigated turnip, cabbage, and cucumber as shown in Tables 13, 14, and 16, respectively. Data in Tables 10 and 12 indicate that approximately two-thirds of this amount is needed to produce maximum seed yields for irrigated onion and mustard, respectively.

The fall application of nitrogen for over-wintering crops should be limited to an amount which will aid establishment and permit a healthy, vigorous growth of plants before they go into a semi-dormant state. This principle is illustrated for cabbage in Figure 38.

Excessive applications should be avoided since this results in a waste of nitrogen by leaching and may cause too much vegetative development, especially if temperatures are unusually mild during the first part of the winter. Data given in Table 15 indicate that fall applications of nitrogen may be unnecessary if the fertilizer level of soils is high as a result of plowing under a legume crop.

The spring application of nitrogen should be applied early to over-wintering crops if maximum yields are to be obtained. Evidence of this principle is shown for cabbage in Table 14 and in Figures 37 and 39. Early application of nitrogen in late February or early March stimulates plant and root development and makes possible a large vegetative growth before moisture and temperature tend to limit production.

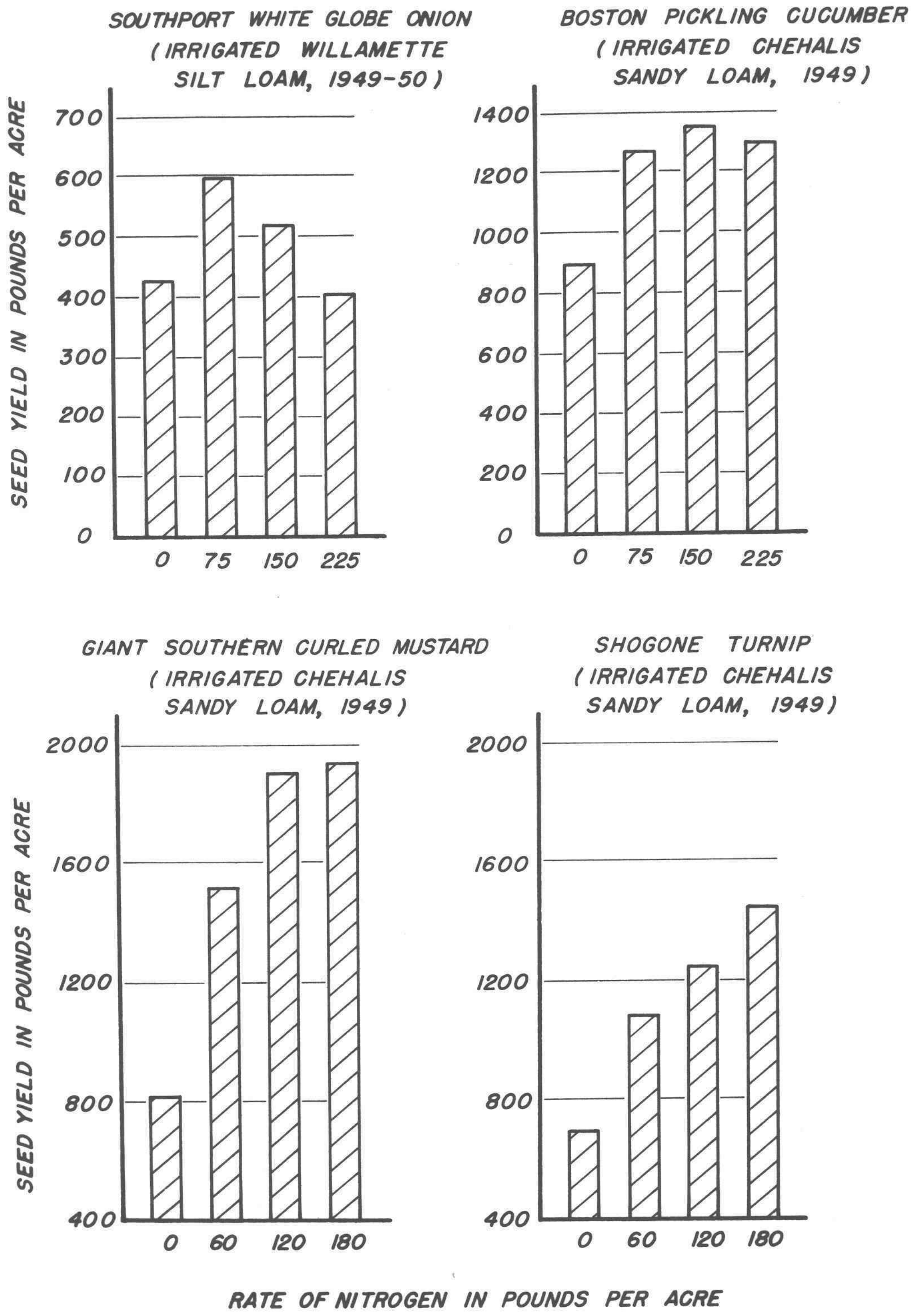

FIG. 32 EFFECT OF DIFFERENT RATES OF NITROGEN ON SEED YIELDS OF VARIOUS VEGETABLE CROPS

Table 10. Seed yields for 36 different combinations of nitrogen, phosphorus, and potassium*, for Southport White Globe Onions. (Irrigated Willamette silt loam, 1949-50)

Amount of phosphorus and potassium per acre 1/	Seed yields with various amounts of nitrogen per acre 2/				
	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.

1/ Differences not significant at the 5 per cent level for phosphorus and potassium means.

2/ Difference for significance at the 5 per cent level for nitrogen means = 98.

Table 10A. Analysis of variance for the effect of 36 different fertilizer treatments on seed yield of Southport White Globe onions, 1949-50.

Source of variation	D/f	Sum of squares	Mean square	F value
Replication	3	178,753.97	59,584.6567	
N	3	851,856.91	283,952.3033	9.85**
P	2	37,336.51	18,668.2550	
K	2	5,099.56	2,549.7800	
N x P	6	45,145.66	7,524.2767	
N x K	6	172,979.61	28,829.9350	2.36*
P x K	4	14,247.78	3,561.9450	
N x P x K	12	58,563.38	4,880.2817	
Error	105	1,282,532.28	12,214.5931	
Total	143	2,646,515.66		

Table 11. 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.

Table 11A. Analysis of variance for the effect of four levels of nitrogen and phosphorus on seed yield of Boston pickling cucumbers.

Source of variation	D/f	Sum of squares	Mean square	F value
Replication	3	249,769.71	83,256.57	
Nitrogen	3	2,041,057.27	680,352.42	11.51**
Phosphorus	3	122,673.71	40,891.24	0.69
Interaction	9	217,441.51	24,160.17	0.41
Error	45	2,659,682.82	59,104.06	
Total	63	5,290,625.02		

Fig. 33. General view of fertility experiment with Boston Pickling cucumbers. Note the luxuriant vine growth. The mottled appearance of field is due to different fertilizer treatments, the darker toned plots having received nitrogen whereas lighter toned plots did not. East farm, July 19, 1949.

Fig. 34. Comparison of nitrogen and phosphorus fertilizers on Boston Pickling cucumbers at harvest. Plot on left center was side-dressed with 150 pounds of nitrogen per acre. Plot on right center received 150 pounds of P_2O_5 per acre. Nitrogen is the key to cucumber seed production in the Willamette Valley.

Table 12. 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	1444	1743	-	1428	-	1480	1524
120 pounds	1828	1940	-	1839	-	1991	1900
180 pounds	1839	1795	-	1963	-	2175	1943
Average	1461	1585	-	1511	-	1615	1543
Year 1950 1/							
None	1269	-	1328	-	1220	-	1272
50 pounds	1807	-	1907	-	1826	-	1847
100 pounds	2079	-	1921	-	1786	-	1929
150 pounds	2007	-	2034	-	1904	-	1982
200 pounds	1992	-	1946	-	1832	-	1923
Average	1831	-	1827	-	1714	-	1791

* 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.

1/ 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 12A. Analysis of variance for the effect of four different levels of nitrogen and phosphorus on seed yield of Giant Southern Curled Mustard, 1949.

Source of variation	D/f	Sum of squares	Mean square	F value
Replication	2	150,545.39	75,272.70	
Treatment	15	10,524,582.44	701,638.83	11.14**
N	3	9,984,118.93	3,328,039.48	52.84**
P	3	178,274.12	59,424.71	
N x P	9	362,189.39	40,243.27	
Error	30	1,889,612.84	62,987.09	
Total	47	12,564,740.17		

Table 12B. Analysis of variance for seed yields of Giant Southern Curled Mustard with 15 various fertilizer treatments, 1950.

Source of variation	D/f	Sum of squares	Mean square	F value
Replication	3	1,346,614.8	448,871.60	
Treatment	14	4,447,180.1	317,655.72	4.36**
N	4	4,136,430.6	1,034,107.65	14.20**
P	2	177,732.0	88,866.00	
N x P	8	133,017.5	16,627.19	
Error	42	3,058,754.1	72,827.48	
Total	59	8,852,549.0		

Table 13. 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	1073	1098	-	1116	-	1020	1077
120 pounds	1268	1275	-	1200	-	1266	1252
180 pounds	1399	1483	-	1484	-	1450	1454
Average	1080	1156	-	1138	-	1106	1120
Year 1950 1/							
None	1097	-	1007	-	912	-	1005
50 pounds	1445	-	1450	-	1596	-	1497
100 pounds	1677	-	1868	-	1653	-	1733
150 pounds	2057	-	1688	-	1802	-	1849
200 pounds	1879	-	2096	-	1942	-	1972
Average	1631	-	1622	-	1581	-	1611

* 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.

1/ 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.

Table 13A. Analysis of variance for the effect of four levels of nitrogen and phosphorus on seed yield of Shogone Turnip, 1949

Source of variation	D/f	Sum of squares	Mean square	F value
Replication	2	30,959.70	15,479.85	
Treatment	15	3,830,150.70	255,343.38	6.96**
N	3	3,721,483.78	1,240,494.59	33.79**
P	3	41,621.98	13,873.99	
N x P	9	67,044.94	7,449.44	
Error	30	1,101,306.16	36,710.21	
Total	47	4,962,416.56		

Table 13B. Analysis of variance for seed yields of Shogone Turnip with 15 different fertilizer treatments, 1950.

Source of variation	D/f	Sum of squares	Mean square	F value
Replication	3	237,975.9		
Treatment	14	7,606,860.6	543,347.1857	12.55**
N	4	6,982,716.6	1,745,679.15	40.33**
P	2	28,226.1	14,113.05	
N x P	8	595,917.9	74,489.74	
Error	42	1,818,114.6	43,288.4429	
Total	59	9,662,951.1		

Fig. 35. The effect of nitrogen on Shogone turnip for seed. Plot on left received 60 pounds of nitrogen and 75 pounds of P_2O_5. Plot on right received 225 pounds P_2O_5. Note difference in height and size of seed pods.

Fig. 36. Too much nitrogen causes lodging of irrigated Shogone turnip. 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. In spite of lodging high levels of nitrogen produce highest yields.

Table 14. Effect of time and rate of nitrogen on bolting and seed yield of Ferrys Round Dutch Cabbage. 1/

(Irrigated Willamette silt 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	1285	96.4	1461	98.2	983
150 pounds	100.0	1573	92.5	1308	87.2	926
225 pounds	98.1	1518	95.9	1319	88.6	961
Average	98.2*	1459 2/	95.0*	1362 2/	91.4*	957 2/

1/ All plots given uniform fall application of 30# Boron, 200# P_2O_5, 100# K_2O and 50# N per acre.

2/ Difference for significance at the 5 per cent level (seed yields for various dates) = 160.

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

Table 14A. Analysis of variance for the effect of time and rate of nitrogen on the seed yield of Ferrys Round Dutch Cabbage.

Source of variation	D/f	Sum of squares	Mean square	F value
Replication	3	2,672,537.97		
Treatment	9	3,209,894.00	356,654.89	9.76**
Date	2	1,703,990.16	851,995.08	23.31**
Rate	2	4,908.16	2,454.08	0.07
Interaction	4	247,658.68	61,914.67	1.69
Ck vs. treated	1	1,253,337.01	1,253,337.01	34.29**
Error	27	986,937.23	36,553.23	
Total	39	6,869,369.20		

Table 14B. Analysis of variance for the effect of time and rate of nitrogen on the bolting percent of Ferrys Round Dutch Cabbage.

Source of variation	D/f	Sum of squares	Mean square	F value
Replication	3	512.738	170.9126	
Treatment	9	626.756	69.6396	2.20
Date	2	278.482	139.2410	4.41*
Rate	2	91.052	45.5260	1.44
Interaction	4	256.782	64.1955	2.02
Ck vs. treated	1	0.441	0.441	0.01
Error	27	853.362	31.6060	
Total	39	1992.856		

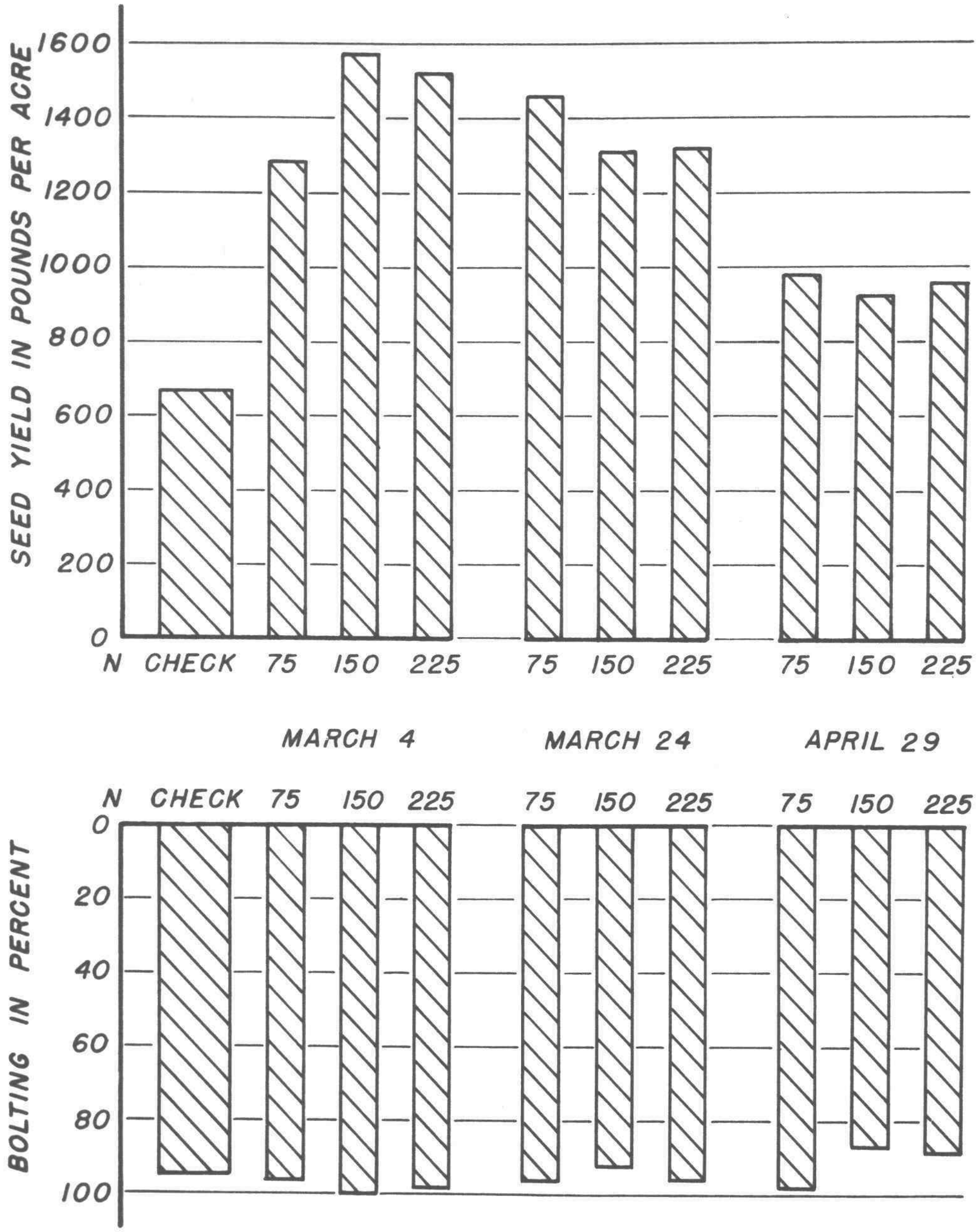

FIG. 37 EFFECT OF TIME OF APPLICATION AND RATE OF NITROGEN ON SEED YIELD AND BOLTING OF FERRYS ROUND DUTCH CABBAGE. (IRRIGATED CHEHALIS CLAY LOAM. 1949-50)

Table 15. The effect of fall applications of nitrogen and phosphorus on bolting and seed yield of Ferrys Round Dutch Cabbage.

(Irrigated Willamette silt loam following subclover, 1949-50)

Treatment	Fall treatment*		Bolting	Seed yield per acre 1/
	Nitrogen	P_2O_5		
	Pounds	Pounds	Per cent	Pounds
Treatment 1	None	None	96.4	1432
Treatment 2	50	-	96.3	1448
Treatment 3	100	-	99.7	1338
Treatment 4	50	200	94.5	1221
Treatment 5	100	200	96.1	1389
Treatment 6	-	200	98.2	1550

1/ Differences not significant at the 5 per cent level.

* All plots received blanket application of 100 pounds of nitrogen in early spring.

Table 15A. Analysis of variance for the effect of fall applications of phosphorus and nitrogen on seed yield of Ferrys Round Dutch Cabbage, 1949-50.

Source of variation	D/f	Sum of squares	Mean square	F value
Replication	3	231,305.67	77,101.8900	
Treatment	5	248,463.00	49,692.6000	1.17
P	1	2,242.67	2,242.67	0.05
N	2	111,664.00	55,832.00	1.31
N x P	2	134,556.33	67,278.16	1.58
Error	15	638,569.33	42,571.2887	
Total	23	1,118,338.00		

Table 15B. Analysis of variance for the effect of fall applications of phosphorus and nitrogen on bolting of Ferrys Round Dutch Cabbage, 1949-50.

Source of variation	D/f	Sum of squares	Mean square	F value
Replication	3	199.2045		
Treatment	5	34.3937	6.8787	0.33
P	1	1.7604	1.7604	0.08
N	2	16.5100	8.2550	0.39
P x N	2	16.1233	8.0616	0.38
Error	15	315.1180	21.0079	
Total	23	548.7162		

Fig. 38. Effect of fall applications of nitrogen on cabbage 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.

Fig. 39. 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.

Table 16. 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 1/
	Nitrogen	P_2O_5	K_2O	
	Pounds	Pounds	Pounds	Pounds
Experiment 1				
Treatment 1	0	0	0	1001
Treatment 2	60	0	0	1213
Treatment 3	120	0	0	1259
Treatment 4	180	0	0	1438
Experiment 2				
Treatment 1	120	0	0	1259
Treatment 2	120	200	0	1408
Treatment 3	120	200	100	1286

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

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

Table 16A. Analysis of variance for the effect of different rates of nitrogen on seed yields of Boston pickling cucumbers.

Source of variation	D/f	Sum of squares	Mean square	F value
Treatment	3	236,009.7	78,669.9	9.91*
Error	11	87,336.5	7,939.7	
Total	14	323,346.2		

Note: The replication sum of squares is pooled with error sum of squares because it is not significantly different from error sum of squares after the f test.

Table 16B. Analysis of variance for the effect of nitrogen phosphorus and potassium on seed yields of Boston pickling cucumbers.

Source of variation	D/f	Sum of squares	Mean square	F value
Replication	3	150,001.7	50,000.6	2.63
Treatment	2	30,531.1	15,265.6	0.80
Error	6	114,144.5	19,024.1	
Total	11	294,677.2		

Fig. 40. Comparison of different fertilizer treatments on Comet radish for seed. Plot on left was treated with 150 pounds nitrogen, middle plot received 150 pounds nitrogen, 200 pounds P_2O_5 and 100 pounds K_2O. Plot on right was a check and yielded only about one-half as much as other plots.

Fig. 41. 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.

Table 17. The effect of various fertilizer treatments on number of culms per plant and seed yield of Early Yellow Globe onions.
(Non-irrigated Willamette silt loam, 1948-49)

Treatment	Fertilizer per acre						Culms per plant	Seed yield per acre
	Nitrogen (fall)	Nitrogen* (spring)	P_2O_5	K_2O	Gypsum	Lime		
	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds		Pounds
Treatment 1 (none)	-	-	-	-	-	-	2.0	318
Treatment 2 (NPK)	50	100	200	100	-	-	2.6	430
Treatment 3 (NPK + G)	50	100	200	100	175	-	3.2	531
Treatment 4 (NPK + G + L)	50	100	200	100	175	1200	3.4	632
Treatment 5 (NPK + L)	50	100	200	100	-	1200	2.8	396
Treatment 6 (G)	-	-	-	-	175	-	2.2	240
Treatment 7 (G + L)	-	-	-	-	175	1200	2.3	405
Treatment 8 (L)	-	-	-	-	-	1200	2.3	327

* 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.

Table 17A. Analysis of variance for the effect of different fertilizers on the seed yield of Early Yellow Globe onions.

Source of variation	D/f	Sum of squares	Mean square	F value
Replication	3	15,407.88	5,135.96	0.53
Treatment	7	434,996.46	62,142.35	6.40*
NPK	1	243,951.31	243,951.31	25.14**
Gypsum	1	56,330.46	56,330.46	5.81*
Lime	1	29,221.53	29,221.53	3.01
NPK x G	1	57,257.28	57,257.28	5.90*
NPK x L	1	5,660.48	5,660.48	0.58
G x L	1	42,355.06	42,355.06	4.37*
NPK x G x L	1	220.34	220.34	0.02
Error		203,761.21	9,702.91	
Total	31	654,165.55		

Table 17B. Analysis of variance for the effect of different fertilizers on the number of culms per plant of Early Yellow Globe onions.

Source of variation	D/f	Sum of squares	Mean square	F value
Replication	3	0.374169	0.124723	0.58
Treatment	7	6.840162	0.977166	4.55*
NPK	1	4.882812	4.882812	22.71**
G	1	1.022450	1.022450	4.76*
L	1	0.275653	0.275653	1.28
NPK x G	1	0.632813	0.632813	2.94
NPK x L	1	0.001954	0.001954	0.01
G x L	1	0.006903	0.006903	0.03
NPK x G x L	1	0.017577	0.017577	0.08
Error	21	4.514919	0.214996	
Total	31	11.729250		

Fig. 42. A good, complete fertilizer program is essential to high onion seed yields in the Willamette Valley. Plot on left received 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.

Fig. 43. Comparison of check plot on left with lime treatment on right. Note the higher plant survival on the limed plot. All onions in the fertility experiment were fall-transplanted.

Table 18. **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 1/
	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	-	-	1286
Treatment 3	120	200	100	30	-	1325
Treatment 4	120	200	100	-	30	1322
Treatment 5	120	200	100	30	30	1276

* Ammonium sulfate provided source of sulfur.

1/ Differences not significant at 5 per cent level for treatments 2, 3, 4, and 5.

Table 18A. Analysis of variance for the effect of boron in the presence of sulfur on the seed yield of Boston pickling cucumbers.

Source of variation	D/f	Sum of squares	Mean square	F value
Replication	3	106,312.0	35,437.3	1.74
Treatment	1	73,344.5	73,344.5	3.59
Error	3	40,825.5	20,412.75	
Total	7	220,482.0		

Table 18B. Analysis of variance for the effect of sulfur in the presence of boron on the seed yield of Boston pickling cucumbers.

Source of variation	D/f	Sum of squares	Mean square	F value
Replication	3	111,579.8	37,193.3	1.41
Treatment	1	75,175.0	75,175.0	2.85
Error	3	79,061.6	26,353.9	
Total	7	265,816.5		

Other Soil Deficiencies. Phosphorus has long been regarded as functioning principally in seed development (111, p.457). There is very little evidence, however, of its need to improve the yield and quality of seed for vegetable seed crops on river-bottom soils in the Willamette Valley as the data in Tables 11, 12, 13, 15, and 16 indicate. Onion has tended to show a slight response to high levels of phosphorus on a Willamette silt loam soil but the increased yeilds have not been statistically significant according to the data in Tables 10 and 10A.

Where phosphorus deficiencies are known to exist, 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, Finnell, and Reimer (65, p.7-10), working with sugar beets, suggested a split application of nitrogen and phosphorus, a small amount being applied in the fall and the remainder the following spring. 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.

The results obtained from the use of potassium in the Willamette Valley have given no measurable seed yield response for either fall-planted or spring-sown crops as shown by the data in Tables 10 and 16, respectively.

Nearly all the soils in the Willamette Valley are known to be deficient in sulfur. The data in Table 17 show that sulfur in the form of gypsum gave a slight seed yield increase for onion on a Willamette silt loam soil. The sulfur need can best be met by supplying this element in the form of gypsum. Plants that are heavy nitrogen feeders should receive part of the sulfur in the form of ammonium sulfate (25 per cent elemental sulfur) (65, p.11).

Most of the Willamette Valley soils are deficient in boron. This deficiency was noted for garden beets in 1940 by Powers and Bouquet (71). Pendleton, Finnell, and Reimer (65, p.12) in 1950 reported increased seed yields of 150 pounds per acre for sugar beet when boron was added to the soil. The data summarized in Table 18 show that cucumber grown for seed failed to give a response to this element. Where boron deficiencies are known to exist, however, borax should be applied at the rate of 25 to 30 pounds per acre, either as a broadcast application or in a mixture with gypsum. Excessive applications should be avoided since an over-supply is toxic to plant growth, particularly for the more tender crops such as cucumber and watermelon.

Balanced Nutrition. It has been pointed out that different soils vary greatly in their nutrient supplying power and that crops differ in their response to different levels of fertility and pH. It is essential for any combination of soil and crop to balance the nutrient supply according to the requirement of the particular crop. Vegetable seed experiments in the Willamette Valley have indicated that yields may be somewhat superior where the key element, nitrogen, is combined with an adequate supply of other nutrients, particularly phosphorus, calcium, and sulfur. The experimental data in Tables 10 and 17 tend to indicate this relationship but are inconclusive in this regard. Undoubtedly as crop removal and leaching continue to deplete the Willamette Valley soils of the basic nutrient elements, the need for the balanced application of fertilizers will become more apparent and necessitate changes in the present recommended fertilizer practices.

CULTURAL REQUIREMENTS OF CROPS

Culture refers to the growing and rearing of crops. It is essential that Willamette Valley seedsmen and farmers know the cultural requirements of crops in order to obtain the highest degree of success with vegetable seed production.

Cultural requirements and field practices related thereto vary widely for different crops and their varieties and are often influenced by such factors as fertility level, soil type, moisture level, and the season. Because of these influencing factors two farmers growing the same crop may follow somewhat different practices in order to obtain optimum seed yields under their particular conditions. Nevertheless, there are certain broad cultural requirements which characterize each crop and these must be dealt with in a realistic manner if production is to be successful.

Seedbed Preparation. Nearly all of the vegetable seed crops grown in the Willamette Valley have similar seedbed requirements. Good seedbed preparation is a prime necessity in order to obtain uniform stands, especially of the small-seeded crops. An ideal seedbed is one that is well-supplied with plant nutrients and moisture, that is weed-free and mellow, yet compact enough so that soil particles are in close contact with the seed (Figure 2). It is also free of trash that interferes with seeding and subsequent tillage operations.

The heavier upland soils should be late fall-plowed for early spring-sown crops, especially if sod crops are to be turned under prior to planting. This allows for more timely seedbed preparation the following spring. Plowing of low-lying, river-bottom soils must by necessity be delayed until spring because of the flood hazard.

It is desirable to irrigate ahead of the final seedbed fitting operations whenever irrigation is needed to put the seedbed in proper shape for tillage and subsequent planting. This practice usually results in better stands than when supplemental irrigation is used to bring up the crop after it is planted.

Small seeds should be planted shallowly, not over one-half to three-quarters inch deep as illustrated in Figure 44 for cabbage, whereas larger seeds such as squash and peas can be planted deeper—one and one-half to two inches, depending on the soil texture.

Additional suggestions on seedbed preparation with respect to the weed problem are discussed on pages 134 to 136.

<u>Seed-to-Seed Versus Transplant Method</u>. Willamette Valley producers of most biennial crops have two choices as to method of production—(1) the seed-to-seed method where the seed is planted and left in situ until crop maturity or (2) the transplant method where the plants, bulbs, or roots are grown in a small plant-bed and later transplanted

Fig. 44. Shallow seeding depths are required for small seeded vegetables. This depth-of-planting trial with Copenhagen Market cabbage illustrates this principle. Note excellent stand with one-half and three-fourths inch depths. Plants have been dusted with nicotine sulfate for aphid control.

Fig. 45. 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.

into the seed field.

The selection of the method employed is governed by several considerations. First is the degree of winter hardiness of the species. If a crop is not winter hardy enough to withstand the minimum temperatures for most seasons it obviously cannot be grown successfully by the seed-to-seed method. Table beet grown in this manner, for example, is a hazardous crop because of its tendency to winter kill when temperatures fall below the average. It is usually wisest to dig the roots in the fall, store them over winter in a protected place and set them out early the next spring. Crops like cabbage, turnip, swiss chard, kohlrabi, parsnip, and kale exhibit a greater degree of cold resistance and can be satisfactorily grown by the seed-to-seed method.

Certain disadvantages of the seed-to-seed method also may influence the choice of method of production. Disadvantages of the seed-to-seed method of production are threefold. First, it is necessary to plant crops like parsnip, kale, swiss chard, mangel, kohlrabi, and dwarf kale during the early summer months, with the crop occupying the land for two full growing seasons. No financial return, therefore, is realized from the land during the first year. Turnip and spinach can be fall-planted and do not present this problem since an early maturing crop can be produced and removed from the land prior to the fall seeding. A second objection of the seed-to-seed method is the difficulty of obtaining uniform stands on large acreages during the hot summer months. Even with supplemental irrigation it is difficult to maintain a satisfactory moisture level that will insure uniform establishment.

The third objection voiced by seedsmen is that there is no opportunity to select and discard off-type bulbs or roots when the seed-to-seed method is used. They claim that the seed-to-seed method results in the production of lower quality seed. This does not appear to be a valid objection, however, if genetically pure stock seed had been used to grow the roots or the bulbs in the first place.

The transplant method of production overcomes the objections stated for the seed-to-seed method, but is usually a more time-consuming and expensive method because of the large amount of labor involved. This disadvantage may not be of any economic significance, however, when one considers the extra financial return that is possible by growing a crop on the land the first year. Any advantage that the transplant method may have, however, may be offset in certain cases by the higher seed yields that are sometimes made possible with the seed-to-seed method of production. This advantage for the seed-to-seed method of production is exemplified in the data shown in Table 9 for cabbage.

The transplant method should be used by seedsmen who are producing stock seed of biennial root and bulb crops since it provides an opportunity to carefully select and discard off-types which they do not wish to propagate further.

<u>Time of Seeding and Transplanting</u>. The timing of seeding and transplanting operations is very critical in the culture of plants in the Willamette Valley and oftentimes is the difference between a seed crop or no seed crop or between a low or a high yield.

Cool-season annual crops usually produce more seed if planted early in the spring as soon as the soil can be put into suitable condition for seeding. The data given in Tables 19 and 20 for spinach and turnip, respectively, illustrate this principle. Magruder and Allard (53, p.506) in 1936 found that long day lengths stimulated bolting of spinach. These results suggest the desirability of early spring planting so as to be able to obtain good-sized plants capable of high seed yielding ability before the long days cause premature bolting. Vine seed crops should be planted ordinarily after soil temperatures have warmed up sometime in May. Planting should not be postponed so late, however, as to run into the problem of lack of seed maturity at the end of the growing season in the fall.

Data presented in Table 9 show that date of seeding and transplanting often influences the degree of winter hardiness, bolting, and the subsequent seed yield of biennial crops like cabbage. Boswell (8, p.393), in 1925, when investigating the factors influencing seedstalk formation in wintered-over cabbage, concluded that the factor most closely associated with bolting was the size of the plant transplanted. The larger the plant, the greater was the percentage of "seeders." Hill and others (42, p.20-22) in 1944 found the same relationship in the Willamette Valley but pointed out the danger of having the cabbage plants develop to the hard head stage at the onset of winter because of their greater susceptibility to winter injury. Under-developed plants often failed to bolt properly the following season and did not usually produce as much seed, even though a higher percentage of the plants survived. They concluded that planting and

Table 19. Effect of date of planting on seed yield of Bloomsdale spinach 1/

(Irrigated Chehalis sandy loam, 1949)

Date of planting	Date of harvest	Yield per acre*
		Pounds
April 16	August 15	1737
May 4	August 24	996
May 20	September 1	704

1/ All plots side-dressed with 150 pounds of N, 200 pounds of P_2O_5 and 100 pounds K_2O per acre a few days after seedling emergence.

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

Table 19A. Analysis of variance for the effect of date of planting on seed yield of spinach, 1949.

Source of variation	D/f	Sum of squares	Mean square	F value
Replication	2	217,248.03	108,624.02	
Date	2	1,701,761.93	850,880.96	36.09**
Error	4	94,307.68	23,576.92	
Total	8	2,013,317.64		

Table 20. Seed yields of Shogone turnip for various dates of planting.
(Irrigated Chehalis sandy loam)

Date of planting	Date of harvest	Seed yield per acre*
		Pounds
Year 1949 1/		
May 2	August 25	1560
May 24	September 6	1359
June 13	Not harvested 2/	-
Year 1950 3/		
April 28	August 8	1793
May 30	August 20	475
June 30	Not harvested 2/	-

* F value significant for both years.

1/ All plots were side-dressed with 120 pounds N and 150 pounds P_2O_5 at time of seedling emergence.

2/ Did not mature properly.

3/ All plots were side-dressed with 100 pounds N and 200 pounds P_2O_5 at time of seedling emergence.

Table 20A. Analysis of variance for the effect of planting date on seed yield of Shogone turnip, 1949.

Source of variation	D/f	Sum of squares	Mean square	F value
Replication	3	131,150.84	43,716.95	
Treatment	1	81,406.12	81,406.12	15.9*
Error	3	15,362.19	5,120.73	
Total	7	227,919.15		

Table 20B. Analysis of variance for the effect of planting date on seed yield of Shogone turnip, 1950.

Source of variation	D/f	Sum of squares	Mean square	F value
Replication	3	179,247.38		
Treatment	1	3,472,930.13	3,472,930.13	126.09**
Error	3	82,632.37	27,544.12	
Total	7	3,734,809.88		

transplanting schedules should be arranged so as to obtain the loose-head stage of development before going into a semi-dormant state.

Varieties of a given crop often have different requirements as to planting dates as illustrated for cabbage in Figure 45. Late varieties of cabbage such as the Ballhead strains, Mammoth Red Rock, and Late Flat Dutch grown by the transplant method should be seeded sometime between June 1 and June 10. Midseason varieties such as Stein's Flat Dutch, All Seasons, Glory of Enkhuizen, Ferrys Round Dutch, and Marion Market are normally planted June 10 to 25, whereas early varieties such as Jersey Wakefield, Charleston, Copenhagen Market, and Golden Acre can be sown June 25 to July 10. Transplanting usually begins about August 10, the varieties being set in order of their maturity range, with completion about the middle of September. Seeding dates should be approximately two to three weeks later for each of the varieties when the seed-to-seed method of production is used since there is no retardation in plant development as is the case with the transplant method.

Seeding dates for root or bulb crops should be aimed at the production of a size of root or bulb that gives the highest seed yield but which can be handled or stored economically. Large-sized roots or bulbs usually produce the highest seed yields but entail extra handling and storage costs (36, p.21; 37, p.9; 77, p.41; 44, p.8). Medium-sized roots of table beets, about the size of tennis balls, are preferred. In order to obtain this size of root, table beets should be seeded in the month of June. Onions should be seeded in early spring if the bulbs are to be grown to their correct size, cured properly and made ready for transplanting the following fall. Fall is the best season for transplanting onions as shown by the data in Table 21 and Figure 46.

Spacing. Spacing of plants both between and within rows varies for the kind of crop and may be influenced by fertility level of the soil, moisture supply and time of planting.

The spacing of vegetable seed crops is often determined by the machinery that the farmer has available for planting and caring for the crop. Although the spacing that is used may not necessarily give the maximum seed yields, it may be the most economical for the farmer since it does not necessitate the purchase of a complete new line of cultural equipment.

The best utilization of soil space is usually accomplished with a uniform distribution of plants consistent with cultural operations. Less space between rows and greater spacing of plants within the row or visa versa can be worked effectively to adjust to the optimum plant population density.

Various experiments have demonstrated the possibilities for obtaining greater seed yields with relatively high plant populations per acre, provided that moisture and fertility are not limiting. Data in Table 22 indicate that cabbage grown in rows four feet apart and with plants spaced one foot apart in the row gives significantly higher yields than the usual wider spacings. Hawthorne (35, p.40) in Utah, found that irrigated carrots, normally grown in rows three feet apart, would produce the maximum amount of seed if spaced in nine-inch

Table 21. Comparison of fall- and spring-planted Early Yellow Globe onions. 1/

(Willamette silt 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.

1/ All plots received 50 pounds nitrogen, 200 pounds P_2O_5 and 100 pounds K_2O in the spring.

Table 21A. Analysis of variance for the effect of time of planting on seed yield of Early Yellow Globe onions, 1948-49.

Source of variation	D/f	Sum of squares	Mean square	F value
Replication	2	22,079.70	11,039.85	70.42
Treatment	1	5,909.48	5,909.48	37.69*
Error	2	313.57	156.78	
Total	5	28,302.75		

Fig. 46. Comparison of fall-transplanted onions on left with spring-transplanted onions on right. Note absence of weeds in spring onions. The ground preparation necessary for spring transplanting greatly reduces the weed problem. Fall-transplanted onions yield higher, however.

Table 22. Effect of spacing and staking on seed yield of Ferrys Round Dutch cabbage under irrigation. 1/

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	1862	1860	1491	1438	1697	1725
1950	1998	2067	1436	1533		
Five feet						
1949	1625	1614	1396	1224	1482	1530
1950	1830	1913	1076	1371		
Six feet						
1949	1258	1276	1155	1200	1313	1237
1950	1549	1470	1289	1003		
Average, all spacings, 1949 and 1950	1687	1700	1307	1295	1497	1497

1/ 1949, Chehalis clay loam; 1950, Willamette silt loam. Fall fertilizer treatment both years consisted of 50 pounds nitrogen, 200 pounds P_2O_5, 100 pounds K_2O and 25 pounds boron; spring treatment of 100 pounds nitrogen was applied to all plots.

Table 22A. Analysis of variance for the effect of spacing and staking on seed yield of Ferrys Round Dutch cabbage, 1949.

Source of variation	D/f	Sum of squares	Mean square	F value
Replication	3	39,356.1	13,118.70	0.16
Row width	2	1,558,454.2	779,227.10	9.72*
Error (a)	6	480,965.0	80,160.83	-
Staking	1	10,121.0	10,121.00	0.11
Staking x width	2	30,393.2	15,196.60	0.16
Error (b)	9	853,330.5	94,814.50	-
Plant spacing	1	842,965.0	842,965.00	22.49**
Spacing x width	2	200,640.7	100,320.35	2.68
Spacing x staking	1	11,501.1	11,501.10	0.31
Spacing x staking x width	2	17,733.1	8,866.55	0.24
Error (c)	18	674,792.6	37,488.48	-
Total	47	4,720,252.5		

Table 22B. Analysis of variance for the effect of spacing and staking on seed yield of Ferrys Round Dutch cabbage, 1950.

Source of variation	D/f	Sum of squares	Mean square	F value
Replication	2	1,559,910.39		
Row width	2	1,113,843.05	556,921.5250	
Error (a)	4	113,749.28	28,437.3200	19.58**
Staking	1	8,010.25	8,010.2500	
Staking x width	2	219,898.50	109,949.2500	
Error (b)	6	82,357.00	13,726.1667	8.01*
Spacing	1	2,431,000.69	2,431,000.6900	
Spacing x staking	1	261.36	261.3600	107.79**
Error (c)	16	360,834.45	22,552.1531	
Total	35	5,889,864.97		

rows. Pendleton (64, p.2), working with irrigated sugar beets, a crop similar to mangel and swiss chard, showed that more seed was produced from rows spaced 20 to 24 inches apart with two to six plants per foot than for wider spacings.

Cultivation. It has been pointed out previously that vegetable seed crops respond to clean culture. Cultivation should be as frequent as necessary in order to obtain good weed control but at a shallow depth so as not to injure the root system of the crop plants. This precaution is especially important for shallow-rooted crucifer crops as shown in Figure 47 and for vine seed crops which have a large portion of the roots in the upper surface layer. Further suggestions on weed control are given on pages 132 to 137.

Roguing. This practice includes the removal of undesirable types from fields whether they are volunteers, hybrids, mechanical mixtures, or degenerative plants.

Langley (49, p.132-133) in 1728 pointed out the necessity for roguing peas which were being grown for seed purposes:

> It is observable, that altho' a Person is as careful and nice as possible a Man can be, in the saving of Pease for Seed; yet there are always, amongst all Sorts of Pease some few that will degenerate the very first Year of sowing, and will not either be in bloom, or ripe so soon as the others, by a full Fortnight, and oftentimes three weeks.
>
> These degenerate Pease are by the Gardiners called Rogues and are discovered by the Over-rankness of their Haulm as well as by their late and untimely Produce.
>
> The reason why I mention these degenerate Pease is, that you may take a careful Survey of them amongst all

Fig. 47. Dead cabbage plants in critical erosion area. Note mass of exposed roots on soil surface. This indicates the danger of deep cultivation of cabbage the second year. Photographed March 3, 1948.

> your Pease intended for seed: For if they are not carefully pricked out from the others, but are suffered to mix therewith, your Kind will immediately be worth nothing, and very much deceive every one that sows the same.

The Willamette Valley seed grower should study the various strains that he is growing and rogue all plants which do not conform strictly to type. It is the responsibility of the contracting seed firm to furnish good stock seed and bulbs or roots to the grower, so as to minimize the amount of roguing necessary. Only when both parties cooperate in this manner is it possible to produce seed of a superior quality that will be in high demand by the user. If this principle is followed, both the seed firm and the seed producer will enjoy a good reputation and be able to compete effectively with other areas for markets of garden seeds.

Other Requirements. Many other cultural practices could be mentioned which bear directly upon the success obtained in growing the various vegetable seed crops. Although considerable information has been obtained on vegetable seed culture in the Willamette Valley in the last decade, not all of the cultural requirements are known for any one particular crop. Much more basic research is needed before all of the problems can be solved. Until such time as this materializes it will be necessary to rely upon the experimental information that has been already obtained and upon the experiences of growers and seedsmen in the Willamette Valley.

PESTS

Pests have been a constant menace to the vegetable seed industry in the Willamette Valley. It is extremely important that the producer develop an awareness of these pests and be prepared to control them. Although birds and rodents cause occasional damage, the most bothersome pests can be classified into three categories: insects, weeds, and diseases.

Insects. Insects are the most important pest limiting yields and quality of vegetable seed crops in the Willamette Valley. Suitable control measures are mandatory if satisfactory yields are to be obtained. Fortunately, with the development of improved insecticides in recent years, most of the more serious pests can be readily controlled.

Insect problems of seed crops fall into three groups: (1) those new to the crop, (2) those accompanied by the introduction of the crop, and (3) those that migrate from food to seed crops (79, p.362).

Smith (79, p.363-367) in 1944 listed a total of 78 species of insect pests which affected the production of 21 vegetable seed crops grown in the western states. Of this number, 48 have been found attacking Oregon's vegetable seed crops. Although this is an imposing list, entomological research on insects affecting vegetable seed crops per se has been extremely limited. This is due principally to the relative newness of the vegetable seed industry and to the fact that most seed producers have been able to cope with insect problems on the basis of information obtained from experiments on vegetables grown for food purposes. The insects that attack vegetable crops whether grown for seed or food purposes are often the same.

One of the insects investigated most intensively in the Pacific Northwest has been the cabbage seedpod weevil (Ceutorhynchus assimilis). This insect, discovered at Lynden, Washington, in May 1935, spread to western Washington, western Oregon, and California and threatened the entire crucifer seed industry (3, p.191). Seed losses of cabbage averaged 25 per cent a year in Washington (79, p.368). Broccoli seed growers in California reported losses up to 50 per cent (12, p.10). Eide (19, p.1-5), studying control methods for this pest, recommended three applications of one-half to one per cent gamma benzene hexachloride dust during the bloom period. Later, Crowell (16, p.546), working in the Willamette Valley, suggested a two per cent parathion treatment applied only once toward the end of the bloom period. This material was nearly 100 per cent effective and superior to benezene hexachloride in that it did not carry with it the danger of residual build-up in the soil and the loss of beneficial pollinating insects.

Insect Problems of the Willamette Valley. Some of the most troublesome insects for various vegetable seed crops in the Willamette Valley are shown in Table 23. This compilation is based on actual field experience in controlling these insects on experimental plantings and observations of commercial fields in the Willamette Valley.

Most seed crops are vulnerable throughout their life span to insect attack. Insects such as the seed corn maggot and wireworms,

Table 23. Troublesome insects of vegetable seed crops in the Willamette Valley, plant parts affected and suggested materials for control.

Crop	Insect 1/	Plant part affected	Suggested insecticides 2/
Bean	Bean aphid	Foliage	TEPP, Parathion, Nicotine (above 70° F.)
	Bean weevil	Seed (in storage)	Fumigation with Carbon Bisulfide and Carbon Tetrachloride
	Seed-corn maggot	Germinating seed and seedlings	Lindane or Aldrin (seed treatment)
	Western spotted cucumber beetle	Foliage	DDT
Pea	Pea aphid	Foliage and pods	Malathon, DDT-sulphur, Parathion, TEPP
	Pea weevil	Seed	DDT and rotenone
	Seed-corn maggot	Germinating seed	See Beans
Cabbage,	Cabbage aphid	Foliage and pods	TEPP, Parathion, Malathon, Nicotine (above 70° F.)
Brocolli and Kale	Cabbage seedpod weevil	Seed	Parathion, Benzene hexachloride
	Flea beetle	Seedlings and all parts above ground	DDT
	Cabbage maggot	Roots	Chlordane, Aldrin, Heptachlor
	Imported cabbage worm	Foliage (head)	DDT
Rutabaga, Turnip and Kohlrabi	Cabbage aphid Cabbage seedpod weevil Cabbage maggot Flea beetle	Same as for cabbage	
Mustard and Chinese cabbage	Cabbage aphid Flea beetle Seedpod weevil (adult only)	Same as for cabbage	
Onions	Onion thrips	Foliage and seed heads	DDT (10%), Dieldrin
	Onion maggot	Seedlings and bulbs	Chlordane, Aldrin, Heptachlor
Table beet, Swiss chard and Mangel	Lygus bug	Seed	DDT
	Cutworm	Seedlings	DDT
	Western spotted cucumber beetle	Seedlings	DDT
Parsnip	Parsnip webworm	Seed	Cryolite
Spinach	Western spotted cucumber beetle	Foliage	DDT
Radish	Flea beetle	Seedlings and foliage	DDT
	Cabbage root maggot	Roots	See cabbage
Squash Pumpkin Cucumber	Western spotted cucumber beetle will occasionally feed on foliage but damage is seldom serious		Methoxychlor

1/ Listing of insects and their effects is based on three years of observations of experimental plantings and commercial acreage in the Willamette Valley.

2/ Control measures were worked out in cooperative experiments and consultation with Dr. H. H. Crowell, Associate Entomologist, Entomology Department, Oregon State College.

for example, are known to attack seed at the time of planting. During the seedling stage such insects as flea beetles and the Western 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. Aphids, flea beetles, and pod-borers are most serious for the crucifer crops. Thrips oftentimes damage onion flowers thereby causing decreased seed yields (63, p.12). Lygus bugs are thought to have a deleterious effect on the viability of table beet seed.

<u>Control of Insects</u>. Recommended control measures for the various insects are given in Table 23.

Some of the newer insecticides such as lindane and aldrin should be used with a fungicide for the control of insects which attack the seed at planting time. These materials should be used exactly according to the manufacturer's directions, otherwise, seed may be injured in its germination.

Growers need to check their crops frequently from the seedling stage through to maturity for the possibility of sudden encroachment of insects. Oftentimes, losses can be attributed to neglect on the part of the grower for not having made timely or proper application of insecticide materials. Insects observed and treated in the initial stages of infestation can often be prevented from spreading to nearby areas by spot dusting with the appropriate insecticide. With the development of new and better insecticides and superior equipment for application as illustrated in Figure 48, there is little reason for allowing insects to gain the upper hand and ruin an otherwise good seed crop.

Weeds. Weeds constitute one of the major problems in vegetable seed production in the Willamette Valley. Failure to control them nearly always causes economic losses, not only in the reduction of crop yields, but in the expense of cultivation practices and time-consuming, expensive hand labor.

There are three main times when weeds are extremely troublesome to vegetable seed crops in the Willamette Valley. The first is in the early seedling stage, just as the crop plants are commencing growth. Weed competition at this stage of crop development can be very serious if allowed to go unattended since excessive competition will often result in death or greatly retarded growth to the crop. Weeds also become an acute problem in early spring for crops which are over-wintered in the field as shown in Figure 49. Because of the mild temperatures which make possible this practice, weedy grasses, especially rye grasses, velvet grass, and annual blue grass, often over-take the crops because of their ability to grow at relatively low temperatures. This is especially true in seasons when weather conditions do not permit early field work. Weeds again constitute a serious problem after the crop has developed to the stage where it no longer can be handled with tillage equipment. Cabbage plants after bolting, for example, grow rapidly and spread widely in a shrub-like fashion and soon limit weed control activities to hand work. Onion seed stalks,

Fig. 48. 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.

Fig. 49. Weeds take their toll in vegetable seed crops as well as other crops. Many over-wintering crops such as the cabbage 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 cabbage.

when they become older, are unusually brittle and oftentimes snap off when a slight pressure is applied to them. Consequently many seed fields are often seriously infested with weeds with the result that weed seeds are harvested with the vegetable seed crop.

<u>Cultural Weed Control.</u> Proper and timely weed control is extremely important since the vegetable seed crops, as a group, respond favorably to clean culture as shown in Figure 50. The grower needs to recognize that producing the vegetable seed crop is simply carrying the vegetable to a later stage of maturity and that weed control in the early stages deserves the same attention that is necessary for commercial vegetable production.

Several approaches can be taken to the weed problem and in many instances a combination of weed control practices might well be the most economical solution to the removal of the competitive weeds.

The first is hand weeding or hoeing, which is expensive and should ordinarily be avoided if at all possible. Oftentimes where machine cultivators cannot get close enough to the row, additional hand weeding may be necessary to eliminate fast growing weeds which compete with the developing seed crop for moisture and nutrients. Increased seed yields for certain high value crops will often justify the labor costs involved in the expensive hand-weeding operation.

The second and usually most effective and widely used method is that of cultivation. Growers should avail themselves of suitable cultivation equipment, adapted to the row spacing of the crop.

Fig. 50. 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.

Cultivators should be equipped with fertilizer attachments, if possible, in order that cultivation and fertilization can be carried on simultaneously.

Extra effort should be made to prepare the soil, germinate a crop of weeds, and kill them before a spring or summer-seeded crop is planted or before a crop is transplanted. Fewer cultivations will be needed to control weeds in the seed crop if this precaution is taken. For over-wintering crops, a cultivation as late in the fall as possible and one as early in the spring as soil conditions permit will greatly lessen the weed competition to the seed crop.

<u>Chemical Weed Control.</u> In recent years much emphasis has been placed on chemical weed control. Only limited success has been obtained in this field to date because most of the vegetable crops are susceptible to injury with many of the present chemicals. A great deal of experimental work is in progress, some of which holds interesting possibilities for the future. Three main approaches can be taken to the weed problem with chemicals: (1, p.173).

1. <u>Pre-planting</u> in which the seedbed is prepared and the chemical is applied before the crop is planted. The application of chemicals should be delayed until most of the weeds in the upper soil layer have germinated and emerged. The chemical will then kill the weed seedlings and the crop can be planted, care being taken to disturb the soil surface as little as possible. This method of weed control is adaptable particularly to crops that need to be transplanted.

2. <u>Pre-emergence</u> treatment in which the chemical application is

made after the crop is planted but previous to the emergence of that particular crop. The principle involved is one of thorough land preparation followed by delayed planting of the crop. The chemical 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 the weeds without injury to the crop. A chemical must be used that is effective on contact with the weeds, but which loses its toxicity quickly so the later-emerging crops are not injured.

Many chemicals have been tested for their effect as pre-emergence treatments for weed control (75, p.199-228). Petroleum fractions with low boiling ranges such as Stoddard's Solvent have been found highly successful as pre-emergence herbicides for many vegetable crops (46, p.342; 82, p.512-513). Calcium cyanamid and potassium cyanate have proved effective for onions in some instances but results have been somewhat inconsistent (97, p.307; 38, p.504). The hormone weed killer 2,4-D has also been tried on various crops but has often given inconsistent results because of the harmful residual effect of the 2,4-D in the soil which severely injures the emerging crop seedlings (97, p.307; 2, p.531-532; 96, p.381; 98, p.525). Hernandez and Warren (40, p.285-286) found that 2,4-D could be used with a greater degree of safety on peat soils than on mineral soils because the chemical did not leach downward into the root zone as rapidly where the organic matter content was high. Timmons, Hawthorne, and Webber (88, p.38-39) pointed out the possibilities of 2,4-D as a pre-emergence treatment on mineral soils after the last hand weeding of seed onions. Their investigations showed that the onion seed crop was not injured provided that the spray was not placed higher than one to two inches on the onion seed stalks. Kosesan (45, p.64) in 1950 reported that the lighter, low-aromatic content oils and sodium acid cyanamide offered promise for pre-emergence weed control in vegetables in the Willamette Valley.

3. Post-emergence treatment refers to any application of chemicals made after the crop emerges. This requires a selective chemical that will kill the weeds without harming the crop plants. Although most of the vegetable crops are sensitive to the selective chemicals now in use, a few crops can be weeded chemically without danger. In 1945, Wain (94, p.120), and Grigsby and Barrons (31, p.308) reported the use of dilute solutions of sulfuric acid for the control of weeds in onions. Shortly thereafter various workers found that weeds in carrots, parsnip, celery, and parsley could be controlled with Stoddard's Solvent and some of the lighter oils (2, p.531-532; 47, p.433; 95, p.419; 83, p.477; 81, p.8). Pendleton and Freed (66, p.1-5) in the Willamette Valley and Dearborn (17, p.278) of New York found that table beets could be weeded with saturated salt solutions. Potassium cyanate has been successful in many parts of the United States for weeding young onions but results in general have been somewhat inconsistent (48, p.433; 38, p.504). Fall and winter applications of IPC have given excellent results for controlling unwanted grasses in beet, cabbage, and onion fields in the Willamette Valley (26, p.7-8). This material has also been used effectively in Utah in ridding onion

seed fields of wild oats (88, p.21-22).

Although the field of chemical weed control has not been fully explored as yet for vegetable seed crops in the Willamette Valley, results to date appear very promising and should in the future aid the vegetable seed producer in solving the weed problem.

Diseases. Vegetables grown for seed like other agricultural crops are subject to diseases caused by viruses, fungi, and bacteria. The presence or absence of disease frequently means the difference between profit or loss to the grower.

The location of vegetable seed-growing areas is often determined by the seriousness of the disease to the host plant and whether or not disease-free seed can be produced. The bean seed industry of the intermountain zone, for example, developed in this region primarily because of the absence of anthracnose and the rare occurrence of bacterial blight. Peas, likewise, were shown to be better adapted for seed production in this region than in others because of freedom from such destructive diseases as ascochyta blight, bacterial blight, and anthracnose (7, p.8-18). Cabbage seed production prospered in the Skagit Valley in northwestern Washington because the climate was such that seed could be produced free of blackrot and blackleg (67, p.829; 7, p.18). The growing of table beet and spinach has not been successful east of the Cascade mountains because of the curly-top virus disease which is carried by the beet leaf hopper, an insect commonly found in sagebrush areas. The virus disease, western aster yellows, has already become limiting to seed production of carrot and lettuce in some parts of California and Idaho (7, p.18-19).

Disease Problems of the Willamette Valley. A disease survey by McWhorter, et al (55) in 1942 showed that Oregon was nearly free of diseases which were limiting production in old, established seed-growing centers. That diseases were a major factor to contend with, however, was evidenced by the initiation of a cooperative vegetable seed disease project, in 1942, between the Bureau of Plant Industry, Soils and Agricultural Engineering, and Oregon State College, Farm Crops Department (41, p.20).

Fortunately, plant diseases have not as yet seriously affected the majority of the vegetable seed crops in the Willamette Valley. A large number of diseases are present but seldom become limiting if reasonable precautions are taken to prevent them. On certain occasions, however, if these precautions are overlooked, diseases can become quite destructive. Onion mildew, perhaps the most important disease for any one seed crop in the Willamette Valley, can develop to such proportions as to cause serious economic losses as shown in Figure 51. Root-rot organisms are often destructive to biennial seed crops like table beet and therein create one of the most important problems facing producers of this type of crops. Certain leaf, pod, and stem diseases, like leaf spots and ring spot, have been noted on some of the crucifers but seldom in epidemic proportions. Seedling diseases caused by damping-off organisms have caused occasional loss of stands, especially for the cucurbits as illustrated in Figure 52, table beet and spinach. New virus diseases like virus yellows of table beet have been reported

Fig. 51. An onion seed field in the Willamette Valley 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.

Fig. 52. Cucumber variety experiment showing stand irregularities due to damping-off disease organisms. Note difference in varietal susceptibility to damage. Experiment was abandoned because of irregular stands.

in recent years. It is the opinion of pathologists that this group of diseases may in the future become a serious problem in the Willamette Valley.

Disease Control. Plant disease control is largely prevention and to be effective must be started before the disease becomes established. Because of the diversity of disease organisms, control measures vary widely depending upon the nature and life requirement of the organism involved (23).

Control of diseases like soft rot or Sclerotina rot, which cause decay of food storage organs, can be attained by modifying the environment of the organisms. This is accomplished by taking proper precautions at harvest time and during the storage period. All bruised and injured roots should be sorted out and discarded. Sound roots should be clean when entering storage and then stored under sanitary conditions where temperature and humidity are carefully controlled (24, p.8-9; 102, p.3-5; 100, p.3; 104, p.6).

Control measures for diseases which cause damping-off of seedlings should be directed at reducing the injurious effect of soil-inhabiting and seed-borne fungi (57, p.1-6). These fungi produce mycelium that penetrate young tissue and unless protection is given to the young developing seedlings, heavy stand losses can be encountered. Observations have shown that losses are particularly severe on cold soils where plants are retarded in growth for a long period. Seed treatment with various fungicides has usually given good control and should be practiced whenever planting vegetable seeds. Gould (29, p.39) in western Washington showed that 17 out of 19 vegetable crops gave significant increases in plant stand after seed treatment. Only kale and celery failed to give improved stands.

Diseases that affect the host plant so as to interfere with procurement of water and nutrients from the soil, such as Sclerotina stalk rot in cabbage, and those that destroy photosynthetic tissue of the plant, such as leaf spots of cucurbits and the crucifers, must be avoided or restricted by rotation, sanitation or spraying.

The use of disease-resistant varieties is the principal means of control for diseases like the viruses that interfere with the translocation of plant food (73). Where suitable varieties are not available other stringent precautions need to be taken. If insect vectors are responsible for spreading the disease, it is mandatory that the susceptible crop be isolated from the source of infection at a distance beyond the range of the vector. Pound (67, p.11-14) in northwestern Washington found that the serious cabbage disease, mosaic, could be controlled by isolating the plant bed several miles distant from the old infected fields. McWhorter (54, p.8) pointed out that carrot, spinach and celery should never be planted adjacent to over-wintered parsnips which often carry the western aster yellows virus.

Crop rotation has long been recognized as an important means of controlling certain plant diseases. The longer the rotation, the better is the chance for elimination of plant disease organisms from the soil. Care must be taken to avoid following a susceptible crop with another which is liable to be attacked with the same disease.

Plant-beds of biennial crops should be located on clean land and at a safe distance away from old, diseased fields. Only healthy plants should be transplanted.

Good sanitation is a very important aspect of disease control. Prompt removal and destruction of the diseased plants as soon as they are noticed, aids in the prevention or spread of diseases. Badly diseased fields should be harvested as soon as possible, the crop refuse removed and burned and the soil then plowed deeply. Strict sanitation is sometimes difficult because of the cultural requirements of plants. Ring spot disease of cabbage, for example, is controlled by plowing under diseased plant refuse before transplanting the new crop. This presents a difficulty with Ballhead varieties which are transplanted in August, at a time before many of the old, nearby seed fields can be cleaned up.

Crops and weeds growing in nearby fields and waste places should be checked for disease. They serve as a source of innoculum if they are infected with the same disease as the main crop and are not controlled.

Other precautions such as the use of disease-free seed, roguing plants that show symptoms of virus disease, choosing proper locations for seed growing, the selection of healthy root stocks, and timely spraying and dusting are other precautions which aid in controlling diseases (54, p.2-5; 56, p.1-3).

DISCUSSION

This study of the economic and production factors affecting vegetable seed culture in the Willamette Valley has emphasized the basic importance of producing maximum yields of high quality seed. As the public becomes more quality conscious and demands better seeds more attention will be focused upon this latter critical consideration.

One of the first steps necessary to obtain quality production is to start with a suitable supply high quality stock seed. Seed companies usually furnish the stock seed or planting material to the seed farmer with whom they have seed acreage contracted. In so doing, they assume responsibility for the maintenance of high quality planting stocks.

The general procedure for the development of stock seed suitable for planting has provoked much discussion and thought in the past. Seed companies are generally in favor of doing their own breeding and development work for new varieties. Most of the larger seed companies have their own plant breeders, facilities and testing grounds to carry on this work. As a result, each seed company has developed and promoted its own varieties, to the extent that a chaotic varietal situation exists at the present time. The continual addition of new varieties, either real or so-called, adds to the confusion from the standpoint of the consumer and the seed producer as well. The progress made by federal and state plant breeders in the southern states in the development of superior, disease-resistant strains in recent years is worthy of note as it relates to quality improvement in vegetable crops.

As soon as a new variety is developed and tested seed supplies must be increased to meet the need. This can be accomplished either under state seed certification programs or by the seed companies in their regular contract operations (39). Seedsmen maintain that they are in a better position to produce high quality stock seeds than are state certification agencies because of their direct control of the crop under the contract arrangement. Also, seed firms have been generally opposed to the relinquishment of their breeder seed to state certification agencies.

Seed companies vary in their standards for producing stock seed. Some tend to be very strict in their requirements for genetic purity and type whereas others with lower merchandising standards are more lax in their quality requirements.

Certification of vegetable seed crops by state agencies has met with varying degrees of success depending upon the demand for the variety and the adequacy of the certification rules. Some states have found it desirable to turn over their foundation seed stocks developed by federal and state plant breeders to commercial seed companies for further increase. This has been necessary where there is a reluctance on the part of the seed growers to produce a variety for which they do not know the market demand. Canadian seedsmen report success with a plan whereby the Vegetable Experiment Station maintains foundation seed stocks and then makes these available to the seed trade for seed production purposes (11, p.9-32). The use of the foundation stock seed is not compulsory and for that reason does not suppress the use of varieties which individual seed firms may wish to develop and promote.

The vegetable seed industry of Holland has certain characteristics that are worthy of note as they relate to seed quality. The broad aims of their program are: (1) to encourage plant breeders, especially private ones, to develop improved strains, (2) to prevent multiplication of inferior strains, and (3) to indicate to the users of vegetable seeds the varieties which are most suitable for their requirements (62, p.532). The Horticultural Plant Breeding Institute of Holland publishes a descriptive list of varieties and gives official recognition to those which are superior. Only those which have been thoroughly tested in field trials and found superior are eligible for seed production. All of the vegetable seed produced is subject to inspection and testing by an official organization whose membership consists of seed firms, wholesalers, exporters, and retailers. The main function of this organization is to inspect and test for varietal purity and authenticity based on the official descriptive list. This plan does not suppress the initiative of private enterprise but still provides a means for keeping the user of vegetable seeds informed as to the best varieties for his purpose. If such a program as this were adopted for the United States, the main disadvantage would be the high cost involved in an extensive testing program because of the widely varying environmental conditions of this country. The plan, nevertheless, has a great deal of merit and should be more fully considered by the American Seed Trade and the Horticultural interests of this country. Such a program, if administered correctly, would do much to clarify the variety problem and thereby simplify vegetable seed production for the Willamette Valley producers.

An appraisal of the various factors indicates that the future of the vegetable seed industry in the Willamette Valley will depend chiefly upon world-wide and national economic considerations and the extent to which large garden seed companies shift their production from old established areas to this area.

It was pointed out that after World War II imports of small seeds from European countries assumed considerable significance. The underlying reasons for this were numerous, the net effect being that production in the United States and the Willamette Valley was greatly curtailed. The recent ECA (Economic Cooperation Administration) program had an adverse effect on the garden seed industry in the Willamette Valley. The objective of this program was to make western European nations self-dependent, to promote trade with each other and to sell to us to gain dollars. Since western Europe had been traditionally a producer of garden seeds a quick restoration of this industry was noted. With this and the devaluation of practically all currencies in the world in relation to our currency standard it was easy for these countries to sell to us but difficult for us to export to them. During the same time our labor and supply costs remained high, and prices were forced to a high level in order to meet the competition of other crops which were supported under government price support programs. Also, import tariffs which have always been very nominal, were reduced to the point where these were of minimum significance. All of these factors combined to make the foreign seedsman a vital competitor to the Willamette Valley producer of small seeds. In spite of these unfavorable relationships, foreign competition has not completely replaced domestic small-seed production. Two reasons probably account for this situation. In the first place, mechanization has made it possible for the Willamette Valley farmer to offset the cheap European labor for certain crops. Secondly, many of the American wholesalers are reluctant to buy foreign seed because of its inferior quality and because of a preference for American varieties. The extent to which the Willamette Valley farmer will continue to produce small seeds in the future, therefore, hinges mainly on two basic concepts: (1) the degree of mechanization which the farmers are able to achieve and (2) the ability to produce high quality seed.

It has been pointed out previously that the Willamette Valley has an ideal physical environment for the production of many kinds of seed. Also, Willamette Valley farmers are seed-minded and have exhibited unusual talent for developing machinery for specialized purposes. The extent to which the larger, well-established seed companies will uproot and shift their production from other states to the Willamette Valley is difficult to predict since it is impossible to foresee what production problems might be encountered in the other areas. A shift to this area has already been noted in the case of vine seed crops where one large company has transferred nearly all of its production from eastern Oregon and Idaho in order to escape the disease hazard encountered there.

It should be re-emphasized that many possibilities and opportunities for small seed production exist in the Willamette Valley. Only during times of national emergency, however, is there a high degree of probability for the development of a large-scale and extensive vegetable seed industry in this area.

SUMMARY AND CONCLUSIONS

A study was made of the various economic and production factors that affect vegetable seed production in the Willamette Valley, Oregon. This was prefaced by a brief historical sketch of the development of the vegetable seed industry and a discussion of the environmental features of the Willamette Valley, Oregon's leading vegetable seed producing area. Data from certain cultural and fertilizer experiments conducted at Corvallis from 1948 to 1950, inclusive, were presented.

The study indicated that the factors of supply and demand through their effect on vegetable seed prices have exerted the strongest influence on the development of the vegetable seed industry. This was true even though the environmental, physical, and human resources of the Willamette Valley favor seed production of many small-seeded vegetable crops. Cost and resource requirements of the vegetable seed enterprise are such that many farmers could readily handle more acreage. A strong deterrent to any unwarranted expansion, however, is the contract operations of the seed companies.

Import data showed that European countries, prior to World War II, supplied most of the domestic garden seed needs, especially those kinds which can be grown particularly well in the Willamette Valley. During World War II when imports were cut off, a rapid expansion of the Willamette Valley vegetable seed industry occurred because of a greatly stimulated domestic and foreign demand which created relatively favorable prices for vegetable seeds. After World War II demand slackened, imports increased, and the vegetable seed industry declined to its pre-war level when less than 1000 acres of vegetable seeds were being contracted each year. Foreign competition increased markedly for small seeds after World War II but to a lesser extent than prior to 1940.

Export data for garden seeds showed that exports have never been of any great significance to the Willamette Valley producer except during the war years.

A study of the production factors revealed the fact that the vegetable seed industry is a highly specialized business and must be handled by seedsmen and farmers who possess personal qualifications that adapt them to this enterprise.

The principal production factors that affect the yield and quality of seed produced and/or the efficiency of production are:

1. Isolation requirements for cross-pollinated crops. Distances from other varieties or kinds of tame or wild species growing nearby with which crossing is likely must be adequate so as to prevent genetical deterioration of the seed crop. Suggested isolation requirements for the various crops are given in the text.

2. Special facilities and/or equipment. Ordinary farm machinery can be used interchangeably for most vegetable seed crops. Where specialized facilities and costly planting, harvesting, or processing machines are needed, seed companies usually furnish these to the seed growers.

3. Kind of crop and variety. Various crops and their varieties differ widely in adaptation and in seed-yielding ability. The beet and spinach groups, the crucifers and certain members of the cucurbits along with onion and parsnip are well adapted for seed production in the Willamette Valley. Some varieties may yield twice as much as others of the same kind. Contract prices do not always reflect these differences.

4. Soil type and management. Productive river-bottom soils such as the Chehalis series, and the well-drained bench land soils of the main valley floor such as the Willamette

series are preferred to the heavier or upland soils. Cropping and soil management practices should be aimed at the frequent renewal of large quantities of organic matter.

5. Supplemental irrigation. Supplemental irrigation is essential for many biennial crops where it is necessary to establish plant beds and to start the transplants. Irrigation makes possible maximum seed yields for all the vegetable seed crops, especially where fertility levels are high and for crops that make their maximum moisture demands during the summer months.

6. Fertilizer requirement of crops. Vegetable seed crops respond to higher levels of commercial fertilizer than do ordinary field crops. Nitrogen is the key element for vegetable seed production and amounts up to 180 pounds of nitrogen per acre have given significant seed yield increases for irrigated cabbage, turnip, and cucumber. Approximately two-thirds of this amount is needed to produce optimum seed yields for onion, mustard, radish, and similar crops. Other nutrient deficiencies exist occasionally but are seldom seriously limiting.

7. Cultural requirements of crops. These vary widely for different crops and their varieties and unless fully met often mean the difference between profit and loss to the grower. All of the vegetable seed crops respond to good care and clean culture. All crops require nearly ideal seedbed preparation, shallow cultivation, timely planting, and/or transplanting and proper spacing in order to produce maximum seed yields.

8. Pests. Insects, weeds, and diseases, in the order named, are a serious menace but fortunately can be controlled for most of the crops.

   Seed crops are vulnerable throughout their life span to insect attack, with flea beetles, aphids, pod borers, thrips, and lygus bugs being the most bothersome. The various insect pests and their respective control measures are given in the text according to crop.

   Weeds constitute a serious problem in the early stages of crop development, in early spring for field over-wintered biennials and in the later stages of crop maturity. Cultivation is the principal means of weed control, with chemicals offering a bright hope for the future.

   Diseases have not been a serious limiting factor in the Willamette Valley provided reasonable precautionary measures are taken to prevent them.

From this study it may be concluded that:

1. The Willamette Valley is well suited for the production of many small-seeded, cool-season vegetable crops for seed purposes and is fully capable of supplying large quantities of garden seeds.

2. The economic factors of supply and demand are most limiting to the expansion of the industry since they determine the allocation of the farmers' resources of land, labor, and capital.

3. The future of the vegetable seed industry in the Willamette Valley hinges on: (a) ability to mechanize so as to be able to compete with cheaper foreign labor, (b) ability to continue to produce optimum yields of high quality seed, (c) the extent to which old, established seed firms in other states will be forced, on account of diseases or other factors, to transfer their production to the Willamette Valley, and (d) future imports of garden seeds.

4. More fundamental research and study is needed to help the growers solve their production and marketing problems.

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19____ CROP

SEED GROWERS AGREEMENT

An agreement is hereby made by and between ....

of ...., party of the first part, herein referred to as the grower, and party of the second part, herein referred to as the company, covering the planting, culture, harvest and delivery of a crop for seed purposes, subject to the terms and conditions set forth in the following paragraphs.

The grower agrees to properly prepare .... acres of suitable soil for ....

..............................and to plant on the same at the proper time only the stock seed furnished by the company and thereafter to properly cultivate and care for the crop and when matured to harvest cure and thresh

the seed and deliver the entire crop to the company at ....

The acreage covered by this agreement is located in Sec.............., Township ....

County ...., and the crop is to be grown for the crop year of 19..............

The grower further agrees to use his best efforts to prevent cross pollination or hybridization of this crop by preventing as far as possible the planting for seed purposes any other crop of the same kind or specie within forty (40) rods of the above mentioned acreage and to destroy any stray plants of like nature growing within that area before they come into bloom.

The grower further agrees that the "stock seed" furnished by the company and used in planting the above mentioned acreage as well as the entire crop produced therefrom shall at all times be and remain the sole property of the company unless otherwise provided for in this agreement.

The grower further agrees to allow the fieldmen of the company the right to enter the field or fields upon which this crop is growing at any time for the purpose of inspection and rogueing or destroying any off-type or undesirable plants which if left to mature would reduce the value or quality of the resulting crop.

The company agrees to furnish sufficient stock seed to plant the above mentioned acreage in exchange for which a like amount of seed is to be taken by the company from the crop delivered in payment for the same.

The company is hereby authorized to clean or re-mill said crop to properly condition it for resale as seed and to pay for the same on the basis of dry, recleaned seed which must have a germination of at least 85% and a moisture content of under 10% to be acceptable to the company. No charge is to be made against the grower for processing and cleaning.

The company shall not be required to accept or pay for the crop produced if it is delivered in a condition which would make it unfit for seed either because of low germination or any other condition which would prevent its ready resale as first class seed. The company shall be the sole judge of the acceptability of the crop for seed purposes and its decision shall be final, it being agreed that in the case of a dispute over the vitality of the seed the test of the United States Department of Agriculture Laboratory at Corvallis, Oregon, shall be accepted by both parties as final.

The company agrees to either furnish the sacks required for shipping the crop or return the sacks if furnished by the grower.

In case the quality of the crop is such that it cannot be put in suitable condition for Seedmans use, at a reasonable cost, or because of low germination, the company is hereby authorized to refuse to accept the same in which case the grower is to be so notified in writing and the title is to revert back to the grower upon receipt of such notice and the grower is to reimburse the company for the stock seed used as well as any transportation charges that the company may have paid on the crop and to remove same at once from the premises of the company or receiving warehouse. If within sixty (60) days after mailing such notice to the grower the crop remains uncalled for, the company is authorized to dispose of the same in any manner without obligation.

The price to be paid the Grower for the clean seed resulting from the crop grown and delivered on this agreement is to be

.... per pound for a quantity not to exceed .... pounds per acre. Payment to the Grower for the seed delivered within the aforementioned quantity shall be due as follows: One third (as near as can be estimated) when delivery has been completed and the balance within sixty (60) days or as soon as cleaned and tested.

It is agreed that in the event the crop yield is in excess of the aforementioned quantity that the balance of the crop will be consigned by the Grower to the Company until sold. The price for the surplus is to be mutually agreed upon at the time of sale. The Company is hereby given the option to accept the entire crop at harvest time on the above payment terms.

Dated and signed this .... day of ...., 19..............

By ....
The Grower

Address ....

By..............................

....
Land Owner

Address ....

Appendix Fig. 1. Common type of seed growing contract used by one of the leading vegetable seed companies of the Willamette Valley.

CONTRACT TO GROW SEEDS

Stock No. ....

IT IS MUTUALLY AGREED this..............day of.........................., 194......, by and between hereinafter called "The Company", and

....of..

County of.............................., State of.............................., hereinafter called "The Grower", the owner or operator

of that certain real property known as.., situate on

....about...........miles from...in the County of

.................................., State of.., as follows:

Upon receipt from the Company of Seed Stock, the Grower agrees to plant at the rate of...........pounds per acre, in the proper season of 194......, on good, clean land situated on the above described premises as follows:

Approximate Acres	Variety	Rate of Payment
		@ per Lb.

The Grower also agrees not to plant any of the said crop within...................... feet of any other crop of the same species grown by the Grower or any one else, without the Company's written consent; when two or more varieties are being grown, to keep the different varieties separate and distinct at all times and in harvesting to mark plainly all bags with labels and tags and other information satisfactory to the Company's representatives; in growing to leave a separation

of at least.................feet between each variety, such intervening land to be planted to a crop which will, so far as practicable, prevent the vines, plants, or seeds from being blown from one variety to another, particularly at harvest time; to keep the crops free of all weeds and weed seeds, particularly at harvest time; to properly cultivate and care for the crop and harvest the crop when ripe; to thresh and clean the same as well as possible with ordinary farm machinery, and immediately deliver the same to the Company; to pay the Company for the full amount of stock seed furnished at contract prices in the event of partial or total crop failure; and in the event of partial crop failure, however, the Grower agrees to perform this contract completely, irrespective of the amount of seed which he may be able to produce.

The Company agrees to furnish seed stock as above set forth and tags and labels for marking the seed raised, and bags for delivery, but the Grower will be responsible for any loss or injury to said materials, all of which will be charged to the Grower, the charge to be refunded to the extent said materials are returned in good condition.

The Company agrees to pay the Grower for raising, producing, harvesting and delivering said seed and for the performance of all other obligations of the Grower hereunder a sum equal to the total value at the rate hereinabove provided of all satisfactory seed delivered by the Grower, less any deductions which may properly be made for seed stock furnished or otherwise provided herein. Said payment shall be made within thirty days after the completion of a satisfactory germi-

nation test by the Seed Laboratory of the State of.., Dept.

of Agriculture, which test shall show a germination of not less than 90%, which being accomplished the said seed shall be accepted by the Company as having fulfilled the requirements of this contract in respect of germination. Such

delivery shall be f.o.b...
If the seeds delivered by the Grower are, in the opinion of the Company, in such condition or of such quality that they will not germinate as so provided, or if said seeds shall have been mixed with other varieties or identification lost, or if there shall be any excess of any foreign matter, or if they shall be in any other respect unfit for sale as seed, and if, in the opinion of the Company, further recleaning, milling or handpicking will be impractical or excessively costly, the Company shall have the right to reject said seed or any part thereof, and the Grower shall be entitled to no compensation whatsoever hereunder for seed so rejected and the Grower shall immediately reimburse the Company for seed stock furnished and other expenses advanced or incurred.

All splits, damaged seeds, or other material removed from seed to make it, in the opinion of the Company, suitable for seed purposes, shall be the property of the party removing it.

The Company shall have the right to remove from the growing crops and destroy all plants that are untrue to type, mixed, or which would, in the opinion of the Company, injure the product for seed purposes.

Title to all seeds delivered to the Grower hereunder and to all crops resulting therefrom or grown as herein provided shall remain in the Company, the Grower acting as bailee with respect thereto, and the Grower shall have no right, title, or lien thereon or therein.

Only such stock seeds as shall be furnished by the Company shall be planted by the Grower, and the equivalent thereof shall be deducted by the Company from the crop delivered hereunder, and the Grower shall receive no compensation therefor.

The Company and its agents and representatives shall at all times have access to the premises on which said seeds are being grown for the purpose of inspection or performing any of the acts herein contemplated to be performed by either party, and the Company or its agents and/or representatives shall not be liable for necessary damage, if any, to the general crop resulting from such work.

The delivery to the Company of seed grown shall not be considered as an acceptance of the same or as satisfaction of the obligation of the Grower hereunder, and all risk of loss, damage, or destruction of the crop shall be borne by the Grower until the Company shall give him notice in writing that the seed delivered has conformed to the tests hereinabove specified and is satisfactory and acceptable to the Company.

Any indebtedness of the Grower to the Company shall be repayable on demand with interest at the rate of 6% per annum and may be deducted from the amount herein provided to be paid to the Grower.

All the work or obligations to be performed by the Grower hereunder shall be strictly in accordance with the instructions of the Company and to its satisfaction, and if at any time the Grower shall neglect, refuse, or for any reason fail to carry out the instructions of the Company, the latter shall have the right to take such action as may be necessary in its opinion properly to care for, harvest, and deliver the crop, and otherwise to perform the Grower's obligations under this contract, and all cost and expenses thereof shall be paid to the Company by the Grower upon demand.

All acts and things herein agreed to be done and performed by the Grower shall be at the Grower's own expense and cost.

The Grower shall at all times act as and be deemed to be an independent contractor and shall have full authority and control over all of his employees, and all debts, obligations, or liabilities incurred or contracted by him shall be paid and discharged by him, and the Company shall not be charged therewith or be in any way liable or responsible therefor.

The Grower shall promptly advise the Company of any attempt to dispossess or deprive the Company of its ownership of the stock seed or the seed crop produced therefrom by means of an execution levy, attachment, or other legal process, or by illegal means, personally or in cooperation with the Company to resist any such interference with the Company's ownership or title to said seed stock or seed crop.

This contract shall be binding upon the heirs, administrators, executors, successors, or assigns of the Grower, but no assignment of this contract by the Grower, voluntarily or involuntarily, or by operation of law, shall be binding upon the Company without its written consent.

IN WITNESS WHEREOF, this agreement has been executed by the parties above named as of the day and year first hereinabove written.

.... Grower

P. O. Address..

By..

Title...

In the event that the Grower is a renter and has agreed to pay crop rent on the above described land, it is hereby agreed between the Owner of the said land and the Company that the Owner's share of the payment for the crop grown under the above contract, amounting to...............% of the total quantity harvested, is included in the above contract and on this quantity all terms and conditions of the above contract are to apply.

.... Owner

P. O. Address..

By..

Title...

Appendix Fig. 2. Another example of a seed growing contract used in the Willamette Valley.

Appendix Table I. Total imports, exports, production, stocks on hand and domestic use of vegetable seeds for United States. 1939 to 1951 inclusive 1/

Year beginning July 1	Total imports		Total exports	Total production		Total stocks on hand	Total domestic use 2/
	Large seeds 3/	Small seeds	All seeds	Large seeds	Small seeds		
	(100 pounds)	(100 pounds)	(100 pounds)	(100 pounds)	(100 pounds)	(100 pounds)	(100 pounds)
1939	-	54,984 4/	16,553	1,134,895	103,965	1,554,880	1,863,213
1940	6,821	5,654	43,988	1,564,686	102,969	956,880	2,107,512
1941	9,423	1,671	60,702	2,518,142	155,515	485,510	2,487,419
1942	7,632	1,730	88,028	3,123,483	208,369	622,140	3,028,716
1943	18,939 5/	3,850	58,063	3,281,920	244,450	846,610	2,834,676
1944	2,013	3,039	128,920	2,588,360	338,710	1,503,030	3,088,962
1945	6,359	4,651	175,900	2,031,540	219,930	1,217,270	2,605,150
1946	3,607	25,251	151,690	2,595,860	130,060	698,700	2,528,038
1947	2,699	21,254	71,260	2,354,440	144,270	773,750	2,009,763
1948	7,213	18,009	48,710	1,693,354	113,246	1,215,390	1,863,372
1949	27,305	26,492	29,120	1,614,640	136,020	1,135,130	1,943,817
1950	2,141	30,763	35,990	2,097,460	103,270	966,650	2,166,184
1951	2,054	25,452	34,650	1,972,940	95,130	998,110	1,925,956

1/ Data from Agricultural Statistics, United States Department of Agriculture and Bureau of Foreign and Domestic Commerce, United States Department of Commerce.

2/ Total domestic use calculated by formula:
(Imports + production + stocks on hand) - (exports + carry out) = Domestic use.

3/ Large seeds include peas, beans and sweet corn; small seeds include all others.

4/ Average imports for 5-year period 1935-39 on calendar year basis. No information available on large seeds.

5/ Includes 17,414 (100 pounds) of horse beans from Mexico.

Appendix Table II. Imports of various kinds of vegetable seeds in 100 pounds admitted into the United States under the Federal Seed Act. 1/

Kinds of vegetable seeds	Calendar year 1935-39	Year beginning July 1											
		1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951
Artichoke		-	-	-	-	-	-	1	-	2	2	5	2
Asparagus		-	-	-	24	19	-	72	43	18	28	101	46
Bean*		-	-	-	-	-	-	-	-	-	-	-	-
Garden		102	26	310	880	131	6	111	1183	1281	322	251	215
Lima		242	1	-	-	1	-	-	77	4644	25850	-	2
Horse or broad		4	5071	4572	17474	1392	4	24	578	532	140	339	615
Runner		-	-	-	-	-	-	-	-	-	20	-	-
Beet, garden	2667	252	33	1	3	162	5	151	103	195	87	473	444
Broccoli		5	15	-	-	-	-	8	13	9	10	17	4
Brussels sprouts		2	0	2	23	21	1	6	7	12	33	39	34
Cabbage	3879	523	8	-	197	4	300	467	160	546	766	957	862
Cardoon		-	-	-	-	-	-	-	-	-	-	1	1
Carrot	149	16	13	2	54	13	15	428	537	13	11	57	24
Cauliflower	154	84	11	-	-	-	34	76	38	47	70	54	48
Celeriac		-	-	-	-	-	-	-	1	-	1	-	2
Celery		-	-	-	-	-	-	2	-	-	1	-	2
Chicory		27	-	1	-	-	56	102	51	70	73	33	53
Collards	-	-	-	-	-	-	-	-	-	1	-	-	-
Corn, sweet*		-	-	8	497	468	44	17	4	52	107	2	-
Cowpea		-	-	-	-	-	-	-	-	-	1	26	2
Cress, garden		1	-	-	-	1	1	23	14	9	257	107	7
Cress, water		-	-	-	-	-	-	-	1	2	2	2	2
Cucumber		7	8	-	1	5	8	11	15	239	57	49	18
Dandelion		1	-	-	-	-	-	-	-	1	4	1	3
Egg plant		1	-	-	-	-	-	4	2	5	3	1	3
Endive		-	-	-	-	-	7	10	4	2	21	3	4
Fetticus (corn salad)		-	-	-	-	-	7	23	11	6	5	30	12
Kale	600	16	-	-	-	3	20	53	31	247	265	498	346
Kohlrabi	177	33	-	-	1	-	-	12	31	45	41	23	43
Leek		4	-	-	-	-	-	4	6	5	32	13	24
Lettuce		1	1	-	5	1	-	29	11	27	2	61	11
Muskmelon		-	1	-	1	8	1	-	1	13	8	1	2
Mustard, cultivated		62	1	-	-	-	1	305	319	431	1511	1050	993
Mustard, spinach		-	60	-	-	-	-	1	-	2	6	64	153
Mustard, vegetable		-	1	-	-	-	-	-	3	5	8	2	1
Okra		-	-	-	-	-	1	-	-	-	-	-	-
Onion	1788	1200	1034	1687	3068	2711	1197	1048	888	670	881	789	408
Pak-choi		-	-	-	-	-	-	-	11	1	1	3	1
Parsley	886	9	-	-	184	1	1	35	17	5	18	25	57
Parsnip	990	1	1	-	-	-	20	1	5	52	249	33	21
Peas, garden*		6473	4325	2742	88	21	6305	3455	857	704	866	1549	1221
Pepper	9	-	3	-	-	6	-	3	12	4	4	41	9
Pe-tsai		-	25	-	2	-	13	31	39	21	27	44	41
Pumpkin		38	4	-	-	-	-	-	2	14	1	5	7
Radish	5990	140	3	8	-	67	82	393	1123	1890	2051	1016	361
Rhubarb		1	-	1	-	-	1	-	-	2	6	2	6
Rutabaga	721	118	7	19	68	10	20	92	109	515	195	90	125
Salsify		-	-	-	-	-	-	3	-	-	1	3	3
Sorrel		-	-	-	-	-	-	10	-	1	2	-	3
Spinach	30935	532	61	-	-	-	2846	21655	17072	11512	13524	22422	18628
Spinach, New Zealand		33	-	-	-	-	2	41	65	43	75	37	129
Squash		2	3	2	3	-	1	4	9	51	2	122	9
Swiss chard		11	-	-	202	-	-	1	22	2	21	56	90
Tomato		24	14	5	6	5	10	90	41	76	17	112	117
Turnip	6929	2509	364	2	8	2	1	56	432	1175	6112	2294	2291
Watermelon	-	1	-	-	-	-	-	-	4	23	-	1	1
Total	54984	12475	11094	9362	22789	5052	11010	28858	23952	25222	53797	32904	27506

1/ Data from Agricultural Statistics, United States Department of Agriculture and Bureau of Foreign and Domestic Commerce, United States Department of Commerce.

* Starred items are large seeds; all others are considered as small seeds.

Appendix Table III. Average contract prices per pound and price indexes for six kinds of vegetable seeds. Willamette Valley. 1940 to 1952 inclusive.

Year	Table Beet		Cabbage		Kale		Onion		Parsnip		Turnip		Average price index
	Ave. price	Price index	Ave. price	Price index	Ave. price	Price index	Ave. price	Price index	Ave. price	Price index	Ave. price	Price index	
1940 1/	12	100	75	100	12	100	35	100	15	100	10	100	100
1941	14	117	75	100	15	125	35	100	18	120	10	100	110
1942	25	208	70	93	20	167	47	135	16	107	12	120	138
1943	31	258	100	133	25	208	85	243	20	133	13	130	184
1944	32	267	104	139	32	267	85	243	22	147	15	150	202
1945	32	267	76	101	25	208	65	186	22	147	12	120	172
1946	25	208	66	88	25	208	50	143	17	113	10	100	143
1947	23	192	62	83	25	208	50	143	19	127	11	110	144
1948	25	208	60	80	20	167	50	143	19	127	11	110	139
1949	23	192	58	77	25	208	50	143	17	113	12	120	142
1950	25	208	57	76	20	167	50	143	17	113	12	120	138
1951	25	208	54	72	17	142	50	143	17	113	12	120	133
1952	30	250	60	80	20	167	50	143	19	127	13	130	150

1/ Year 1940 = 100.