Cost and Efficiency in the Operation of Oregon Commercial Seed Processing Warehouses

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AUTHOR: C. H. Greene was a former Assistant in Agricultural Economics, Department of Agricultural Economics, Oregon State University, and Agricultural Economist with the Marketing Economics Division of the Economic Research Service, U. S. Department of Agriculture, and stationed at Oregon State University. Present address: Department of Agricultural Economics, New Mexico State University, University Park, New Mexico.

COST AND EFFICIENCY IN THE OPERATION OF OREGON COMMERCIAL SEED PROCESSING WAREHOUSES

C. H. Greene

INTRODUCTION

Production of grass and legume seeds has been an important enterprise in Oregon's agriculture for many years. The years since 1945 have been a period of increasing production. Concurrent with that development has been the evolution of a large seed processing industry.

The Seed Processing Industry

Production

The seed producing region in western Oregon lies in the Willamette Valley. It covers an area of approximately 3,600 square miles (Figure 1). This region has a mild winter climate with moist springs and generally dry summers. These are ideal conditions for seed production. Oregon is the source of about 25 percent of the nation's supply of turf, forage, and cover crop seeds, most of which is produced in the Willamette Valley (6, 9, 10).

Within this seed producing region, production of certain seed crops has become localized to some extent. The most important crops in each county are indicated in Figure 1. All counties included in the region produce several different kinds of seed, so that the local seed production areas tend to overlap. For example, Linn County produces 75 percent of the ryegrass seed, but some ryegrass is produced in each of the other counties (6).

Processing

The dots in Figure 1 indicate the approximate number and dispersal of plants through the Valley. The exact number of seed processing warehouses in the region is unknown. It is estimated that there are at least 350. Approximately 100 of these are commercial warehouses, with the remainder being operated by seed growers. Over two-thirds of the grower-operated warehouses process only the seed of the owner. These are designated as farm plants. The others process some quantity of seed on a custom basis in addition to that of the owner. These are designated as semi-commercial warehouses.

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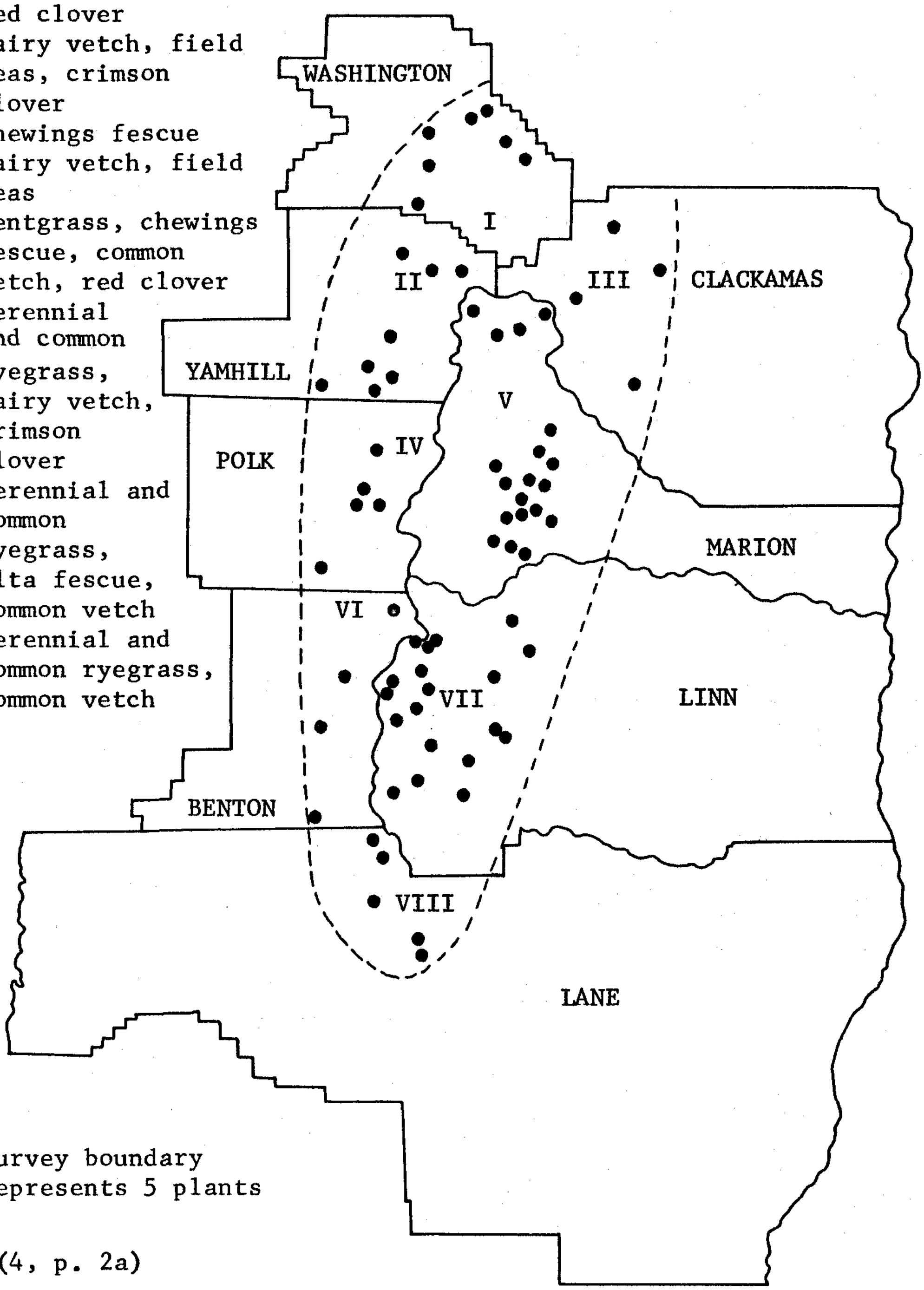
Figure 1. Willamette Valley Counties, Showing Seed Producing Area, Approximate Location and Concentration of Seed Processing Warehouses, and Major Production of Specified Seed Crops by Counties.

Production Areas:

- I. Red clover
- II. Hairy vetch, field peas, crimson clover
- III. Chewings fescue
- IV. Hairy vetch, field peas
- V. Bentgrass, chewings fescue, common vetch, red clover
- VI. Perennial and common ryegrass, hairy vetch, crimson clover
- VII. Perennial and common ryegrass, alta fescue, common vetch
- VIII. Perennial and common ryegrass, common vetch



KEY

- - - Survey boundary
● Represents 5 plants

Source: (4, p. 2a)

The average annual volume of all plants is about 750,000 pounds clean seed. Farm plants range in size from less than 50,000 pounds to over one million pounds, averaging about 200,000 pounds per year. Semi-commercial plant sizes lie in about the same range, but have a mean volume of around 450,000 pounds per year. Commercial plants average about one and one-half million pounds per year, ranging in size from less than 50,000 pounds to over five million.

Willamette Valley seed plants are grouped in several size classifications in Table 1. The table shows the percentage of warehouses falling in each size group and the percentage of total production which is processed by each group. The larger plants process the majority of the seed, even though they represent only a small percentage of the total number of plants.

Some plants process only one or two different kinds of seed, while others clean as many as fifteen. There appears to be no relationship between plant size in terms of annual volume and the number of different seeds processed by any one warehouse, though the commercial plants as a whole tend to have a greater variety. Geographical location within the Valley (with respect to local seed production patterns) appears to be the major factor which has bearing on the kinds of seed which a plant processes.

Table 1. Percentage of Warehouses and Volume of Clean Seed Processed by Specified Volumes (70 Warehouses)

Season's volume (pounds)	Percentage of warehouses (percent)	Percentage of total volume (percent)
Under 50,000	19	1
50,000 to 100,000	9	1
100,001 to 200,000	16	3
200,001 to 500,000	21	10
500,001 to 1,000,000	11	11
1,000,001 to 2,000,000	14	26
Over 2,000,000	10	48
Total	100	100

Source: (4, Table 2, p. 4)

A common characteristic of Oregon seed processing warehouses is the coexistence of the seed processing enterprise with one or more other enterprises. In the case of the farm plants, they present an example of vertical integration of seed growing and seed processing. The same is true of semi-commercial warehouses.

Few, if any, of the commercial warehouses have integrated seed growing with their processing operations. Rather, they have undertaken such enterprises as the sale of fertilizers, herbicides, and insecticides; cleaning and handling of cereal and feed grains; and the processing of livestock and poultry feeds. In many instances, it is the seed processing which is or was originally supplementary to one or more other enterprises.

Although over 80 percent of the warehouses store field-run seed in bulk storage bins or pallet boxes, over one-third of the plants use handling methods which require manual handling of the field-run seed into or out of storage (4). Only about 15 percent use a fork-lift truck in handling clean seed. Size of plant (annual volume) and type of plant--farm, semi-commercial, or commercial-- has no discernible bearing on seed handling methods, except the farm plants have a lower percentage using fork-lift trucks.

Commercial and semi-commercial warehouses process seed on a custom basis. The grower delivers his seed to the warehouse, where it is weighed, recorded, and placed in temporary storage. Later, usually at the convenience of the warehouse operator, the seed is cleaned of impurities and bagged. The clean seed is again placed in temporary storage while waiting for sampling and analysis to determine purity, germination and other qualities of the lot of seed. The grower has retained ownership throughout this procedure.

When the quality characteristics of the seed are indicated by the analysis, a sale may take place. Oftentimes, the warehouse operator will buy the seed. Otherwise, the operator acts as the grower's agent in selling the seed, obtaining a commission for his services. The interval from harvest to final sale may be as little as two weeks or more than six months.

For the services the processor performs, he charges the grower a fee. In most cases, a flat rate is charged per ton of field run seed delivered to the warehouse. The charge varies with the kind of seed. A minority of processors assess their fees on the basis of the length of time required to actually clean the seed. That is, a set fee per hour of machine time is supposed to cover the cost of most services. Services excluded from the inweight or hourly charge are those connected with selling. As indicated above, the processor receives a commission if he acts as the grower's agent. If he buys the seed from the grower, he may or may not deduct the commission from the proceeds. If the grower withdraws his seed from the warehouse after cleaning and without allowing the processor to participate in its sale, the grower is usually assessed a handling fee equal to the usual commission.

The grower also pays for bags, insurance on the seed while it is in the warehouse, purity and germination tests, and sometimes storage when the seed remains unsold for an extended period (six months or more).

Marketing

Seed marketing channels are summarized in the following tabulation[1]:

[1] Dashes indicate transfer of ownership or of selling function to the right.

Grower - Local dealer - Retailer
Grower - Local dealer - Wholesaler - Retailer
Grower - Local dealer - Broker - Retailer
Grower - Local dealer - Broker - Wholesaler - Retailer
Grower - Local dealer - Local dealer - ....

Sales to local dealers is the most important method of selling used by farm and semi-commercial processors. For the commercial processors, sales to local dealers are of equal importance to sales through the plant's parent company or subsidiary outlets. Since the local dealers are actually the larger commercial warehouses, the majority of the seed passes through the hands of the commercial processors.

The majority of farm plants often contract for sale at some time prior to cleaning, usually after harvest. These contracts are with local dealers, and usually call for future delivery of a specified kind and quantity of seed. However, in some cases the quantity may be determined at a later date.

Direct sales to seed dealers (wholesalers and retailers) in other areas are practiced by a small number of semi-commercial and commercial processors. These are generally the larger processors, so that this is an important method in terms of the volume sold.

Commercial warehouses also sell seed through parent company or subsidiary outlets, as well as directly to retailers. A smaller volume passes through the hands of brokers and speculators.

The Problem

In addition to differences in organization, differences in methods used, length of season, rates of output, and plant sizes in terms of fixed volume are found in seed processing warehouses in Oregon (4). The presumption therefore exists that operating costs vary between plants. Further strength is added to this presumption by the fact that most seed warehouses process several different types and varieties of seeds, and the product mix differs between plants both as to volume and kind.

Many of the plants are using methods and technologies that are quite efficient for the particular conditions under which they must operate. Others are operating with considerably less efficiency than could be achieved. This is partly due to innovations and changes which were unforeseen or unrecognized by the operators at the time of initiation of the business. Also, new technologies tend to be adopted slowly in existing plants as old equipment wears out. Perhaps equally as important in slowing down adoption of new technology, is lack of information. Operators may not be aware of the cost relations involved in comparing new to old. Or they may sometimes be completely unaware of the new technologies.

This report provides managers of existing warehouses, and those contemplating construction of new facilities, with information concerning construction and operating costs. No published information is available that is designed to provide management in the seed industry with these basic tools for decision making. Specifically, information is needed concerning the input-output relationships of the various factor inputs, the optimum (least cost) combinations of resources, and how departures from optimum effect (total annual fixed plus variable) costs per unit of output.

The study on which this report is based was carried out in order to:

1. Estimate comparative costs of different methods, annual volumes, and product mixes in seed processing.

2. Compare the results from objective 1 to known characteristics of the Oregon seed processing industry.

The problem is approached primarily from the industry or long-range point of view. Results are interpreted for the long run. Implications for the individual firm in the short run are more meaningful when presented within the context of the overall industry or long-range implications. This simply means that the industry is a dynamic one. Adjustments to current and possibly temporary situations should be based on the longer period of time, when all firms in the industry have had an opportunity to adjust to changing conditions.

METHODOLOGY

Stages in Seed Processing

Seed processing can conveniently be divided into six distinct but interrelated stages: receiving, storage, cleaning and bagging, shipping, procurement, and buying and selling. This study was concerned with the receiving, storage, cleaning and bagging, and shipping stages. (Figure 2) Procurement, buying and selling were not included because: (1) buying and selling functions are not carried out by every individual seed processor; (2) seed processing is often carried out jointly with other enterprises[1]; and (3) the functions of procurement and buying and selling do not lend themselves to the economic engineering approach.

The receiving stage consists of those operations involved in accepting delivery of field run seed at the warehouse. These include weighing and/or recording the amount of each delivery, assigning a lot number and storage position, unloading the delivery truck, and placing the seed into storage.

Storage is simply a temporary holding operation to even out the flow of product between the other stages. Three storage operations are distinguishable within the storage stage itself. First, there is storage of the field-run seed. When the field-run seed is delivered and handled in bags, the volume of field-run seed sets the total storage requirements for warehouse space. When the field-run seed is delivered and handled in bulk, separate storage facilities are needed for field-run and clean seed. Field-run and clean seed could utilize the same storage facilities when field-run seed is delivered in pallet boxes, but pallet boxes of field-run seed can be stored in a pole type shed. This reduces total storage costs from what they would be if the pallet boxes were stored in the more expensive enclosed warehouse.

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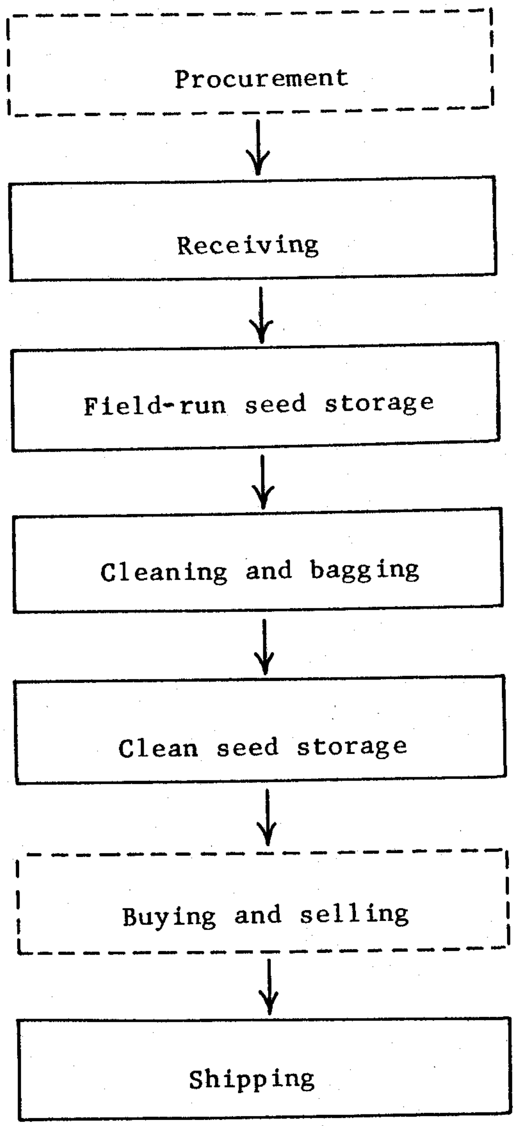
1 Examples are: a commercial seed processing warehouse which also carries on a grain and feed enterprise; and a farm plant under management of the grower-operator.

Figure 2. Typical Process Chart of Activities in Seed Processing Warehouses.[a]



a The arrows indicate flow between activities. Solid blocks indicate activities studied and broken blocks indicate activities not studied.

The second storage operation is needed for the clean seed during the interval between bagging and performance and reporting of the analysis. This analysis, required by Oregon law on all agricultural seeds offered for sale, is used to indicate the kind of seed, and certain quality characteristics. When the results of the analysis are known, the seed may be transferred to a temporary and more economical holding storage[1] (the third storage operation), or it may directly enter the shipping stage.

Cleaning and bagging includes removal of the field-run seed from storage and transferring it to the cleaning line. The seed is processed through the cleaning line and placed in burlap or cotton bags. Also included is transferal of clean bagged seed from the cleaning line to test storage.

The shipping stage involves removal from storage, placing of the required analysis tag on each bag,[2] and placing the seed on rail cars for shipment. (Truck shipments were not prevalent enough to warrant analysis at the time of this study.)

Characteristics of the Seeds Affecting the Processing

Oregon farmers produce a great variety of seeds. For purposes of analysis this study was restricted to those eight seeds which are in largest supply at the present (1962). These are: annual ryegrass, perennial ryegrass, tall fescue, crimson clover, chewings fescue, red fescue, bentgrass, and Merion Kentucky bluegrass. The generic, specific, and/or varietal differences represented here are reflected in differences in costs of handling and processing of the seeds.

Even within a given kind or variety of seed, there are characteristics which contribute to differences in handling and processing costs. For example, the kind and amount of contaminants affect hourly capacity of the cleaning line. If processing costs are constant per unit of time, costs per unit of output will fluctuate as these conditions change. Certain standardizing assumptions concerning these and other conditions are presented in Table 2.

The assumptions concerning cleanout and density are based on observations taken in commercial warehouses in 1960, as well as conversations with warehouse operators and cleaner men. They represent average conditions in the Willamette Valley.

Relative cleaning rates reflect average conditions of cleanout (percentage yield of clean seed from a given unit of field-run seed) as well as varietal differences which affect the rate at which the seed can be cleaned through a given set of machinery. Also, the rate is affected by the kind and amount of contaminants.

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1 In test storage, the bags must be stacked so that the person taking the analysis sample has access to each bag. A more compact stacking method is employed in holding storage.

2 These two operations may be done in reverse order when bags of seed are stored and handled on pallets.

Table 2. Characteristics of the Seeds which Affect the Cleaning Process

Kind of seed	Density[a]		Cleanout[b]	Relative cleaning rate[c]	Harvest season[d]		Proportion certified[e]
	Field run	Clean			Beginning date	Ending date	
	(pounds per bushel)		(percent)				(percent)
Annual ryegrass	24	24	90	1.00	Jul 15	Aug 15	0
Perennial ryegrass	24	24	90	1.00	Jul 8	Aug 8	90
Alta fescue	23	24	85	.77	Jul 1	Jul 25	70
Crimson clover	50	60	70	.77	Jun 25	Jul 15	40
Chewings fescue	17	20	75	.32	Jul 10	Aug 10	0
Red fescue	17	20	75	.33	Jul 15	Aug 15	80
Bentgrass	27	32	70	.35	Aug 20	Oct 1	85
Merion bluegrass	15	22	50	.14	Jul 15	Aug 15	60

[a]Average pounds per bushel.
[b]Average percentage yield of clean seed from the field-run input.
[c]Index based on survey results (3) and plant record data.
[d]Approximate.
[e]That which meets certification standards. Data are based on historical records of certification officials (7).

The dates given for harvesting seasons are approximate. Both beginning and ending dates would depend on weather conditions preceding and during the harvest period. The usual pattern of harvest for any particular seed is one which starts slowly, building up to a peak volume about midway in the season, and declines. It is assumed that the capacity of the receiving activity will need to be at least twice that required if the seed were received in an even flow throughout its harvest period.

The proportions of certified seed shown in the table are approximations based on historical records of certification officials. Certified seed requires more handling labor than noncertified, hence its inclusion as a factor affecting costs.

Estimation of Costs for Each Stage

Generally, costs can be separated into fixed and variable components. Variable costs are easily separated at each stage. There are some fixed costs which are peculiar to a single stage - these are ascertainable. However, there are other fixed costs common to two or more stages. The level of these joint costs is determined by the overall requirements of the several stages but are inseparable in any analysis of total costs for any stage.[1]

In order to obtain information on the physical requirements for inputs of the various stages, case studies were conducted in seed processing warehouses. In late 1958 and early 1959, the author conducted a survey of 70 seed processing warehouses in the Willamette Valley (4) (Figure 1). Information gained from that survey was used to select a smaller number of plants for more intensive study. Selection was based on methods used, annual volume, and kinds of seed processed. Cooperation was secured from 20 warehouses. Preliminary studies were made of the various stages in each plant. The purpose of the preliminary studies was to provide a basis for selecting the two or three plants which appeared to be achieving the greatest output per unit of input within a particular stage. Thus, a plant may have been selected for studies of its receiving setup, but further studies may not have been made of its cleaning or shipping stages. A total of 11 warehouses was selected, each of which had one or more unique methods of performing the requisite processing operations.[2] The plants are enumerated below with the operations studied.

1. Bulk receiving, hand trucks handling of clean seed.
2. Lift truck handling of clean seed (use of pallet dolly in carloading).
3. Bulk receiving, lift truck handling of clean seed (use of ramp to enter car in carloading).
4. Receiving field-run seed in bags.

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1 The same problem of joint costs exists when considering multiple product plants.

2 For the purposes of this study, "method" is defined as a particular way of performing an operation in seed handling and cleaning. It may therefore refer to crew organization, equipment used, or type of container in which the seed is stored or handled.

5. Cleaning and intermittent bagging (holding bin over bagging station).
6,7. Receiving field-run seed in pallet boxes, lift truck handling.
8. Cleaning and bagging chewings and red fescue, bent, crimson clover.
9. Cleaning and bagging, receiving field-run seed in bags.
10. Cleaning and continuous bagging (no holding bin over bagging station).
11. Pallet box receiving, bulk receiving.

Time and motion studies, work sampling studies, and production studies were conducted on the methods used at the various stages. In this way, input-output data, in terms of labor and equipment requirements per unit of output of seed, were derived for the methods. These requirements, or standards, have been published previously by the Oregon Agricultural Experiment Station (3).

The standards represent higher than average levels of efficiency which can be (and are) achieved in well organized, well managed plants. Since the standards apply to separate operations, they may be combined in various ways to form a synthesis of a total plant--a model of efficiency. When cost data are applied to these standards, the resulting models represent low-cost combinations of inputs. These are theoretical models and should not be identified with actual warehouses. Rather, they should be taken as indicative of what can be achieved under ideal conditions.

Components of Cost Estimates

Separation of seed processing operations into stages was convenient from the standpoint of obtaining the physical input-output data. Because of the problem of joint use of certain inputs by two or more stages, the cost estimates in this study are presented as estimates of total (for all stages) annual ownership plus operating costs of processing seed under specified conditions.

In general, ownership costs consist of depreciation, interest on investment, insurance, taxes, and maintenance. Operating costs include labor, fuel and power, lubricants, and variable repairs.

Annual Ownership Costs

Depreciation is calculated on a straight-line basis with no salvage value allowed. Useful life of the machinery and other facilities is based on estimates of warehouse operators and recommendations of equipment manufacturers.

Annual interest on investment is calculated as 3 percent of the replacement cost of the building or equipment. This amounts to about 5.5 percent on the average value of an item having a depreciable life of 10 years. Replacement cost includes purchase price f.b.b. the seed warehouse plus installation.

Insurance and taxes are each computed at 1 percent of the replacement cost annually. Fixed maintenance is calculated as 1.5 percent of replacement cost per year.

Variable Costs

Labor charges are assessed at the uniform rate of $1.75 per hour, except for temporary labor, whose rate is $1.50 per hour. The above rates are fairly representative averages for the industry, and include overhead charges for social security, pension plans, and employee compensation plans. Jobs have not been given a more detailed classification because of the overlapping of functions which occurs in most seed plants. For example, a cleaner man will normally spend a good deal of time at jobs other than tending the cleaning line and bagging clean seed.

Fuel, power and lubricant requirements are based on manufacturer's recommendations. Variable repairs are calculated at 5 percent of replacement cost per 1,000 hours annual operation of the equipment.

Basic Plant

In order to arrive at estimated annual processing costs, hypothetical plants were synthesized from the physical data. The models are presented in detail in the relevant sections on handling methods, volume-cost relationships, and product mixes.

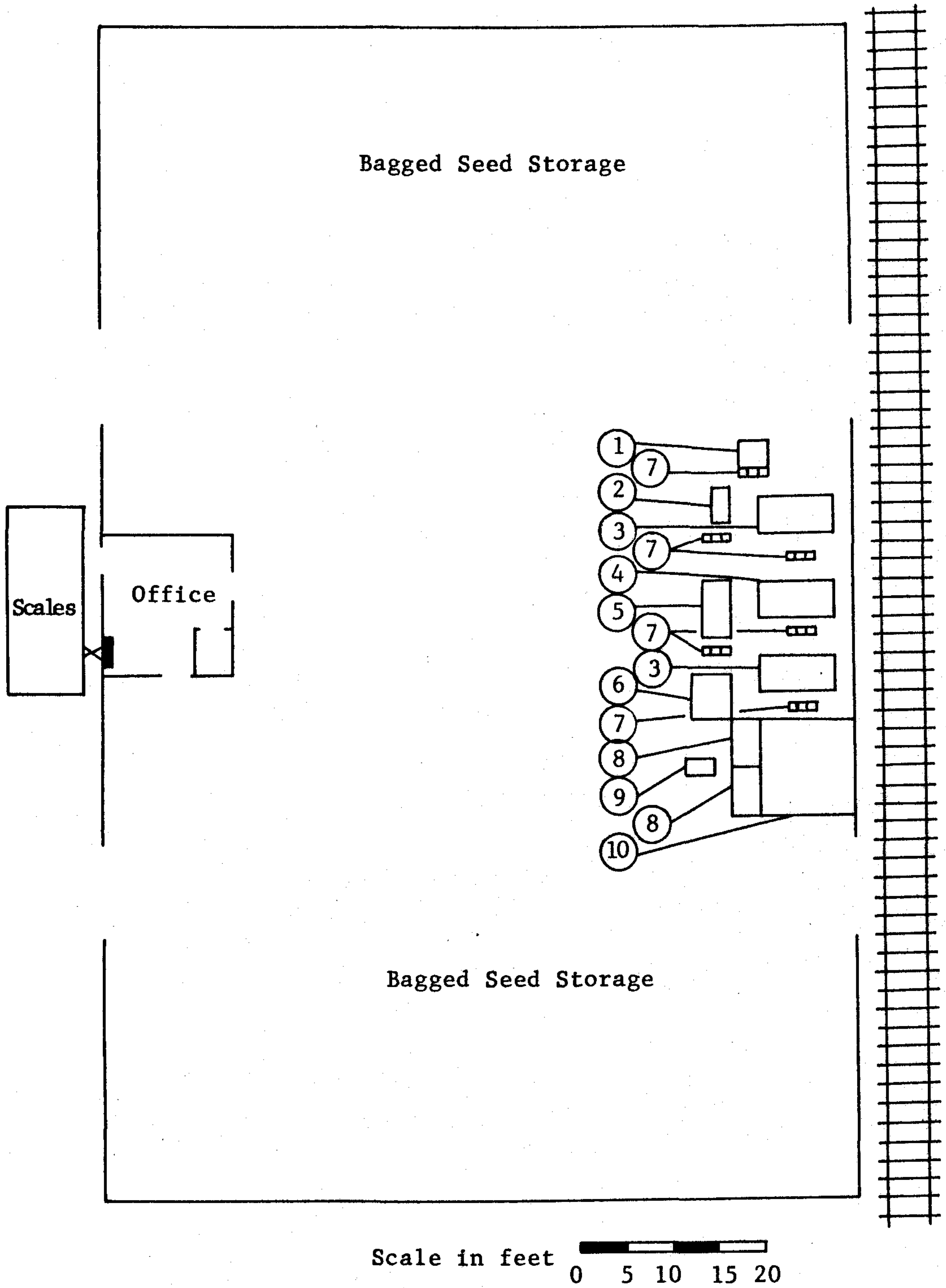
Physical requirements were determined for storage space for field-run and clean seed, handling equipment, and cleaning equipment. For a fixed output, storage requirements depend on method of handling the seed, the kind of seed, the conditions and seed characteristics presented in Table 2, and the amount of seed cleaned during the receiving period. Handling equipment requirements are dictated by method of handling and kind of seed.

The basic cleaning line used on all seeds is made up of an air-screen cleaner, an indent disc-cylinder separator, and another air-screen cleaner. Seed flow through these machines is in the order named. Auxiliary equipment, which may be utilized as required, includes a revolving screen (squirrel cage or rat-tail reel) used to remove rat-tail fescue (F. myuros) from ryegrasses; a debearder for bluegrass--also used to break up "doubles" in chewings and red fescues and bentgrass; and a specific gravity separator for use on bluegrass and crimson clover. Other special purpose machines, such as electrostatic and electromagnetic separators, have not been included, though they may be desirable in individual situations.

Seed flow between the above machines is by elevators and conveyors. Gravity flow is utilized where feasible. The cleaning line is designed as a single story installation (Figure 3).

The capacity of this line is assumed to be 1,250 pounds per hour when used on ryegrass seed. Capacities on the other seeds, in line with the relative cleaning rates presented in Table 2, are (in pounds per hour):

Figure 3. Layout of Seed Processing Warehouse, 1,000 Tons Annual Volume, Seed Handled by Hand Trucks (Method A).



KEY:

1. Floor hopper, 2' x 3' x 3', input to line
2. Debearder
3. Air-screen cleaner, four screens
4. Indent disc-cylinder separator
5. Rat-tail reel
6. Specific gravity separator
7. Elevator, 100 bu. per hour capacity
8. Clean seed bagging bins
9. Bag scales, 500 lb. capacity
10. Screenings bin

Alta fescue	962
Crimson clover	962
Chewings fescue	400
Red fescue	425
Bentgrass	438
Merion bluegrass	175

Because the cleaning line is a common element of all models, its estimated annual costs are presented in this section (Table 3).

Total investment in basic cleaning equipment is \$20,019.30. This includes conveyors, scales, sewing machines, and other items necessary to clean and bag the seed. It does not include special purpose separators and cleaners which are required for certain seeds. Depreciation, insurance, taxes, interest on investment, and maintenance combine for total annual fixed costs of \$3,300.55.

Hourly operating (variable) costs for this set of equipment amount to \$1.05396. Variable costs of the cleaning line may be more useful if put in terms of cost per unit of output of clean seed. This may be done by dividing the hourly cost by the number of units of output per hour. For example, the hourly output of ryegrass was assumed to be 1,250 pounds or .625 tons. Dividing \$1.05396 by .625, the cost per ton of ryegrass is found to be \$1.68634 for the basic line. To this should be added the costs incurred through use of the rat-tail reel ($\frac{\$.0175}{.625} = \$\ 0.28$) plus the cost of thread for closing the bags (estimated at \$.05 per ton) for a total of \$1.76434 per ton of clean ryegrass seed processed.

The basic cleaning line is the nucleus of all the cost estimation models. One cleaning line is budgeted for those models centered on 1,000 tons annual output. A second line is added for the models with an annual output of 2,500 tons, and a third for the 5,000 ton models.

SEED HANDLING METHODS

The definition of a seed handling method, as used in this report, depends on the means of conveying the seed from point to point within the warehouse. It also depends on the form or container in which the seed is transported. The following are in general use in Oregon warehouses:

1. Bagged seed handled with two-wheel hand trucks.
2. Bagged seed handled on pallets with fork-lift trucks.
3. Bulk seed handled by elevator and conveyor.
4. Bulk seed handled in pallet boxes with fork-lift truck.

In the warehouse, these can be intermingled and combined in several ways. The combinations listed below were considered in this study:

Table 3. Estimated Costs of the Basic Cleaning Line

Item	Number used	Replacement cost[a]	Annual ownership costs: Depreciation[b]	Other costs[c]	Total annual Operating costs	Operating cost per hour: Repairs[d]	Power[e]	Total
Air-screen cleaner	2	$8,000.00	$ 800.00	$ 520.00	$1,320.00	$.40	$ .15	$.55
Disc-cylinder separator	1	4,000.00	400.00	260.00	660.00	.20	.03	.23
Elevator 100 bu., 15', ½ hp.	5	2,240.00	224.00	145.60	369.60	.112	.025	.137
Elevator 50 bu., 15', ½ hp.	5	2,100.00	210.00	136.50	346.50	.105	.025	.130
Distributing pipe, 6"	100'	350.00	35.00	22.75	57.75	--	--	--
Valves, 2-way, 6"	5	150.00	15.00	9.75	24.75	--	--	--
Input hopper, 2'x 3'x 3'	1	25.00	1.67	1.62	3.29	--	--	--
Screenings bin, 1,000 bu.	1	30.00	1.20	1.95	3.15	--	--	--
Extra screens, discs and cylinders[f]	--	2,756.80	275.68	179.19	454.87	--	--	--
Associated equipment								
Sewing machine, portable, .4 hp.	1	300.00	30.00	19.50	49.50	.00529	.00167	.00696
Bag scales, 500 lb. cap.	1	67.50	6.75	4.39	11.14	--	--	--
Total for basic line	--	$20,019.30	$1,999.30	$1,301.25	$3,300.55	$.832	$.222	$1.05396
Auxiliary cleaners[g]								
Specific gravity separator	1	$4,500.00	$ 450.00	$ 292.50	$ 742.50	$.225	$.100	$.325
Rat-tail reel	1	150.00	15.00	9.75	24.75	.0075	.010	.0175
Debearder	1	1,486.00	148.60	96.59	245.19	.0743	.105	.1793

Footnotes on following page.

Table 3. (footnotes)

[a] 1960 prices, estimated from equipment dealers catalogs, tax assessors' files, and warehouse records. Includes installation.

[b] Based on useful life: 10 years for cleaning machinery and conveying equipment; 15 years for input hopper, and 25 years for screening bin.

[c] Includes the following percentages of replacement cost: interest 3 percent; taxes and insurance, 1 percent each; maintenance 1.5 percent.

[d] Calculated at .005 percent of replacement cost per hour of operation.

[e] Electricity cost calculated at 1 cent per horsepower per hour of operation.

[f] Fifteen extra screens for each air-screen cleaner, at $28.56 per screen; 2 extra sets of discs at $500 each and 2 extra cylinders at $450 each for the disc-cylinder separator.

[g] Specific gravity separator used only on crimson clover and Merion bluegrass; rat-tail reel used only on annual and perennial ryegrass; debearder used only on chewings and red fescue, bentgrass and Merion bluegrass.

A. Field-run seed and clean seed handled in bags by two-wheel hand trucks.
B. Field-run and clean seed handled in bags on pallets by fork-lift truck.
C. Field-run seed handled in bulk by elevators and conveyors; clean seed handled in bags by hand truck.
D. Field-run seed handled in bulk; clean seed handled in bags on pallets by fork-lift truck.
E. Field run seed handled in pallet boxes by fork-lift truck; clean seed handled in bags on pallets by fork-lift truck.

These combinations are termed "handling methods" for convenience in presentation.

The various operations included in each of the five handling methods are described below. Rates of output for the operations will be different depending on crew size, equipment used, and plant layout. The description and analysis which follows is based on the capacity rates given in Appendix Tables 1 to 4.

Description of Seed Handling Methods

Method A: Field-run and Clean Seed Handled in Bags by Two-Wheel Hand Truck

Field-run seed is delivered to the warehouse in bags on trucks, 150 bags per truck. At the receiving dock, a five-man crew unloads the bags and transfers them to temporary storage. It is assumed that the bags will be placed in 20-high piles, about 400 to 500 bags per pile, with the use of a belt-type, portable elevator. Three men operate hand trucks, carrying five bags per load. Each hand-truck operator sets his load off on the elevator, one bag at a time. Two men on top of the pile take the bags off the elevator and place them into position on the pile.

When the seed is to be cleaned, bags are broken out of the piles and transferred to the cleaning line. There they are opened and emptied into a floor hopper, from which the seed is elevated to the cleaning line. After it is processed through the appropriate machines, it flows into burlap or cotton bags. Net weight of the seed in the filled bags is 100 pounds for all seeds except Merion bluegrass. It is packed to a net weight of 50 pounds because of its bulk. The bags are closed by means of a hand portable electric stitcher.

The bags are placed on hand trucks and trasferred to test storage where they are placed into rows of 5-high piles so that the seed tester has access to each bag. If the seed sample meets minimum legal quality standards, the seed may be shipped or transferred to 20-high piles for later shipment. If the sample fails to meet the standards, it may be reprocessed, or it may be held for blending with a seed lot which exceeds the standards. In this report, it will be assumed that all seed lots meet or exceed the standards so that no reprocessing or blending is required.

At the time of shipment, an analysis tag is attached to each bag of seed. If it is certified seed, a certification tag is attached also. In some Oregon counties, this tag is affixed by certification officials. In others, it is affixed by warehouse labor. Labor charges for attaching certification tags will be included for seed which meets certification standards. (Table 2)

As mentioned above, the seed may be shipped from test storage or from holding storage. Shipment from holding storage involves an extra movement of the seed, but this must be balanced against the greater storage space requirements of test storage. For simplicity, it will be assumed here that half the seed is moved into holding storage prior to shipment, with the remainder being shipped directly from test storage. Seed shipped from test storage can be pretagged with the analysis tag (and certification tag when needed) before the actual shipping operation. Seed that is placed in holding storage and then shipped is tagged during the loading operation to prevent loss of tags during movement and handling of bags. Pretagging requires less labor time than tagging during loading.

Pretagged bags are moved directly from test storage into the rail car by hand truck. Inside the car, a small sack elevator is used to assist in piling the bags high enough to fill the car. The elevator is set up three times in each end of the car, once for each tier of sacks. The door or center section is filled last, with the top bags thrown up by hand.

Bags in holding storage are broken out of the piles and moved by hand truck to an intermediate tagging station. There the hand truck operator affixes the tags and moves the seed into the rail car. From this point, loading proceeds as above.

Method B: Field Run and Clean Seed Handled in Bags on Pallets by Lift Truck

Field-run seed is received in bags on farm trucks. At the warehouse it is transferred to pallets, which are then transferred to storage.[1] The use of pallets and lift truck represents an additional investment over Method A, but crew sizes, and thus the total labor bill, are reduced. Storage space requirements are also reduced when palletized seed is stored three or four pallets high.

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[1] A pallet is a four foot by five foot double-faced two-way entry wooden device on which the bags of seed are stacked for transportation or storage. The lift truck picks up the pallet with the stack.

All movements of bagged seed in the warehouse is by pallet and lift truck. Clean seed in test storage is placed two pallets high with clearance on all sides for the seed tester. Clean seed in holding storage is four pallets high, with access aisles so that the lift truck operator does not have to penetrate more than four pallets deep within a row.

Labor and equipment requirements for this method and Methods A and C are based on a warehouse having a floor height level with the floor in a rail car. This provides for ease of entry into rail cars for shipment.

All sacks may be pretagged before loading when seed is moved on pallets, because the individual sacks are not handled and loss of tags is minimized. The pretagged seed is moved directly into the rail car on the pallet. Bags are transferred by hand from the pallet. An elevator is not required to place the upper layers in the tiers under this method, as the pallet height is governed by the lift truck.

Method C: Field-Run Seed Handled in Bulk by Elevator and Conveyor, Clean Seed Handled in Bags by Hand Truck

This method differs from Method A only in the handling of field-run seed, which is delivered in bulk on highway trucks. The average truck load is 400 bushels - this figure has been used in computing labor and equipment requirements and costs.

After being weighed and recorded, the seed is dumped from the truck into a hopper set in the ground. Dumping is accomplished by raising the front end of the truck in a cradle hoist to approximately a 40-degree angle with the ground. Infrequently a grower will have a dumping mechanism installed on his truck bed. Those who have a self-dumping truck feel that the extra expense is offset by avoiding the wear and tear on the truck frame and motor mounts caused by the cradle-hoist method. Self-dumping is also quicker than cradle-hoist dumping.

A third dumping method, not observed in Oregon, is worthy of consideration. It is utilized in other areas, e.g., to receive rice at commercial dryers in Texas, Arkansas, and Louisiana (8). It is termed "hook-hoisting." The truck bed is hinged at the rear, and fastened at the front with a latch. Hooks on either side of the front of the truck bed are engaged by a hoist to raise the bed to the required angle of elevation. This method requires less labor time and less heavy machinery, and also is not as hard on the trucks as cradle hoisting. "The cost of adapting a farm truck to this method is much less than for the self-dumping method" (8, p. 3).

In the study cited, the computed costs to the dryer for receiving an annual volume of 2,000 truck loads of rice by the three methods were:

Method	Cost per Truckload
Self-dumping	$1.64
Hook hoisting	1.77
Cradle hoisting	1.81

Comparable cost figures are not available for seed processing warehouses, but the three methods would be expected to bear the same cost relationship to one another even if the level of costs were different. Because of the lack of data, only the cradle-hoisting method was considered here.

The receiving setup includes a receiving hopper large enough to hold the average load - 400 bushels. It is assumed that the hopper is double-hoppered, i.e., tapered from the sides and one end to the exit gate at the outlet end. The elevator entrance is positioned next to the hopper outlet to eliminate a difficult-to-clean conveyor.

The bulk seed is elevated to a spout selector controlled from the dumping area. From here it is directed to the various bulk bins. The bins, constructed of low-grade, laminated 2" x 4" and 2" x 6" dimension lumber, have hoppered bottoms for ease in cleaning. From the bins the seed is directed by conveyors and elevators to the cleaning line. From this point the procedure is as described under Method A above.

Though the bulk receiving method required additional expense in machinery and facilities over the two methods described above (A and B) crew size is reduced to one pit man. The weighmaster is eliminated by having the receiving hopper set into the truck scales and having the pit man perform the weighing and recording.

Method D: Field-Run Seed Handled in Bulk by Elevators and Conveyors, Clean Seed Handled in Bags on Pallets by Lift Truck

This method is essentially the same as Method C above except that the clean seed is transported by lift truck rather than hand truck, and the warehouse is assumed to be at ground level rather than car level.

A ground level plant requires a variation in loading method from a car level plant. A concrete ramp may be used to enter the car, or a pallet dolly may be used inside the car.[1] The ramp method will be utilized in this analysis. Labor requirements are about 10 percent lower (7.54 man-hours per 1,000 bags for the ramp method, versus 8.36 for the pallet dolly). The extra cost of the ramp method over the pallet dolly is offset by this labor advantage at an annual volume of about 2,500,000 pounds of clean seed. Below that volume the pallet dolly method becomes the more economical based on total direct and indirect labor costs of $1.75 per hour (at lower wage rates the break-even volume is correspondingly higher).[2]

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1 A pallet dolly is a small platform with casters used to move the pallets.

2 The annual cost of the ramp is $42; that of the pallet dolly is $6.60. To compute the break-even volume for the two methods at different wage rates, use the formula:

$$x = \frac{\$42.00 - \$6.60}{.82\ w},$$

where x is the break-even volume, w is the labor cost in dollars, and .82 is the labor time differential between the two methods.

Other than the use of the ramp, car loading is as described above under Method B.

Method E: Field-Run Seed Handled in Pallet Boxes by Lift Truck, Clean Seed in Bags on Pallets Handled by Lift Truck

Pallet boxes used in Oregon are usually of plywood construction built upon a two-way entry pallet. Three sizes are in general use: 4' x 4' x 4', 4' x 6' x 3', 4' x 6' x 4'. The largest size is preferable for grass seeds and the smallest for legume seeds. The intermediate size proves useful for grass seeds in plants with less than 4,000 pound capacity lift trucks.

When field-run seed is delivered in pallet boxes, the weight of seed and number of boxes are recorded and the boxes are removed to storage under a pole type shed. Empty boxes are then placed on the truck for the next load.

At cleaning time, the boxes are moved to the cleaning line and dumped by means of an inversion type mechanical dumper; the seed flows into a hopper and thence into the cleaning line. Clean seed handling and shipping are identical with the other methods utilizing lift trucks.

Comparative Costs of Seed Handling Methods

Cost estimates were developed for three levels of annual volume - 1,000, 2,500, and 5,000 tons of clean seed. Within these volume levels, estimates are presented for five handling methods as applied to annual ryegrass. The procedures used in arriving at estimated costs for these models are presented below.[1]

Labor and equipment performance standards developed under this project and previously published (3) were used to establish a physical basis for the cost estimates. Prices were then applied to the equipment items to determine the investment in fixed factors. Ownership costs, on an annual basis, were computed from depreciation schedules. Ownership or fixed costs also include interest on the investment, taxes, insurance, and maintenance. Appendix Table 5 presents the equipment items and their prices, as well as the ownership and operating costs. Variable or operating costs include fuel or power costs and repairs.

To illustrate the procedures, cost computations will be presented for Method A at the 1,000 ton volume level (Table 4). The optimum crew size of five (optimum in the sense that a larger or smaller crew cannot handle as much seed per man-hour) was assumed for receiving field run seed and for shipping of clean seed. It was assumed that the receiving season would extend from about July 10 to around August 25, approximately 40 working days or 400 hours. Since the receiving crew must be on hand during the full

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1 Cost estimates developed for each handling method for various product mixes are given in the original thesis (2).

Table 4. Calculation of Annual Costs for a Seed Processing Warehouse Handling 1,000 Tons Annual Ryegrass per Year by Hand Truck (Method A)[a]

Item	No. used[b]	Total replacement cost	Annual ownership costs	Annual operating costs	Total annual cost
Truck scale	1	$ 6,026.00	$ 692.99	$ --	$ 692.99
Hand trucks	10	500.00	82.50	--	82.50
Dock plate	2	100.00	16.50	--	16.50
24' Sack elevator, 3 hp.	2	3,200.00	528.00	90.40	618.40
10' Sack elevator, 1 hp.	1	850.00	140.25	8.56	148.81
Warehouse (sq. ft.)	10,000	22,500.00	2,362.50	--	2,362.50
Cleaning line	1	20,169.30	3,325.30	1,764.34	5,089.64
Handling labor (hrs.)	2,385	--	--	3,609.00	3,609.00
Cleaning labor (hrs.)	1,600	--	--	2,800.00	2,800.00
Subtotals--------	--	$53,343.30	$7,148.04	$ 8,272.30	$15,420.34
Misc. and overhead 10%	--	--	714.80	827.23	1,542.03
Total------------	--	$53,343.30	$7,862.84	$ 9,099.53	$16,962.37
Cost per ton	--	--	7.86	9.10	16.96

a From Appendix Table 1.

b Based on the following: five-man receiving crew, 40 days or 400 hours; one man on cleaning line; four-man crew on car loading (included in handling labor); cleaning line, capacity 1,250 pounds clean seed per hour, operates 1,600 hours; warehouse space for half the total annual volume of clean seed, or for the amount of field run seed not cleaned during receiving, whichever is larger, plus 800 square feet used by cleaning line.

receiving period, a total of 2,000 man-hours is charged to receiving. During slack hours in receiving this crew is available for warehousing and shipping of the clean seed after the receiving period.

A cleaning line with a capacity of 1,250 pounds clean ryegrass seed per hour was assumed to operate 16 hours per day until about October 1, and eight hours per day thereafter, for a total of 1,600 hours. One man can tend the cleaning line and move seed out of and into storage.

The amount of seed cleaned during the receiving period is 800,000 pounds or 400 tons (1,250 pounds per hour times 16 hours per day times 40 days). Hence, storage space is required for 600 tons. On the basis of 26.12 sacks field run seed per ton of clean seed, and .585 square feet per bag in 20-high piles, this is 9,168 square feet, rounded to 9,200. Allowing 800 square feet for the cleaning line and bagging equipment, the total warehouse space is 10,000 square feet.

Two 24-foot sack elevators for making and breaking 20-high piles, one 10-foot sack elevator for use in carloading, ten hand trucks and two dockplates complete the equipment requirements. These last equipment items were also used in the models for Method A at 2,500 and 5,000 tons annual volume. The major changes in the model to accommodate the higher volume level were in storage requirements, hours operated, and the addition of a cleaning line and a cleaner man for each step up in plant size.

Computing annual costs was the next step in the procedure. Ownership and operating costs were used from Appendix Table 5. Operating costs shown in that table are on an hourly basis. Thus it was necessary to calculate the number of hours each item was in operation. This was done by taking the appropriate labor standard (or standards, if the items were used in more than one operation), and putting it on the basis of hours per ton of cleaned seed. Multiplying by total volume handled and then by the hourly cost yields the annual operating cost for that item. When machinery was used to handle field run seed, the volume of clean seed was converted to a field run basis by dividing by the appropriate clean-out percentage.

After finding a total for ownership and operating costs, an allowance of 10 percent of this total was added. This allowance includes land charges and miscellaneous tools and supplies.

The above procedures were followed for each handling method for the three volume levels.

There is relatively little difference in cost per ton of clean seed among the five methods at any of the three volume levels (Table 5). This suggests that handling method is relatively unimportant as a decisive factor in processing costs. Before accepting this conclusion, it is desirable to investigate more closely the composition of these cost estimates.

Handling and Cleaning Components

The ownership and operating costs for the five methods were broken down into handling and cleaning components at the three levels of annual volume (Table 5).

Table 5. Ownership and Operating Cost Components of Handling and Cleaning Costs per Ton for Specified Volumes of Ryegrass Seed, for East of Five Handling Methods

Method of handling	Cost component	1,000 Tons			2,500 Tons			5,000 Tons		
		Handling	Cleaning	Total	Handling	Cleaning	Total	Handling	Cleaning	Total
					(Dollars per ton clean seed)					
A	Ownership	4.20	3.66	7.86	2.20	2.93	5.13	1.87	2.20	4.07
	Operating	4.08	5.02	9.10	1.77	5.02	6.79	1.11	5.02	6.13
	Total	8.28	8.68	16.96	3.97	7.95	11.92	2.98	7.22	10.20
B	Ownership	4.38	3.66	8.04	2.14	2.93	5.07	1.97	2.20	4.17
	Operating	3.12	5.02	8.14	1.54	5.02	6.56	1.04	5.02	6.06
	Total	7.50	8.68	16.18	3.68	7.95	11.63	3.01	7.22	10.23
C	Ownership	7.39	3.66	11.05	4.71	2.93	7.64	2.67	2.20	4.71
	Operating	1.25	5.02	6.27	.74	5.02	5.76	.28	5.02	5.59
	Total	8.64	8.68	17.32	5.45	7.95	13.40	2.95	7.22	10.30
D	Ownership	7.98	3.66	11.64	4.84	2.93	7.77	2.67	2.20	4.87
	Operating	.98	5.02	6.00	.45	5.02	5.47	.28	5.02	5.30
	Total	8.96	8.68	17.64	5.29	7.95	13.24	2.95	7.22	10.17
E	Ownership	7.46	3.66	11.12	5.99	2.93	8.92	2.93	2.20	5.13
	Operating	.48	5.02	5.50	.20	5.02	5.22	.21	5.02	5.23
	Total	7.94	8.68	16.62	6.19	7.95	14.14	3.14	7.22	10.36

Cleaning costs per ton are constant for all methods within a given volume level, because all methods use the same cleaning line. The diminution of cleaning cost from one volume level to the next highest is entirely due to spreading of ownership costs over more units, since operating costs per ton do not change with volume.

Since cleaning costs per ton are constant between methods for a given annual volume, differences in total annual costs are due entirely to differences in handling costs.

Consideration of Convenience and Timing

There are other considerations, however, which are not reflected in the cost estimates presented here. For instance, the greater part of the variable costs in Method A are labor costs. The actual quantity of labor needed is 3,600 man-hours for the 1,000 ton plant, 6,000 man-hours for the 2,500 ton plant, and 10,000 man-hours for the 5,000 ton plant. This labor demand is seasonal and is no longer in dependable supply in Oregon nor in other areas.

From the standpoint of seed growers, Methods A and B may both be rejected. Present day large scale seed producers need handling methods which will permit them to harvest their crop and transfer it to the processing plant with a minimum of delay. Producers are also faced with a seasonal labor shortage. These and other considerations are prompting the trend to bulk handling in the field and in field to plant transportation. To provide their customers with the fast efficient service they need and want, commercial processors are having to change to bulk handling methods in their receiving setups.

Time and labor considerations, as well as convenience, have caused growers who operate their own processing facilities to change to bulk handling methods. The use of bulk facilities enables an individual operator to perform all or most of his own field run seed handling chores and thereby reduce cash costs for hired labor. (The question of economic efficiency in grower-operated seed warehouses will be explored in a later section.)

Of the three bulk handling methods (C, D, E), Method E cannot compete on a cost basis except at the lowest volume level considered. In an analysis presented before the Oregon Seed Processor's Short Course in 1961, it was demonstrated that pallet box receiving of ryegrass is lower in cost than bulk receiving up to about 1,625 tons of clean seed annually (1). The comparison there was only for receiving and storing the field run seed. Inclusion of costs for other warehousing operations, as in the present study, might change the break-even volume. However, since Methods C and D have very similar cost estimates, and Methods D and E utilize the same crew organization equipment for clean seed handling, it is doubtful that the break-even volume is greatly changed.

VOLUME-COST RELATIONSHIPS

Seed processors are vitally interested in volume-cost relationships both from a long-range and short-run point of view. The long-range aspects are considered first in deference to the fact that they are important in plant design - that is, in selecting or attempting to achieve an optimum scale of output or plant size (optimum in the profit maximizing sense). The discussion here will center around the models developed for Method D at the three specified volume levels (See Table 5).[1]

Long-Range Volume-Cost Relationships

Hourly output rates are not based on total annual volume. Output rates for handling operations are based on work sampling and time studies. The cleaning line output is based on representative equipment items and average seed conditions. One basic cleaning line was budgeted for the 1,000 ton plant. By synthesizing several models, it was found that lower cost estimates resulted when two rather than one or three lines were budgeted for the 2,500 ton plant. For the 5,000 ton plant, three lines provided lower cost estimates than either two or four lines.[2] This in no way changes the conclusions to be drawn from the reduction in cost per ton as volume increases, illustrated in Table 5. The reader is cautioned that the construction of the models is such as to prevent interpolation of costs at intermediate points.[3]

The data in Table 5 indicate that the 5,000 ton level of annual volume does not exhaust all possible economies to size. However, most economies to size are evidently exhausted in the move from 1,000 tons to 2,500 tons. Further reductions in unit costs could very well be possible at volumes greater than 5,000 tons, though costs were not estimated at larger volumes, for several reasons. One of the most important reasons is that the 5,000 ton plant is larger than any encountered in Oregon. Secondly, the geographical pattern of seed production in the state is such that some difficulty might be experienced in accumulating larger volumes. Concurrent with this is the fact that, of the crops considered, only the ryegrasses are in sufficient supply to warrant such a large plant. Also, the large number of grower-operated warehouses would tend to make it difficult for a larger plant to attract sufficient customers to supply its seed requirements.

Short-Run Volume-Cost Relationships

Once the decision as to plant size has been made, the processor is concerned with the short-run aspects of the volume-cost relationships. Here, consideration must be given to historical trends and fluctuations in seed

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1 The volume-cost relationships for the other product mixes are given in the original thesis (2).

2 The question of optimum capacity of the cleaning line within a fixed plant is different from the long-range viewpoint expounded here.

3 For an interesting and detailed discussion of this point, see Hutchings' unpublished Ph.D. thesis (5, pp. 177-182).

production. A warehouse processing a single product is particularly vulnerable to year-to-year variations in annual volume.

An illustration of the effect of variations in annual volume from the optimum is provided by the examples below. First, consider a warehouse designed for 1,000 tons, using Method D. Using the data in Table 5, ownership costs are $11,641.44 and operating costs are $6,003.51 or a total of $17,644.95. If volume in any year fell 10 percent to 900 tons, operating costs would be reduced to $5,480.17 but ownership costs remain the same, so that total costs become $17,121.61. Dividing this sum by 900 tons, total cost per ton is found to be $19.02, versus the original $17.64 if 1,000 tons were processed. The percentage increase in total cost is found to be 7.4 percent. In almost any industry, this could be the difference between profit and loss from that year's business. A warehouse manager can calculate his own total annual cost by listing the annual operating costs in a table like Appendix Table 6.

Now consider the opposite case, where volume increases above that for which the warehouse was designed - 1,000 tons, using Method D. Again, the original situation is $11,641.44 ownership costs and $6,003.51 operating costs for a total of $17,644.95. If total volume were to increase to 1,100 tons, total operating costs would be $6,526.86. Ownership costs could not be held at the same level $11,641.44 because storage facilities are designed to handle only 1,000 tons. Additional storage must be provided. This could mean construction of additional facilities, either permanent or temporary. Construction of permanent facilities could only be justified if the warehouse operator considered the increase a permanent one. A warehouse manager could calculate his own total annual cost by listing both the annual ownership and annual operating costs in a table like that illustrated in Appendix Table 6.

An alternative solution would be to sack the extra field run seed at the warehouse, a common practice in Oregon warehouses. This involves additional labor, construction and maintenance of sacking facilities, and either rental of additional bagged seed storage or overcrowding of existing facilities. Just the extra labor amounts to $1.65 per ton of seed handled in this way.[1]

Even without budgeting costs for sacking facilities or additional storage, the evidence is sufficient to indicate that volumes higher than the optimum (for which the plant was designed) cause costs per ton to be higher than for the optimum volume. Since it was also shown that costs per ton are higher for volumes less than optimum, it is obvious that annual volume is a critical factor in the short run. One means of protecting income from diminishing under such conditions would be for the processor to utilize methods which have a high proportion of operating costs to ownership costs. A cursory inspection of Table 5 reveals that of the five methods analyzed there, none has that characteristic at the lowest volume level. At the intermediate volume level (2,500 tons) only Method A has higher operating costs than ownership costs. Methods A, B, C, and D, exhibit this characteristic at the 5,000 ton level. Even here, the operating costs represent only 52 to 55 percent of the total annual costs.

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[1] Based on a labor requirement of .865 man-hours per ton for packing and placing the seed in storage at the warehouse, and .236 man-hours per ton for removing it from storage and transferring it to the cleaning line, with labor at $1.50 per hour.

Since the ratio of ownership to operating costs for a seed plant offers little income protection from variations in annual volume, some means must be sought to protect against volume variations. Other than contractual arrangements with growers, the most obvious solution is to operate a multiple product plant. Different varieties of seeds rarely fluctuate in production simultaneously in magnitude and direction. Thus deviations in production of one seed crop would be expected to be offset by other seeds, in terms of annual volume coming to the warehouse. The next section of this report elucidates this theme.

PRODUCT MIX AND COST RELATIONSHIPS

It is apparent that product mix in multiple product plants is not necessarily an independent decision on the part of management. Seed production follows certain geographical patterns of adaptation, including climatic factors. Even within a major seed producing region such as the Willamette Valley, certain seed crops tend to become localized.

Within the context of local production patterns, however, managers do have the option of varying their product mix if they so desire. Once they have established the kinds of seed they will handle, they have another set of strategies to consider. One strategy would be to solicit a group of customers and accept passively the yearly fluctuations in volume caused by production shifts and changes due to climatic and other conditions. Another strategy would be to focus on a predetermined volume level, and accept or refuse customers on this basis. The latter strategy may be more appealing from the standpoint of its effect on processing costs, in view of the high proportion of fixed costs in seed processing. However, it may not be feasible from the standpoint of customer relations and long-term operations. Other strategies might revolve around selection of products on a continuous basis to take advantage of production fluctuations. All these strategies provide some degree of flexibility in plant operation. This is always desirable, but flexibility generally is available only at some expense.

The organization of processing in multiple-product seed plants is generally around a constant mix in terms of the kinds of products processed, with the proportions of the seeds varying from year to year.[1] The various commodities are handled and processed with the same or slightly altered facilities in separate time periods. When this is so, products may be added with relative ease, sometimes requiring only an additional small investment in special separating machines.

Product Mix and Annual Costs

Several models were synthesized to demonstrate the interrelationship of product mix and annual costs. The basic construction of these models is that explained in the section on volume-cost relations. Physical requirements

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1 Processing more than one product with the same facilities brings up the problem of allocating between the products their fair shares of common or joint costs. Any such allocation is arbitrary to some degree.

were budgeted and prices applied. The basic model was arbitrarily selected as a plant specializing in cleaning annual ryegrass. Any other commodity could have been selected. However, there are existing plants which are similar to the basic plant in volume and specialization.

The second model considered equal proportions of annual and perennial ryegrass, since the two are so similar in handling characteristics. Alta fescue, crimson clover, chewings fescue, red fescue, bentgrass, and Merion bluegrass were then introduced into the model, one at a time. Total volume, within any one volume level, was held constant. Each new seed which entered in after perennial ryegrass, was introduced at a volume which represented 10 percent of the total volume of the model. The proportions of each seed for eight product mixes considered are shown in Table 6.

The analytical procedure was followed for all five handling methods at three volume levels. When a new seed was entered into the model, the physical requirements were altered according to whether that seed took more or less of a particular input than the ryegrass it replaced. Labor requirements and operating hours were adjusted to conform to the new product mix. Cleaning line capacities, storage facilities, and special equipment requirements were also considered.

Storage Facilities

The additions of alta fescue and crimson clover to the basic model required no increase in field run storage facilities. This is true because their harvesting seasons are earlier than ryegrass and thus the original storage facilities suffice. It was assumed that these two seeds are marketed in early summer so that no conflict arises in clean seed storage facilities.

The overlapping of ryegrass cleaning season and fine fescue receiving season requires that additional storage be added when chewings and red fescue are entered into the model. Storage requirements are further increased by the additions of bentgrass and Merion bluegrass.

Storage requirements may be estimated by the following formula:

$$W = (T_r - T_c)\ S,$$

Where W is the warehouse space required; T_r is the tons of a particular seed received (clean basis); T_c is the tons (clean basis) of a particular seed cleaned during the receiving season; and S is the storage requirement per ton of seed (Table 7).

Cleaning Line Capacities

The effect of different output capacities for the various seeds was to lengthen the operating season for the cleaning line. This is so because ryegrasses have a higher output rate than any of the six other seeds considered (Table 2). The increase in total cleaning hours would have been even greater had the total volume been increased by the amount of each seed added, rather than being held constant.

Table 6. Product Mix Proportions Used in Estimating Costs for Multiple Product Seed Processing Plants

Kind of seed	Product mix							
	1	2	3	4	5	6	7	8
	(Percentage of total volume)							
Annual ryegrass	100	50	45	40	35	30	25	20
Perennial ryegrass	--	50	45	40	35	30	25	20
Alta fescue	--	--	10	10	10	10	10	10
Crimson clover	--	--	--	10	10	10	10	10
Chewings fescue	--	--	--	--	10	10	10	10
Red fescue	--	--	--	--	--	10	10	10
Bentgrass	--	--	--	--	--	--	10	10
Merion bluegrass	--	--	--	--	--	--	--	10
Totals	100%	100%	100%	100%	100%	100%	100%	100%

Table 7. Total Storage Requirements per Ton of Clean Seed Output for Specified Seeds and Five Handling Methods.[1]

Kind of seed	Method of handling				
	A	B	C	D	E
	sq. ft.	sq. ft.	bu.	bu.	boxes
Annual ryegrass	15.28	9.80	92.6	92.6	1.39
Perennial ryegrass	15.28	9.80	92.6	92.6	1.39
Alta fescue	16.24	10.41	102.2	102.2	1.48
Crimson clover	18.57	11.90	57.1	57.1	1.24
Chewings fescue	20.74	13.30	156.9	156.9	2.67
Red fescue	20.74	13.30	156.9	156.9	2.67
Bentgrass	22.31	14.30	105.8	105.8	1.40
Merion bluegrass	39.08	25.05	222.2	222.2	4.44

1 Based on the data in Table 2 above, and material in Reference 3, Tables 1 and 2, Page 5.

An upper limit of 6,000 machine hours per year was placed on the cleaning season. This is less than the total number of hours in a year (8,760), but it allows for holidays, vacations, and unpredictable breakdown of the machinery. This 6,000 hour maximum was not limiting to the product mixes, except at the 5,000 ton level of annual volume. When Merion bluegrass was added to the product mix, the cleaning season extended to 6,045 hours. The excess was charged to Merion bluegrass at the rate of $2.63 (time and one-half) per man-hour. The product mix could have been altered as to the proportions of the various seeds, but the results would not then have been consistent with the other models.

The optimum product mix to utilize all available hours in the cleaning season, within the constraints of available storage, receiving facilities, and other considerations can be solved for the individual warehouse, given the costs and returns structure for that warehouse. More general solutions are possible, but convey little information of value to the industry. Hence, they are not attempted here.

Special Cleaning Equipment

In addition to adjustments in operating hours to correspond to differences in cleaning rates of the various seeds, the cleaning facilities were modified by the addition of special purpose machines. Alta fescue requires no additional machines. Crimson clover requires the addition of specific gravity separation machinery. A debearder for each cleaning line was added to use on chewings and red fescue to break up "doubles." Doubles are two or more seeds which remain attached to each other and would be rejected from the clean seed if not separated. Merion bluegrass utilizes the specific gravity separator(s) and the debearder(s) in addition to the regular line.

Multiple Product Processing Costs

Seeds were added to the initial single-product plant in ascending order in terms of their processing cost per ton. That is, if each seed were processed in a single-product plant, alta fescue would be more expensive to process than ryegrass, crimson clover would be more costly than alta fescue and so forth. Differences in processing costs between the various seeds are caused by several factors. Among these are: different densities; different shapes; differences in texture of seed coat; difference in kind and amount of contaminants. All these affect handling characteristics and therefore labor and equipment requirements and cleaning capacity on a given set of machinery.

Cost estimates were computed for each of eight product mixes at the three volume levels - 1,000, 2,500, and 5,000 tons (Table 8). This procedure was followed for each of the five handling methods discussed.

From Table 8 it can be seen that Method B is the least costly for all product mixes except mix 4 at the lowest volume level. When volume is increased to 2,500 tons, Method B becomes the least costly for all product mixes.

Method D becomes the least costly method of handling seed in all product mixes at the 5,000 ton level of annual volume.

Table 8. Estimated Total Annual Cost per Ton of Clean Seed Output for Various Product Mixes at Specified Annual Outputs, by Seed Handling Methods

Annual volume (tons)	Handling method	Product mix[a]							
		1	2	3	4	5	6	7	8
		(Dollars per ton clean seed output)							
1000	A	16.96	16.97	17.53	18.98	20.94	22.53	24.08	28.82
	B	16.18	16.21	16.61	17.90	19.66	21.07	22.49	26.85
	C	17.32	17.35	17.62	18.78	20.50	21.96	23.14	27.52
	D	17.64	17.66	17.91	19.05	20.75	22.19	23.36	27.71
	E	16.62	16.63	16.78	17.60	19.78	21.42	23.02	28.79
2500	A	11.92	11.95	12.44	13.66	14.92	15.94	16.89	19.56
	B	11.63	11.66	12.08	13.28	14.52	15.48	16.46	19.31
	C	13.40	13.43	13.67	14.63	15.88	16.88	17.74	20.93
	D	13.49	13.50	13.73	14.69	15.94	16.91	17.77	20.96
	E	14.14	14.14	14.29	14.64	15.99	17.06	17.98	21.33
5000	A	10.20	10.23	10.56	11.44	13.10	14.39	15.63	19.67
	B	10.23	10.26	10.54	11.38	12.91	14.18	15.42	19.48
	C	10.30	10.33	10.54	11.29	12.95	14.49	15.85	19.94
	D	10.17	10.18	10.37	11.13	12.79	14.20	15.56	19.66
	E	10.36	10.36	10.51	11.16	13.12	14.76	15.91	20.28

[a] Proportions of the various seeds in each product mix are given in Table 6.

It will be noted that the cost spectrums for product mix 8 at level three overlap those at level two. This is true since overtime charges were needed in order to process 5,000 tons of these seeds within the limit of a 50 week maximum cleaning season.

SUMMARY AND CONCLUSIONS

The purpose of this study was to develop data relating to comparative costs of different handling methods, annual volumes, and product mixes in seed processing warehouses. The procedure was to synthesize cost estimates from economic and engineering data obtained through time and motion studies, work sampling, production studies, and plant record data. Supporting data were obtained through interviews with plant managers, building contractors, equipment salesmen, and the Oregon State Tax Commission.

The study revealed that there are considerable economies to size (in terms of annual volume) in specialized seed processing. The number and size of plants in the Willamette Valley indicate that these economies are not being taken advantage of by the industry. If the industry consisted only of plants of the size of the largest model presented here (5,000 tons), there would need to be only around 20 plants to process the Valley's annual production (based on 1960 production of 200,894,000 pounds) (6).

Twenty warehouses would represent a dispersal of one plant for each 180 square miles in the production area. This is opposed to the present situation in which there are 350 warehouses--approximately one plant for each 10 square miles. It is thus apparent that any increase in average size of warehouse accompanied by a decrease in number of warehouses would increase transportation costs for the field run seed. The hypothesis that the result would be a net decrease in total processing costs for Oregon's seed production can only be tested by further research.

The importance of local production patterns would be minimized if larger plants became more prevalent. Warehouse managers could initiate an active procurement policy directed toward some product mix goal. The costs of such a procurement policy could be defrayed by savings in processing costs arising out of the larger volume.

There are also problems connected with larger volumes and fewer plants. The increase in field run transportation costs mentioned above is one example. Another problem for further investigation is the effects of variations in annual seed production. Variations arising from natural conditions--climate, insects, disease--and variations due to market conditions may be either general or specific in their effects. That is, they may affect all or only a few seed crops. General variations would be shared by all seed processing warehouses, whereas specific variations might be confined to only a small segment of the industry. Integration or combination of seed processing with other enterprises might provide some income protection against general variations. This is worthy of further research.

Variations which are specific to a locality or only a few kinds of seed present a different sort of problem from more general variations. Diversification of enterprises might provide some income protection. Warehouses specializing in seed processing would require an active procurement policy if they wished to maintain their volume or product mix. The success of this policy would depend on how many warehouses were competing for a particular kind of seed, and also on the relative bargaining strength of the competitors.

An active procurement policy would have to be based on the individual warehouse manager's knowledge of costs and returns at various volume levels and for various product mixes.

Past experience in warehouse operation might provide the manager with sufficient knowledge to set product mix and volume goals. However, a solution arrived at by formal budgeting or programming would be expected to strengthen knowledge gained by experience. Budgeting and programming are means of considering alternative combinations of inputs and selecting that combination which is least costly or most profitable under given conditions of costs and returns, i.e., the optimum solution.

Management, to solve for an optimum product mix and volume level, would need data on expected supplies of various kinds of seed; expected return for processing each kind of seed (cleaning charges per unit of seed less any procurement costs); supplies of inputs such as labor, storage space, cleaning season hours, receiving season hours, shipping season hours; costs of the various inputs (per unit of seed); and the input-output coefficients of the various inputs.

The data do not include costs and returns from marketing the seeds. These should be included if the warehouse operator intends to participate in the marketing of his customers' seed. If the marketing problem is not kept separate from the processing operations, however, it would tend to disguise the true cost and return picture of the processing operations.

A processor could use the knowledge gained from a programmed solution to aid in setting up contracts with growers to supply his seed requirements. Contracting is a device which is more powerful and more flexible for large processors than for small ones. Conceivably, large processors could contract in advance and on a continuing basis for the total quantity and kinds of seed they would process each year, similar to what is being done currently in vegetable processing.

Market conditions would of course, play an important role in such contracting. Contracts would transfer the risks (and the benefits) of unforeseen price changes from the producer to the processor. Large processors, as first handlers, would be in position to deal directly with retailers and wholesalers. They would thus be sensitive to changing market conditions and could adjust their operations accordingly.

Barriers to the Evolution of Large Plants

Expansion in numbers of grower-operated warehouses was concurrent with expansion of seed production during and after World War II. Apparently, commercial warehouse operators did not or were not able to expand their facilities to accomodate the increased production. This, simultaneous with a change to bulk handling methods, created a bottleneck at the commercial warehouses. Delays in harvesting due to inadequate receiving facilities were experienced. To avoid such delays, many growers set up their own processing facilities. Another factor which contributed to the establishment of grower-operated warehouses was a desire on the part of many growers to have their seed cleaned quickly to provide flexibility in marketing their product.

In many instances, farm plants were set up in existing buildings, such as unused horse barns or dairy barns. Investment in facilities was thus minimized. Major outlays were for cleaning and handling equipment. In most cases, these farm plants utilized labor of the operator and his family, or labor which was already hired for farm operations. The seed processing enterprise provides a means of utilizing labor which at this time of year (fall and winter) might otherwise be unemployed.

Grower-operated seed processing warehouses are at present using depreciated buildings and facilities which were purchased at a much lower price level than now exists. The grower's slack season labor supply is often not charged against the processing enterprise. Thus they tend to view their processing costs as only those cash costs incurred for operation of the machinery, repairs, and supplies. These costs are invariably less than what the grower would have to pay to have his seed crop cleaned at a commercial warehouse. Even when fixed costs are included, they are based on original investment or its present value, rather than what would be the current replacement cost of the inputs.

The obvious economies to size demonstrated herein provide no economic basis,in themselves, for the existence of grower-operated seed processing warehouses. If they are justified on the basis of their utilizing off-season farm labor, then that justification must include some estimate of the opportunity costs of other alternative uses. If they are justified on the basis of providing flexibility in marketing the seed, then quantification must be made of the costs of sacrificing such flexibility. Farm plants can continue to exist within the seed industry only so long as they are not required to replace (or value) their facilities at current replacement costs. Because seed processing charges have not enjoyed the same upward trend as prices of inputs over the past 15 years, the same statement can be made about small commercial warehouses not supported by other enterprises.

The present importance of small warehouses in the seed processing industry must not be under estimated. Through the existence of excess capacity in cleaning facilities, they are capable of processing much more seed than they presently process. However, their very existence presents a barrier to evolution of larger plants. On the other hand, the possibility of cost savings (per unit of output) from processing larger volumes, and the fact that marketing channels favor the larger warehouses make it likely that the future trend will be toward larger warehouses.

No great differences were found between estimated costs of the various methods of seed handling. However, there was a slight cost advantage in favor of Method D (bulk receiving, with clean seed handled in bags on pallets). Thus the present trend toward bulk handling of field run seed and the adoption of more mechanized clean seed handling methods appear likely to continue. This hypothesis is further supported by the shortage of seasonal laborers required for other methods.

Other Implication of the Study

Seed processing is carried out in western Oregon almost entirely as a joint enterprise with seed farming, feed and fertilizer distribution, and/or small grain handling and cleaning. The coexistence of these enterprises within a firm certainly has a bearing on management decisions. Further research is needed on the relationship of seed processing to other enterprises found within the same firms. Research should be aimed at providing the answers to such questions as why expansion in the Oregon seed processing industry took the form of additional grower operated plants rather than larger commercial plants. This study has demonstrated that there are substantial economies to size in seed processing, but it provides no information as to why those economies have not been more fully taken advantage of by firms in the industry. The question of optimum combinations of enterprises should be investigated.

In view of the potential cost savings from larger plants, research should be directed at determining the optimum size and location of plants which would most efficiently serve the Oregon seed industry.

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A P P E N D I X

Appendix Table 1. Performance Rates for Lift Truck Operations in Seed Processing Warehouses

Bags of seed on pallets

Operation[a]	Performance rate[b]	Handling method[c]
	(Bags per man-hour)	
1. Receive bags on truck, transfer to pallet and store 3 pallets high: 3-5 man crew.		
Bag (20/pallet)	156.5	B
Bag (25/pallet)	163.4	B
2. Transfer palletized bags of field run seed from storage to cleaning line and dump bags by hand into hopper:		
20 bags per pallet	83.0	B
25 bags per pallet	107.9	B
3. Transfer clean seed from cleaning line to test storage; stack 2 pallets high.	833.3	B,D,E
4. Transfer clean seed from test storage to permanent storage, 3 or 4 pallets high.	1,010.1	B,D,E
5. Carloading from ground level plant using ramp and entering car.[d]		
Pretagged noncertified	163.4	B,D,E
Pretagged certified	132.6	B,D,E
6. Carloading from ground level plant using pallet dolly in car.[d]		
Pretagged noncertified	144.1	
Pretagged certified	119.6	
7. Carloading from car level plant, entering car.[d]		
Pretagged noncertified	179.2	
Pretagged certified	142.9	

Appendix Table 1. (continued)

Pallet boxes

Operation[a]	Performance rate[b]	Handling method[c]
	(Boxes per man-hour)	
8. Receive boxes, store in open side shed, replace empties on truck.	23.75	E
9. Move boxes from storage to cleaning line and dump with mechanical dumper.	27.51	E
10. Move boxes from storage to cleaning line and dump with turnhead on fork lift.	29.68	

[a] Transportation distances have been standardized at 60 feet one way.

[b] Based on one man crew unless otherwise specified in description of operation.

[c] Operations designated with capital letters in this column were used in estimating annual costs for the five handling methods considered in this study.

[d] Additional labor is required for car preparation and closing. See Appendix Table 4.

Appendix Table 2. Performance Rates for Hand Truck Operations in Seed Processing Warehouses

Operation[a]	Performance rate[b]	Handling method[c]
	(Bags per man-hour)	
1. Unload bags of field-run seed or clean seed from highway truck, transport to storage and pile on floor; 20% of bags loaded on hand truck by hand, 80% by sticking load. Bags moved from truck to storage, unloaded and piled by hand.		
Piled on floor 5 sacks high	275.5	
Piled on floor 6 sacks high	164.2	
Piled on floor 7 sacks high	157.5	
Piled on floor 8 sacks high	149.7	
2. Unload bags of field run or clean seed from highway truck, transport to storage and high pile with drag chain or belt elevator. 20% of bags are loaded on hand trucks by hand, all are unloaded and placed on elevator by hand. Five man crew.[d]	102.8	A
3. Transport bags of field-run seed from storage to cleaning line, open bag and dump into floor hopper.		
Bags in storage are 5 high	73.3	
Bags in storage are 6 high	71.9	
Bags in storage are 7 high	68.2	
Bags in storage are 8 high	66.7	
Bags in storage are high piled, 20 high.[d]	63.7	A

Appendix Table 2. (continued)

Operation[a]	Performance rate[b] (Bags per man-hour)	Handling method[c]
4. Transport bags of clean seed from cleaning line to storage. Load bags by hand on hand truck.		
Unload by hand onto sack elevator. Two man crew.	87.6	A,C
Buck 5 bag load onto floor stacks.	180.1	A,C
5. Move bags of clean seed from test storage to high pile. Two man crew.[d]	112.7	A,C
6. Load rail car with 100# bags clean seed from 5-high test storage; includes tagging. Four man crew.[e]		
Noncertified seeds,		
Pretagged	138.1	A,C
Tagged by loaders	109.5	A,C
Certified seed,		
Pretagged	115.5	A,C
Tagged by loaders	83.0	A,C
7. Load rail car from high piled storage; includes tagging. Four man crew.[d,e]		
Noncertified seed,		
Tagged by loaders	92.2	A,C
Certified seed,		
Tagged by loaders	72.6	A,C

[a] Transportation distances have been standardized at 60 feet one way.

[b] Based on one man crew unless otherwise specified in description of operation.

[c] Operations designated with capital letters in this column were used in estimating annual costs for the five handling methods considered in this study.

[d] Requires use of 24 foot bag elevator.

[e] Additional labor is required for car preparation and closing, and for setting up, moving and removing 10 foot bag elevator used in car. See Appendix Table 4.

Appendix Table 3. Performance Rates for Bulk Receiving Operations in Seed Processing Warehouses

Operation[a]	Performance rate[b]	Handling method[c]
	(Bushels per man-hour)	
Maximum possible receiving rate including weigh in, select bin, clean up, lift and lower truck, convey seed to bins with 10,000 bu. elevator	4,800	C,D
Weigh in, select bin, lift and lower truck, clean up, convey seed to bins with 5,000 bu. elevator.	2,400	C,D
Weigh in, select bin, lift and lower truck, clean up, convey seed to bins with 1,600 bu. elevator.	1,200	C,D
Weigh in, select bin, lift and lower truck, clean up, convey seed to bins with 500 bu. elevator.	400	

a Receiving set up includes scales, 400 bu. dump pit, cradle hoist, and designated elevator.

b Based on average load size of 400 bu.

c Operations designated with capital letters in this column were used in estimating annual costs of the handling methods considered in this study.

Appendix Table 4. Labor Requirements for Miscellaneous Operations in Seed Processing Warehouses

Operation	Labor requirement
	(Man-hours per occurrence)
1. Place bag on hopper, fill with clean seed, weigh, and place on hand truck or pallet, record and stencil.	
Bags sewn by hand	.037
Bags sewn by portable stitcher	.032
2. Prepare car for loading, close and seal doors, handle dock plate.	
For hand truck loading	.900
For lift truck loading	.759
3. Place conveyor in car or remove from car.	.038
4. Reset car conveyor for next tier loading.	.009
5. Place pallet dolly in car or remove from car with lift truck.	.008

Appendix Table 5. Estimated Replacement Costs and Fixed and Variable Annual Costs for Seed Handling Equipment and Facilities

Equipment, item	Replacement cost[a]	Useful life	Depreciation	Other fixed cost[b]	Total fixed costs	Fuel and power[c]	Repairs[d]	Total variable costs[e]
	(Dollars)	(Years)	(Dollars)	(Dollars)	(Dollars)	(Dollars)	(Dollars)	(Dollars)
Hand truck, two-wheel	50.00	10	5.00	3.25	8.25	--	--	--
Dock plate, hand truck	50.00	10	5.00	3.25	8.25	--	--	--
Dock plate, lift truck	150.00	10	15.00	9.75	24.75	--	--	--
24' sack elevator, 3 HP	1,600.00	10	160.00	104.00	264.00	.033	.08	.113
10' sack elevator, 1 HP	850.00	10	85.00	55.25	140.25	.011	.0425	.0535
Warehouse (sq. ft.)	2.25[f]	25	.09	.14625	.23625	--	--	--
Shed, pallet box storage (sq. ft.)	1.50[g]	25	.06	.0975	.1575	--	--	--
Bulk bins[h] (per 1,000 bu.)	408.00[h]	30	13.60	26.52	40.12	--	--	--
Pallet box, plywood								
4' x 4' x 4'	20.00	10	2.00	1.30	3.30	--	--	--
4' x 6' x 3'	22.50	10	2.25	1.4625	3.7125	--	--	--
4' x 6' x 4'	25.00	10	2.50	1.625	4.125	--	--	--
Pallet box dumper	750.00[i]	15	50.00	48.25	98.25	.00825	.0375	.04575
Pallet, wood	3.50	15	.233	.22	.453	--	--	--
Pallet dolly	40.00	10	4.00	2.60	6.60	--	--	--
Fork-lift truck, 4,000 lb.	5,700.00	10	570.00	370.50	940.50	.39	.285	.675
Receiving apron, concrete	1,400.00[j]	25	56.00	91.00	147.00	--	--	--
Loading ramp, concrete	400.00[j]	25	16.00	26.00	42.00	--	--	--
Truck hoist, with cradle	1,500.00[k]	15	100.00	97.50	197.50	.055	.075	.13
with hook	1,250.00	15	83.33	81.25	164.58	.044	.0625	.1065
Platform scale, 50 T.Cap.	6,026.00[l]	20	301.30	391.69	692.99	--	--	--
with dump pit	8,826.00[k]	20	441.30	573.69	1,014.99	--	--	--
Bucket elevator, 9" x 5"	2,980.00[m]	20	149.00	193.70	342.70	.055	.149	.204
11" x 7"	3,672.00[n]	20	183.60	238.68	422.28	.0875	.1836	.2711
14" x 7"	4,019.00[o]	20	200.95	261.24	461.29	.11	.201	.311

Footnotes on following page.

Appendix Table 5. (Footnotes)

[a] F.O.B. the warehouse, plus installation.

[b] Includes the following percentages of replacement cost: Interest - 3%, Insurance - 1%, Taxes - 1%, Maintenance - 1.5%.

[c] Electricity at $.011 per horsepower per hour; gasoline at $.30 per gallon, oil at $.40 per quart.

[d] Repairs computed as .005% of replacement cost per hour of operation.

[e] Per hour of operation converted to cost per ton by the following formula: $C_T = \frac{C_H}{V}$, where C_T = variable cost per ton, C_H = variable cost per hour, and V = tons of seed handled per hour.

[f] Warehouse costs based on the following specifications: Concrete floor, wire reinforced - $.55 per square foot, frame sidewalls and truss roof, sheet metal covered - $1.70 per square foot of area enclosed.

[g] Pole type shed, sheet metal roofing, asphalt floor.

[h] Cribbed bin costs based on the following specifications: Concrete footings - $1.75 per square foot under the bins, Laminated 2" x 4" and 2" x 6" lumber - $89 per 1,000 board feet in place, Sheet metal siding--$.25 per square foot of area covered, Frame roof, sheet metal clad - $.65 per square foot of area covered.

[i] Steel frame, inversion dumper, .75 horsepower, portable.

[j] Based on concrete cost of $33 per cubic yard, in place, including excavation and forms.

[k] Used for methods C and D at all volume levels.

[l] Used for methods A, B, and E at all volume levels.

[m] Used for methods C and D at 1,000 tons annual volume.

[n] Used for methods C and D at 2,500 tons annual volume.

[o] Used for methods C and D at 5,000 tons annual volume.

Appendix Table 6. Example of Calculation of Annual Costs for Seed Warehouse[a]

Item	No. used	Replacement cost	Annual fixed costs	Annual variable costs	Total annual costs
Handtrucks	10	500.00	82.50		82.50
Dock plate	2	100.00	16.50		16.50
Truck scale	1	6,026.00	692.99		692.99
24' Sack elevator 3 HP	2	3,200.00	528.00	90.40	618.40
10' Sack elevator 1 HP	1	850.00	140.25	8.56	148.81
Warehouse, sq. ft.	10,000	22,500.00	2,362.50		2,362.50
Cleaning line	1	20,169.30	3,325.30	1,764.34	5,089.64
Handling labor	2,406			3,609.00	3,609.00
Cleaning labor	1,600			2,800.00	2,800.00
Subtotal			7,148.04	8,272.30	15,420.34
Misc. & overhead 10%			714.80	827.23	1,542.03
Total		53,345.30	7,862.84	9,099.53	16,962.37
Cost per ton clean seed			7.86	9.10	16.96

[a] Equipment and labor requirements and costs in this table are based on handling of 1,000 tons annual ryegrass by Method A.