AN ABSTRACT OF THE THESIS OF

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Title: THE ECONOMIC FEASIBILITY OF SOYBEAN PRODUCTION IN OREGON

Abstract approved: A. Gene Nelson

Commercial production of soybeans in Oregon has been limited. In 1977, less than 1,500 acres were grown, primarily in the Columbia Basin area. However, interest in soybeans as a possible "new crop" for Oregon has arisen because of the (1) recent strong soybean price, (2) the high cost of transporting soybean meal and oil to the Pacific Northwest, (3) Oriental demand for soybeans, and (4) search for another crop alternative for newly irrigated cropland.

The Oregon State University Agricultural Experiment Station has determined that soybean production in Oregon is technically feasible. However, information is lacking as to the economic feasibility of soybean production in Oregon.

The agronomic feasibility of soybean production in Oregon was first reviewed. General agronomic requirements for soybean production were compared with typical weather conditions and soils found in the major agricultural centers of Oregon. It was concluded that the Ontario, Columbia Basin, and Willamette Valley areas possess the greatest agronomic potential for soybean production in Oregon.

The irrigated crops considered to be soybeans' primary competitors were identified in each of the three regions. Typical costs and returns were estimated for the competing crops based on 1976 costs of production and normal yields and prices.

Cultural operations and input requirements for soybean production in Oregon were based on what typically has been done in the major soybean producing areas of the United States. Costs of producing soybeans were then estimated based on the same assumptions used for the competing crops. Soybean yields were based on Agricultural Experiment Station variety trials and the experience of the limited number of commercial growers in Oregon.

The yield, price, and cost data along with agronomically sound crop rotations were analyzed using linear programming models for a typical farm in each region. An estimate of the minimum price necessary for soybeans to compete with the other crop alternatives was determined. The results indicated that for the successful introduction of soybeans the price per bushel could be no lower than \$11.22, \$10.15, and \$8.25 in the Willamette Valley, Columbia Basin, and Ontario areas, respectively.

Four potential marketing alternatives which may exist for Oregon-grown soybeans were identified: (1) exporting raw soybeans to Japan; (2) exporting raw soybeans to other regions of the United States; (3) processing soybeans at Portland to meet the Pacific Northwest demand for meal and oil; and (4) processing soybeans at Portland and exporting meal and oil to other regions of the United States. The alternatives were evaluated using the Decatur base-point pricing scheme to determine the maximum Portland soybean price that could be offered. The results indicate that the variability in the maximum Portland price may range from \$2.69 to \$10.07 per bushel based on data for the past six years. The lack of data and current experience limited the evaluation of two other potential marketing alternatives: (1) on-farm use of raw soybeans and (2) processing soybeans at Portland and exporting meal and oil to Japan.

The economic feasibility of soybean production was analyzed by (1) subtracting the average transportation costs to Portland from each of the three areas from the maximum Portland soybean prices and (2) comparing the results with the minimum price required for soybeans to successfully compete with the alternate crops in each of the areas derived from the linear programming analyses.

Based on the assumptions and data used in this study, it was concluded that soybean production in Oregon is not economically feasible at this time. The minimum prices required by farmers to grow soybeans ranged from $0.65 to $3.36 per bushel higher than the average prices which would have been offered over the past six years. Changes in energy costs for transportation, irrigation pumping, and fertilizer production, as well as the development of new, higher-yielding varieties suited to Oregon could improve the outlook for soybean production.

The Economic Feasibility
of Soybean Production in Oregon

by

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CHAPTER 1

OVERVIEW OF THE STUDY

Justification

The soybean is a major agricultural crop in the United States. Nationally, soybeans generate about eight billion dollars worth of gross farm income annually.[1/] In perspective, soybeans rank second or third among all major crops in cash receipts exceeded only by corn and sometimes wheat (United States Department of Agriculture, Economic Research Service, "State Farm Income Statistics").

The Corn Belt is the leading soybean producing area of the United States. However, much of the surge in soybean output over the last two decades has come from the profitable expansion of this crop in other regions (Caldwell, pp. 589-591; Tables A-1 and A-2).

There is interest in soybeans as a possible "new crop" in Oregon. This is stimulated by (1) a relatively strong soybean price compared to the prices received for crops presently grown; (2) the increasing use of soybean meal and oil and the high cost associated with transporting these products to the Pacific Northwest; (3) an advantageous seaport location which could be utilized to capture part of the Oriental export market; and (4) the search for another crop alternative on newly irrigated croplands ("Soybeans: New-Old Crop for Oregon," p. 3).

[1/] The annual gross farm income is estimated from the acreage, yield, and price data presented in Tables A-1 and A-4 for the years 1972 to 1976. Tables with letter designations are included in appendices.

Soybean variety trials conducted by the Oregon State University Agricultural Experiment Station indicate that soybeans can be grown in Oregon. Yields over 60 bushels per acre were achieved in trials near Hermiston (Tables C-1 and C-2). To date, however, commercial soybean production in Oregon has been limited. In 1977, less than 1,500 acres were grown, primarily in the Columbia Basin area (Wilson). While soybean production appears technically feasible, information is lacking as to economic feasibility.

Objectives

The purpose of this research was to study the economic feasibility of soybean production in Oregon. To do so, certain objectives were specified. These are:

1. To assess the agronomic feasibility of soybean production in selected Oregon regions.

2. Determine the cultural practices and production input requirements for soybean production.

3. To analyze the competitive position of soybean production compared with the other major crop alternatives available.

4. Identify and analyze the marketing alternatives which would exist for Oregon-grown soybeans.

Procedure

A general review of current research in soybean management and production practices is presented in Chapter Two. Temperatures, soils, moisture, and other agronomic requirements for soybean production are described.

In Chapter Three, these general requirements are compared with typical weather conditions and soils which exist in major agricultural areas in Oregon. The agronomic potential for soybean production in six Oregon areas is discussed.

The cost of producing soybeans, based on input prices paid and machinery costs incurred for typical farming situations is estimated in Chapter Four. Costs and returns for alternate crops considered to be soybeans' major competitors are also presented. With these data, the competitive position of soybeans in Oregon is evaluated in two ways. A linear programming model and break-even analysis are both employed to determine the price required for soybeans to successfully compete with the other crop alternatives.

In Chapter Five, the marketing alternatives which may exist for Oregon soybeans are identified. The most promising alternatives are analyzed to estimate the price which could be offered for Oregon soybeans.

The results of the linear programming and marketing alternatives analyses are compared in the last chapter. An evaluation of the economic feasibility of soybean production in Oregon is performed based on this comparison.

CHAPTER 2

SOYBEAN PRODUCTION: A GENERAL REVIEW OF LITERATURE

The history of the soybean from its legendary beginnings in China through its rise to prominence in United States agriculture is briefly traced below. A review of the agronomic aspects which influence soybean production is also presented.

Soybean History in the World and United States

The early history of the soybean remains a legend. One such tale most often repeated by Far East story tellers is about a caravan of Chinese merchants who, upon returning home from a profitable exchange of their wares for gold, silver, and furs, were besieged by a group of relentless bandits (Dies, pp. 6-7). The merchants took refuge in a rocky fortress. Days went by. Provisions ran low and starvation seemed certain. By chance, a merchant's servant stumbled across an unfamiliar vine-like plant bearing seeds. Skepticism was overpowered by hunger. So, the men pounded the seeds into a flour, added some water, and made crude cakes. With renewed strength, they were able to hold off their foes until help arrived. From that day on, the legend goes, the "miracle bean" became a mainstay of life in China.[1/]

Man's earliest use of the soybean was recorded in the books "Pen Ts'ao Kong Mu" by Chinese Emporer Sheng-Nung published sometime between 2838 B.C. and 2383 B.C. (Caldwell, p. 1). In later records, the soybean

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1/ Regardless of the legend's validity, it is generally conceded that soybeans are native to Eastern Asia, probably the north and central regions of China (Caldwell, p. 2).

is repeatedly mentioned as "one of the five sacred grains - rice, soybeans, wheat, barley, and millet - essential to the existence of Chinese civilization" (Markley, p. 4). Early uses ranged from a highly valued food source for man and animal to medicinal "cure alls".

Production of soybeans was generally confined to China for hundreds of years. It was not until the late 19th and early 20th centuries that soybeans and soybean products attracted world-wide attention.

Soybeans first found their way into the United States in 1804 (Dies, pp. 8-9). A Yankee clipper ship captain was searching the ports of China for a return cargo. Not knowing how long the return journey would take, he ordered several bags of soybeans be brought aboard as a reserve food supply.[2/] But it was not until after the successful utilization of the soybean as an oilseed in European countries that United States agricultural researchers became interested in the grain (Caldwell, p. 7).

Imported soybeans were first processed into oil and meal in 1911 at a crushing plant in Seattle, Washington (Caldwell, pp. 3-8). Domestically produced soybeans were first processed in 1915 by a few cottonseed-oil mills in North Carolina. Until about 1940, however, the principal use of soybeans was as a forage crop. They were used primarily for hay, silage, soilage, and in combination with corn as a pasture for fattening hogs and sheep. With the increasing demands for soybean meal and edible fats and oils, the acreage of soybeans harvested for beans increased from about 40 percent in 1939 to nearly 100 percent in 1970.

2/ "Soybeans: New-Old Crop for Oregon", indicates that the soybean found its way into the United States in the 19th Century as ballast in a sailing vessel from Manchuria.

Production Trends in the United States

Acreages

The growth of soybean production in the United States has been phenomenal. The total acreage of soybeans harvested for beans grew from less than a half million acres in 1924 to a peak of slightly under 55.8 million acres in 1973, an increase of 110 times in only 50 years (Caldwell, p. 8; Table A-1). In the period from 1960 to 1972, the United States soybean acreage nearly doubled. Ten million more acres came into production in 1973. Since then, a slight decrease in the acreage planted to soybeans has occurred (Figure 1 and Table A-1).

In 1919 the leading soybean producing states were in the east and south (Caldwell, pp. 9-11). By 1924 soybean production reached the Corn Belt and expanded rapidly. More than 84 percent of the United State acreage harvested for beans was in the Corn Belt in 1939. As the production of soybeans spread into still other areas, the relative dominance of the Corn Belt decreased. However, today nearly half of the total United States soybean acreage remains in that region.

Yields

Average soybean yields for 1960 to 1976 have ranged from 22.8 to 28.8 bushels per acre. Generally, average yields have been increasing but greater variability has occurred in recent years reflecting the limited rainfall during the growing seasons of 1974 and 1976 (Figure 2 and Table A-1).

The Corn Belt States lead in average yields with nearly 30 bushels per acre in 1976. The highest average state yield was reported by Illinois in 1975 with 36 bushels per acre (Table A-3). Individual

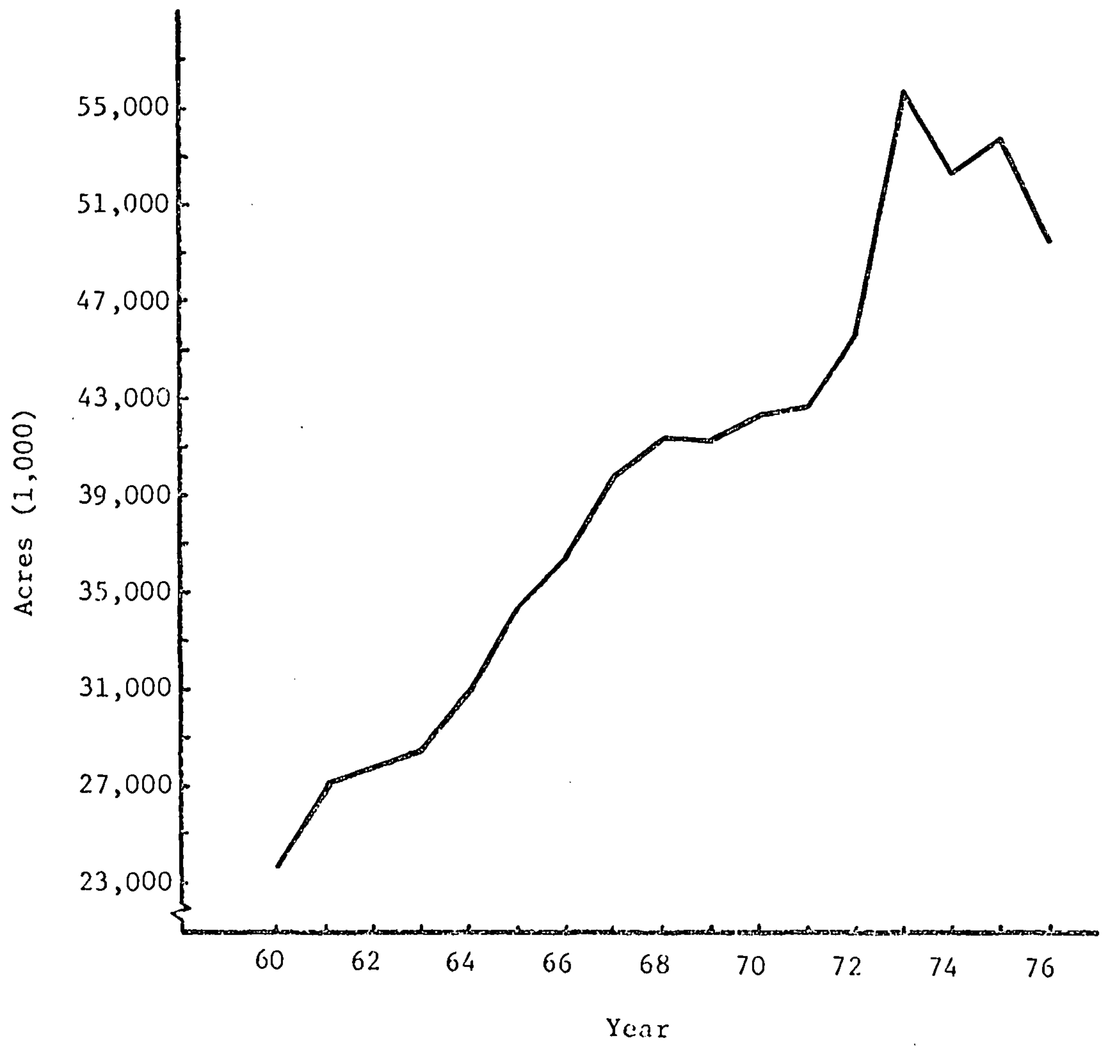

Figure 1. United States soybean acreage harvested for beans, 1960-1976.

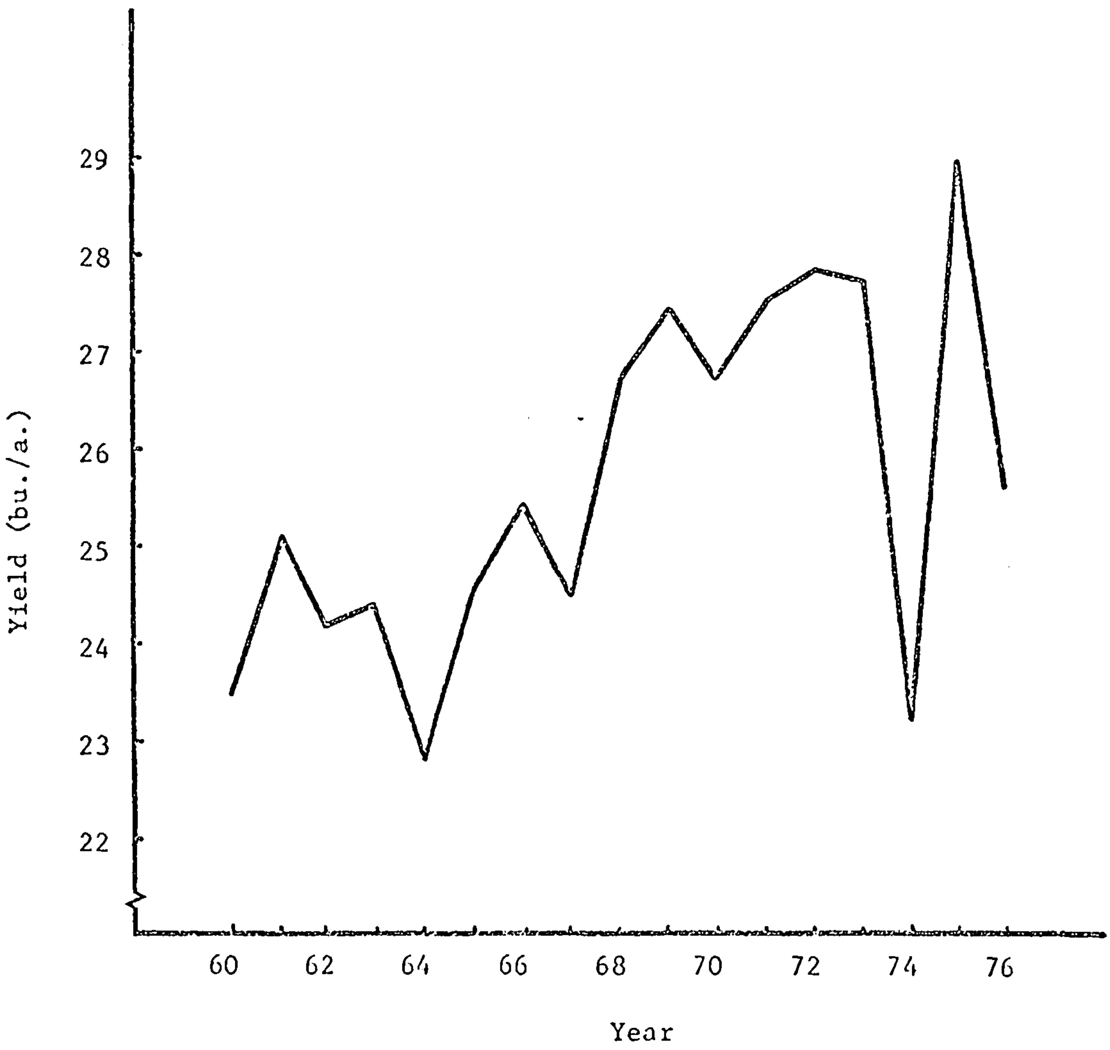

Figure 2. Average United States soybean yield, 1960-1976.

farmers around the country have recorded yields from 60 to over 80 bushels per acre ("Inoculants Help Growers Achieve Top Yields").

Farm Prices

From 1960 through 1971 there was little variation in average annual prices farmers received. During that period, the average United States farm price was a little over $2.50 per bushel. Since that time the average annual and monthly prices have been sporadic but substantially higher (Figures 3 and 4 and Tables A-4 and A-5).

Utilization and Processing

The sharp increase in soybean production in the United States has been stimulated, in part, by the rapid expansion of the foreign demand for soybeans and soybean products. Exports of soybeans (either as beans, meal, or oil) have increased from about 30 percent of the United States' annual production in the early sixties to over 50 percent in the mid-seventies (Caldwell, pp. 573, 583; Steyn, p. 50). The approximate percentage of United States' soybeans and soybean products exported and used domestically are shown in Figure 5.

As Figure 5 indicates, about 63 percent of the United States' annual production of soybeans in processed into meal and oil using mechanical or solvent methods. The mechanical processes - the hydraulic press and the continuous expeller or screw press method - yield less oil and more meal, but with less protein, than the chemical solvent processes. Chapman (p. 356) points out that mechanical processes recover about 15 pounds of oil and 80 pounds of 41 percent protein meal while the solvent method recovers about 18 pounds of oil and 76 pounds of 44 percent protein meal from 100 pounds of beans.

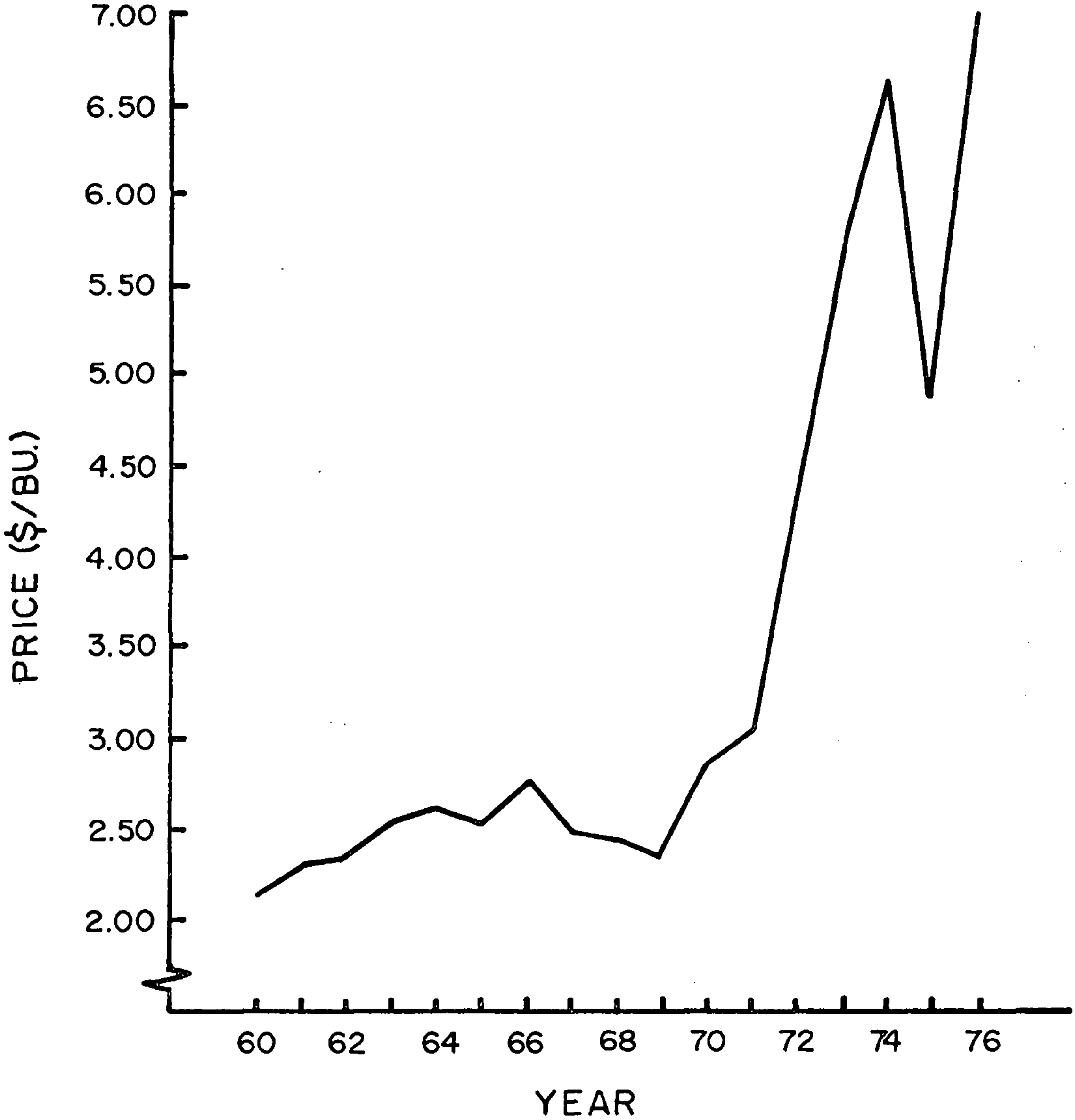

Figure 3. Average annual soybean prices received by United States farmers 1960-1976

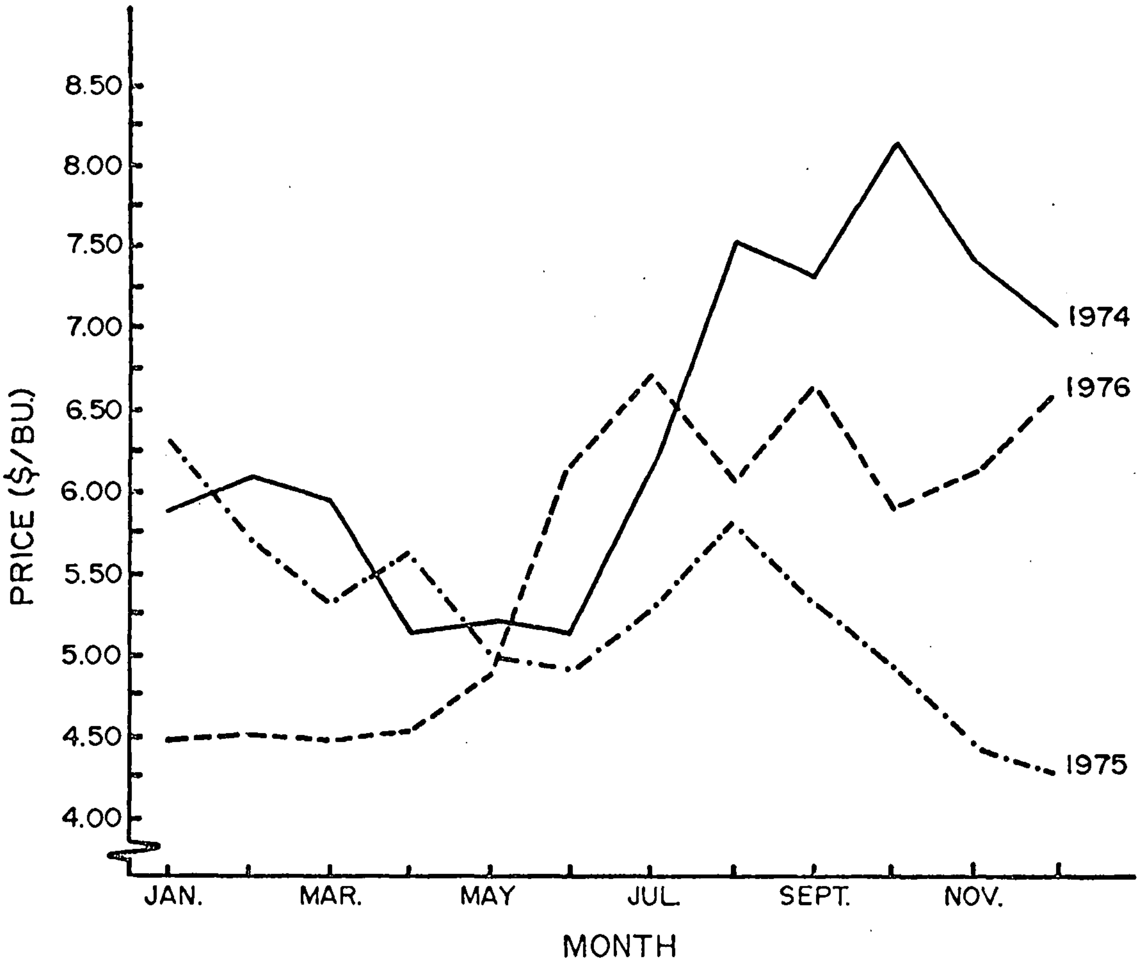

Figure 4. Average monthly soybean prices received by United States farmers 1974-1976

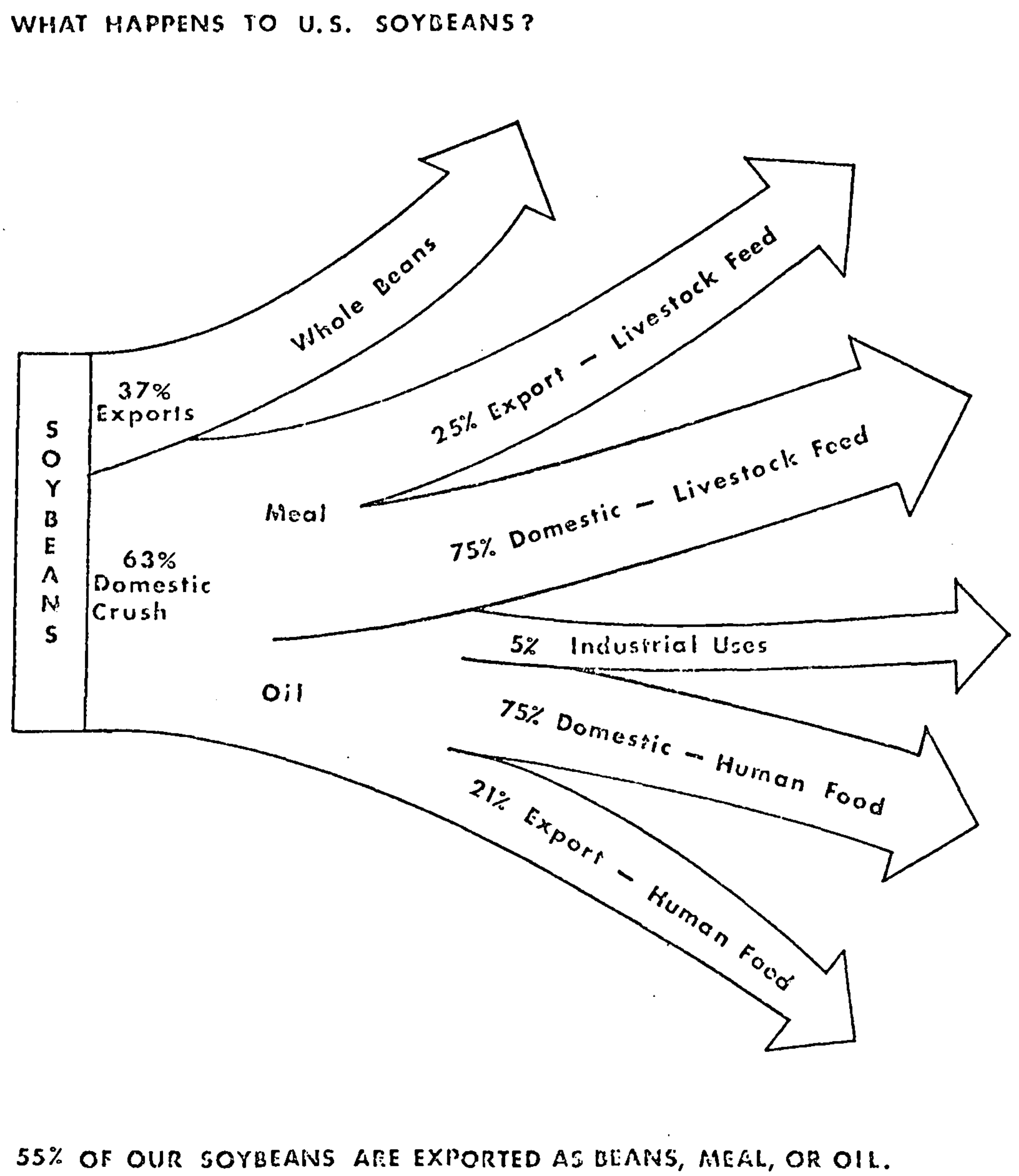

Figure 5. Approximate percentage distribution of soybeans and soybean products exported and used domestically (Steyn).

The chemical solvent method is used on more than 95 percent of the soybeans processed today (Caldwell, p. 621). The first step in the chemical process is the cracking of the soybeans to loosen the hulls and to break each bean into about eight pieces. Shakers and aspirators remove the hulls and rollers flake the pieces.

Soybean oil is extracted from the flakes by adding a solvent (purified petroleum hydrocarbons known as hexane). The crude oil, after the solvent has been recovered, is mixed with water and the soybean lecithin and oil are separated by centrifugation. The major commercial use of soybean lecithin is as a natural emulsifier for food, nonfood, and pharmaceutical use. The oil is refined with alkali and is bleached, hydrogenated, and deodorized. At this point, the oil is ready for use as a salad oil, shortening, margarine, etc., accounting for 60 percent of the domestic supply of fats and oils (Steyn, p. 58).

Raw soybeans contain a number of antinutritional factors which are still present in the defatted flakes (Caldwell, pp. 619, 646). The flakes are heated with 20 to 30 percent moisture inactivating the antinutritional factors and milled into feeds. Soybean meal accounts for 65 percent of the high-protein concentrates found in livestock and poultry rations (Steyn, p. 51). Quality and dependability of supply are cited by Steyn (p. 57) as the main reasons for the use of this high-protein source. Soybean meal is also used in baked goods, meat substitutes, and other human foods accounting for two percent of the domestic use.

Although the chemical solvent process is the preferred method, the mechanical processes still operate to make certain products (Caldwell, p. 621). The extruder-cooker (a modification of the continuous screw press method) has shown promise for full-fat soy flour, cereal grain-soybean combinations, and pet foods.

Interest in processing and feeding whole or ground soybeans on the farm has arisen because of the development of relatively inexpensive soybean roasters. The antinutritional factors are inactivated by the heat produced in the roaster and the cooked, full-fat soybeans can be fed. However, a full-fat soybean product in a swine ration causes "soft pork" (more liquid fat in the meat). No problems are encountered with feeding a full-fat product to poultry or cattle, but soybean oil is usually more valuable for human food than as a source of fat in feed rations (Caldwell, p. 647).

Agronomic Aspects of Soybean Production

Environmental Factors

Soybeans are a warm-season crop. Rapid germination and seedling vigor are promoted by soil temperatures of 60°F or above (Chapman, p. 346). Soybeans are generally produced in areas having a 120 day minimum frost free period with a mean summer temperature of 70°F or above. However, the minimum temperature for effective growth is about 50°F. Yields and oil quality are reduced by very warm (90°F or above) midsummer temperatures. Flowering is delayed by sustained temperatures below 75°F during this same period.

Light intensity is as important as temperature. Competition for light from taller growing weeds and other soybean plants require strict weed control practices and care in planting rates and spacing. Since soybean growth is slowed by excessive cloudy weather, they are best adapted to areas having few cloudy days during the summer months.

Soil Factors

Soybeans are adapted to a wide variety of soil types (Markley, p. 15; Martin, p. 694; Norman, p. 168; Piper, p. 57). In general, those soil types conducive to the growth of other crops are suitable for soybean production. Soybeans perform best on "deep, friable soils with good drainage and aeration characteristics; also desirable are medium-textured soils with a high water-intake and water-holding capacity" (Beard, p. 16).

Soils such as the loams, silt loams, clay loams, and silty clay loams usually have a moderate to large water-holding capacity. The coarse-textured sands, sandy loams, and loamy sands have low water-holding capacities but produce good soybean yields provided adequate water is available either through precipitation and/or irrigation.

Internal drainage of some fine-textured soils is often restricted. This promotes a water-logged or saturated condition causing an oxygen deficiency which slows plant growth. Excessively wet soils are also favorable for disease organisms and may delay planting because they warm slowly in the spring.

Clay soil types or the existence of a plow pan (compacted layers caused by tilling at the same depth) may inhibit root penetration. Shallow rooting results, and the plants are unable to exploit nutrients and water in the subsoil. Nutrients can be added to the plow layer but the limited supply of water in the root area makes it difficult for the plant to survive periods of water stress.

Saline soils may cause problems. Salinity decreases the availability of soil water to the plant. More frequent irrigation of soybeans will help to compensate for soil salinity. Some varieties are more tolerant of salts than others. However, seed germination and rate and percent of emergence decrease in all varieties as salinity increases (Beard, p. 16).

Soybeans tend to mellow the soil and leave little residue in the field increasing the potential for soil losses from wind and water erosion. Soybean seedlings are sensitive to drifting sands in wind erosion areas, however, erosion is mainly a problem in the year after soybeans are planted rather than while they are growing. Conservation practices of minimum tillage, contour planting, and seeding a small grain or cover crop after the soybeans have been harvested may help control erosion.

Water and Its Distribution

Soybeans require 20 to 30 inches of water - from precipitation and/or irrigation - for optimal yields (Chapman, p. 348). However the seasonal distribution of water is most important and often is the limiting factor in soybean production (Rogers and Thurlow; Caldwell, p. 223).

Daily water use of the soybean plant depends upon the weather conditions and the stage of growth (Kansas State University Cooperative Extension Service). Figure 6 relates typical water use with four stages of the soybean plant's life cycle: germination and seedling, rapid growth, reproductive, and maturity.

Although water use in the germination and seedling stage is low, it is extremely important that sufficient water be available. In order for germination to occur, water must be absorbed by the seed (Caldwell, p. 245). The root system of the young seedling is not very extensive nor does it develop rapidly (Kansas State University Cooperative Extension Service). For this reason, the seedling is susceptible to drought injury

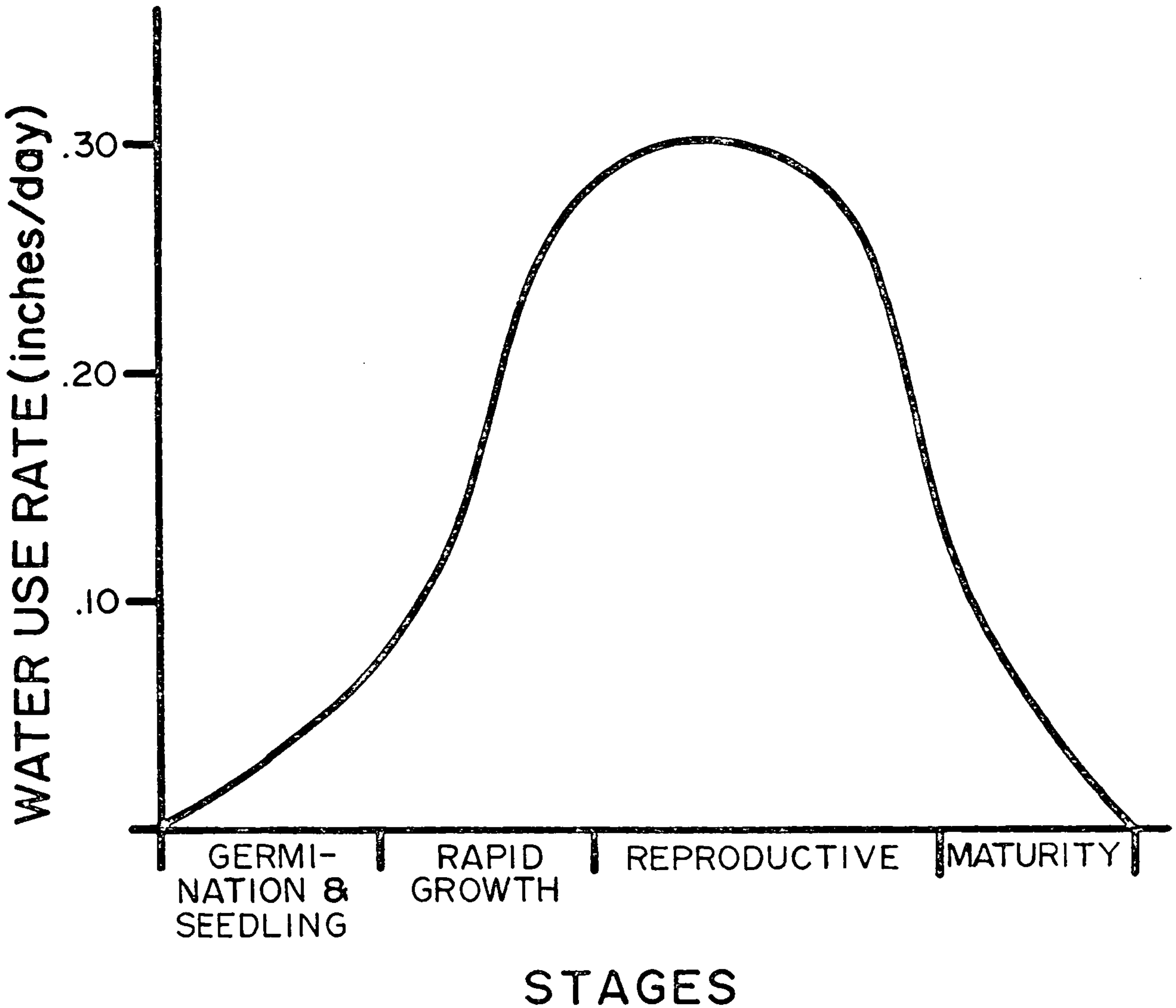

Figure 6. Characteristic life cycle and water use pattern of soybeans (Kansas State University Cooperative Extension Service).

making adequate water essential during the germination period (Doss and Thurlow). However, too much water at this stage may be detrimental. Excess soil moisture may be responsible for poor germination, decreased root growth and nodule information, and poor emergence (Caldwell, p. 246).[3/]

During the rapid growth stage of development, water use increases slowly as the plant expands its foliage and root system (Kansas State University Cooperative Extension Service). The soybean plant can withstand some moisture stress without yields being greatly influenced (Buntley). Too much water in the latter part of this stage and the subsequent early bloom phase promotes excess vegetative growth. This results in a heavy plant that not only is more susceptible to lodging and subsequent harvesting problems, but wastes nutrients that might better be used later on in the reproductive stage ("Moisture Shortage: Trouble for Soybeans"; Brady).

It is during the reproductive stage that the number of pods and seeds and the size of the seeds are determined (Buntley). Considering that these factors determine yield and that about 50 percent of plant's total water needs are required during this stage, water management is extremely important (Kansas State University Cooperative Extension Service). The soybean plant can tolerate short periods of drought stress during early bloom. The result is that some flowers abort, however, failure of the early flowers to set pods may be compensated by an excellent pod set of late flowers if moisture becomes available (Caldwell, p. 223). The soybean plant may also compensate by increasing the number of beans per pod or by increasing seed

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3/ For more information on nodule formation, see the section on "Inoculation".

size to maintain yields, again provided moisture becomes available ("Moisture Shortage: Trouble for Soybeans").

Water appears to be most critically needed by the soybean plant later in the reproduction stage, from late pod setting through the first few weeks of seed development (Rogers; "Moisture Shortage: Trouble for Soybeans"; Buntley; Doss, Pearson and Rogers; Brady). This period corresponds to about the fifth week after the first blooms appear. If drought stress hits during this time, yields may be decreased by 50 percent.

In the maturity stage the beans continue to develop and mature. Water use is considerably lower than in the reproductive stage, although sufficient water is essential to produce full, plump seeds. Prolonged moderate drought stress during this period results in shriveled seed, and hence, reduced seed weight and yield (Kansas State University Cooperative Extension Service).

The amount and seasonal distribution of water is an important consideration in soybean production. Results of other experiments involving the water-soybean relationship are summarized below.

(1) Varieties differ in response to soil moisture stress (Mederski).

(2) Yields are influenced more by irrigation or variety than by row width or population (Doss and Thurlow).

(3) Irrigation effects on maturity are not significant. However, prolonged water deficits hasten maturity (Beard).

(4) Irrigation does not markedly effect oil and protein content of the seed (Beard).

Varieties

North American plant scientists classify soybean varieties into ten maturity groups (Figure 7). The relatively large number of maturity groups is due to the sensitivity of soybean plants to light duration. Each variety requires a particular day length to initiate flowering (Hanway). The classification range is based on varieties best adapted to long days in the north, shorter days in the south, and intermediate day lengths. When moved out of a southern zone into one farther north, a given variety may not mature before frost kills the plants. A southward shift may cause the plant to mature too early to obtain optimum yields (Martin, p. 696).

Temperature also effects the time of flowering. Martin (p. 697) indicates that the average July temperature decreases about 1.3°F for every 100 miles in a northward direction. This 1.3°F temperature change is enough to delay flowering by about three days. Inasmuch as altitude and large bodies of water affect temperature, the delay can be observed without the northward movement.

The avoidance of lodging and shattering are necessary to prevent harvesting losses. When lodging and shattering are severe, 10 to 20 percent of the soybeans can be left in the field (Kansas State University Cooperative Extension Service). Shattering is a more severe problem under low humidity conditions commonly encountered in arid or semi-arid climates. However, varieties have been developed that are lodging and shattering resistant.

In summary, there are three important considerations to keep in mind in selecting a variety for a particular area: (1) maturity; (2) yield potential; and (3) lodging and shattering resistance. Disease tolerant

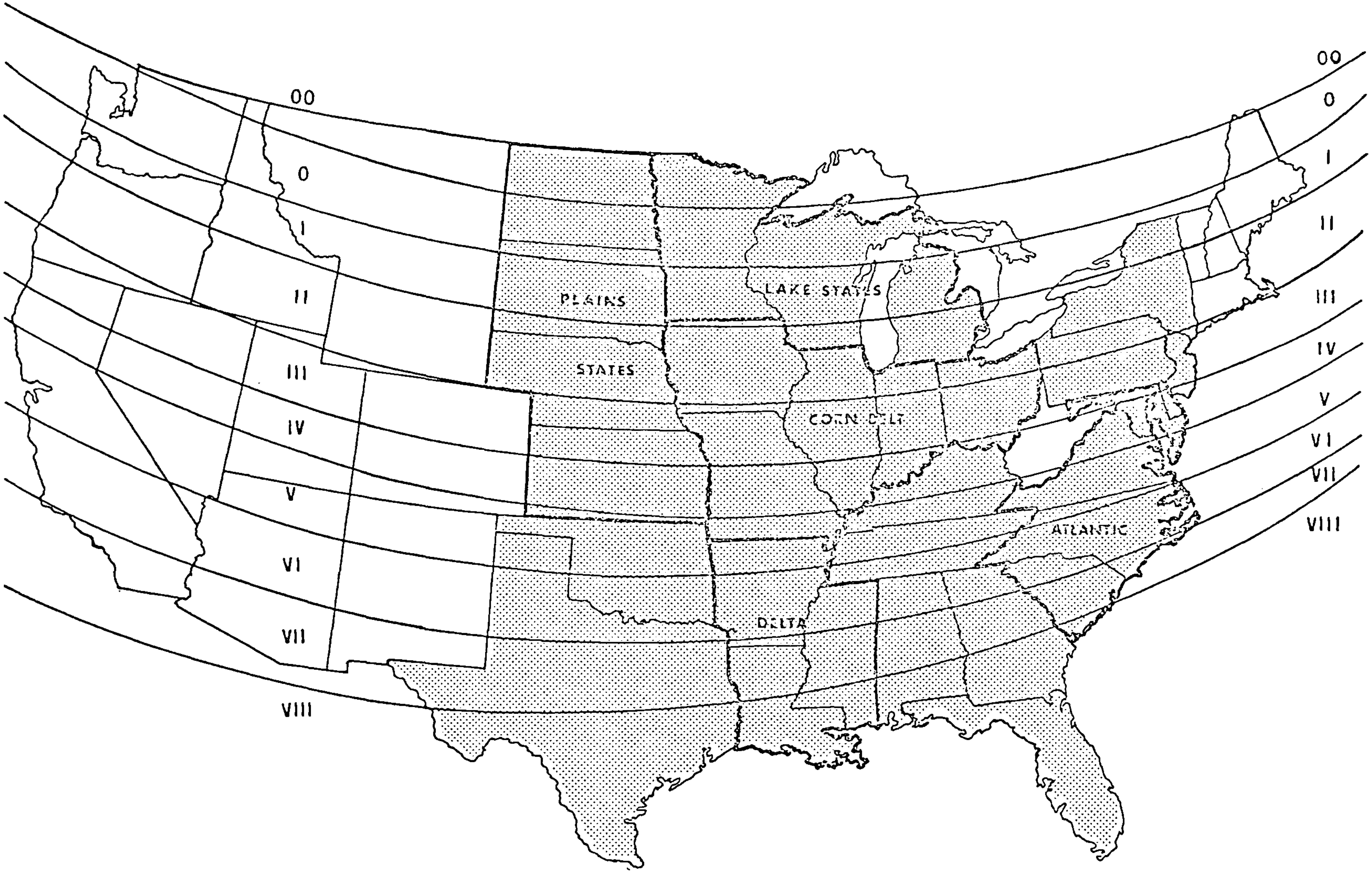

Figure 7. Production regions and maturity Groups for United States soybeans (adapted from Caldwell; Scott).

The maturity group lines across the map are hypothetical. There are no well defined areas where a variety is or is not adapted.

varieties should also be a consideration if potential diseases reduce yields.

Tillage

A primary tillage operation buries crop residues, kills weeds, and loosens the plow layer (Scott, p. 39; Kansas State University Cooperative Extension Service). Surface trash interferes with cultivation and limits the effectiveness of herbicides. The moldboard, chisel, or disk plows are the main tools used to perform this operation. The lister and rotary tiller are other alternatives.

Seedbed preparation is particularly important for soybean production. A firm, well-pulverized, level seedbed is required for uniform seedling emergence and minimum harvesting losses. This secondary tillage operation can be performed by a tandem disk, spring-tooth, field cultivator, culti-packer, or spiked-toothed harrow. The tandem disk is also an effective tool for incorporating herbicides.

Reduced tillage operations are receiving more interest and are easily adapted to soybean production. Decreasing the number of trips across each acre cuts operating expenses and reduces soil erosion and compaction. However, reduced plant stands and increased weed problems are more likely with reduced tillage systems as compared to conventional tillage practices (Caldwell, p. 222).

Double Cropping

Double-cropping soybeans with a small grain crop (wheat, barley, rye, etc.) is being tried by more and more farmers (Owens). The grain crop serves as a winter cover crop reducing erosion in addition to being a cash grain crop. Certain varieites of grain crops may be harvested early enough so that the soybeans can be planted in time to mature.

Double-cropping soybeans and small grains has proved effective in the southern and coastal plain states where water was not a limiting factor (Caldwell, p. 221; Owens). Yields of each crop are usually less than if produced alone, but when taken together, are generally more profitable than single-cropping. With the development of earlier maturing varieties of both small grains and soybeans, improved herbicides, and new planters, the interest in double cropping has moved to the north-central soybean-producing areas.

Fertilization

Research on the mineral nutrition of soybeans is complex and much is yet to be understood. However, soybeans do respond to applied fertilizers when the soil cannot meet the plant's nutrient requirements (Scott, p. 67; Hanway).

Soybeans use more nitrogen than any other major crop. A 50 bushel per acre soybean yield requires nearly 300 pounds of nitrogen per acre. A corn yield of 150 bushels per acre requires only 235 pounds; a 40 bushel wheat yield only 70 pounds (Scott, p. 177).

Research involving nitrogen fertilization of soybeans has been extensive. The results of numerous experiments are remarkably the same. Nitrogen fertilization of soybeans does not significantly affect yields ("Researchers Face Unique Yield Barriers"). The lack of response to nitrogen fertilization appears to be related to the activity of the nitrogen-fixing bacteria.[4/] As the level of nitrogen fertilization increases, the amount of nitrogen fixed from the air by the bacteria decreases proportionately resulting in little change in the total amount of nitrogen available to the soybean plant (Johnson).

[4/] For further details see the section on "Inoculation".

Thurlow and Rogers speculate that soybeans may respond to applied nitrogen under certain conditions. These include: (1) lands not previously planted to soybeans; (2) acid soils; (3) coarse textured soils low in organic matter; (4) poorly drained soils; and (5) where all other factors permit unusually high yields.

There may be another possible need for nitrogen fertilization (Norman, pp. 130-131; Kansas State University Cooperative Extension Service). Until the bacteria form nodules and fix nitrogen (about three to five weeks after the seed sprouts), the young seedling is exclusively dependent on the soil and the seed to meet its nitrogen needs. For this reason, a starter fertilizer containing nitrogen may be beneficial.

A pale green or yellowish coloring of the leaves may indicate a nitrogen deficiency. It is not commonly observed. However, the symptoms of nitrogen deficiency may appear in fields not previously planted to soybeans, where the seed was not inoculated, or where nodule development has been inhibited (Scott, p. 146).

Soybeans require relatively large amounts of phosphorus. A 50 bushel per acre yield contains 25 pounds of phosphorus in the above-ground plant parts. This compares to 11 pounds for a 50 bushel wheat yield (Scott, p. 70).

Soybeans consistently respond to direct phosphorus fertilization on soils testing very low to low in available phosphorus (Kansas State University Cooperative Extension Service). Responses of phosphorus applied to soils with higher test levels have been erratic but usually quite small.

There are no clear-cut phosphorus deficiency symptoms. For this reason, Scott (p. 146) suggests applying phosphorus according to soil test recommendations.

Potassium is consumed in large quantities. A 50 bushel per acre crop of soybeans removed about 105 pounds of potassium while a 40 bushel wheat crop contains only 12 pounds of grain (Scott, p. 74, 177).

Like phosphorus, responses to potassium fertilization are dependent upon the amount of available potassium in the soil. A soil test is probably the best index for potassium needs (Kansas State University Cooperative Extension Service).

Potassium deficiency symptoms first appear as an irregular yellowing around the edges of the older leaflets. The deficiency is most common on sandy, weathered, and highly organic soils, but also may appear in plants where root penetration has been restricted by wetness or hardpan (Scott, p. 144).

Soybeans require several other nutrients as well. Calcium, magnesium, sulfur, iron, manganese, zinc, copper, boron, molybdenum, and cobalt are used by the soybean plant in small amounts. Deficiencies in these nutrients can be determined by soil or plant tissue tests and corrected with appropriate fertilization.[5/]

Liming acid soils is probably the first fertilizer management consideration toward increasing soybean yields. Besides supplying calcium and magnesium, liming to a pH between 5.8 and 7.0 has many other advantages (Scott, p. 89). Soybeans grow best in the pH range because: (1) the best overall nutrient balance is obtained; and (2) a favorable environment for nitrogen fixation is created.

Fertilizer placement is an important consideration. The soybean seedling is especially sensitive to salts of nitrogen and potassium (Scott,

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5/ Scott (pp. 144-147) describes briefly the symptoms of selected nutrient deficiencies.

p. 97). If dry weather occurs, these salts draw water out of the roots and the plant wilts. The plant may survive but be stunted, or it may die, depending on the degree of injury. Broadcast applications of fertilizers or keeping a row fertilizer a minimum of 1½ inches to the side and 1½ inches below the seed, minimizes salt injury.

Inoculation

Inoculation, as related to soybean production, means to supply a bacteria to the soybean. These bacteria are unicellular, microscopic plants that invade the root hairs of the soybean plant (Scott, p. 60). If appropriate conditions exist, the bacteria form nodules. Each nodule is a cluster of millions of bacteria which work with the soybean plant (Weber). The bacteria convert nitrogen from the air into ammonia, a nitrogen form the soybean plant can utilize.[6/] The plant in turn provides food to the bacteria in order for them to function and survive ("Inoculation-Worth It or Not").

Is inoculation required? Research and extension workers in 19 of the major soybean producing states were asked that question. Scott reports the results: Seven of the 19 states surveyed recommend inoculating every year regardless of the cropping history (pp. 60-61). The other 12 states generally agreed that if a crop of well-nodulated soybeans had been produced on a field within the last three to five years, inoculation is not needed. Thompson points out, however, that there are no specific tests to indicate whether inoculation would be profitable on a given field. Since the cost per acre for inoculation is relatively small, he re-

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[6/] As new roots develop, the nodules formed on the older roots slough off and the nitrogen fixed in them (nitrogen previously in a form unavailable to the plant) becomes available to the plant as part of the soil's organic matter (Chapman, p. 233).

commends inoculation to make sure nodulation is not limiting yields. Workers in all the surveyed states agreed that inoculation is necessary on land where soybeans have not been grown or where it has been a number of years since the last soybean crop.

There are over 1,000 strains of inoculum bacteria ("Soil Inoculation - Good Insurance"). The type of legume grown, and perhaps even the variety determines which strain of bacteria to use. Those which form nodules on alfalfa and sweet clover will not form nodules on soybeans (Frederick).

Three types of inoculants are commercially available for soybeans: peat based, broth based, and freeze dried (Frederick). They can be in liquid, dry powder, or dry granular form. Pre-inoculated seed is also available.

Vincent worked with the survival of bacteria on sub-clover seed. A peat based inoculant and a concentrated liquid inoculant had the best survival rates. Freeze dried inoculant was the least successful, and Frederick adds pre-inoculated seed to this category.

There are two general ways in which the bacteria can be made available to the developing root hairs: seed or soil implant treatments. With the seed treatment method, it is assumed that the bacteria will stick to the seed and survive until they can enter the developing root hairs. But, Frederick points out, not all of them stick and not all of those that do stick survive. However, by using a gum arabic "food" (a water soluble gum) both the sticking and survival rates are increased (Vincent; Frederick).

The soil implanting treatment may be another way to circumvent the problems associated with the seed treatment method. Since the bacteria is applied to the soil in close proximity to the seed, the problem of getting the bacteria to stick does not exist. To the extent that up to 10,000 times the amount of bacteria that is applied via the seed treatment can be applied with the soil implant method, the number that survive may be increased ("Inoculants Help Growers Achieve Top Yields"). Soil implanting may be most beneficial on lands newly planted to soybeans where naturally occurring effective bacteria are small in number.

The most effective on-farm seed treatment is the slurry method (Scott, p. 61). A combination of the inoculum and water is mixed with the seed and allowed to dry before planting.

Alternating layers of inoculum and seed in the seed hopper at planting time is a more common practice (Scott, p. 61). The shaking of the planter as the seed feeds down through the layers of inoculum will mix the two.

Planter attachments can be utilized with the soil implant method. For example, unused insecticide or herbicide boxes can be filled with a powder or granule inoculant and applied close to the seed as it is planted.

Planting

Generally, soybean varieites adapted to the area where grown can be planted any time in May (Thompson). Earlier planting usually increases the difficulty of obtaining good stands and controlling weeds. Late planted soybeans generally are more susceptible to lodging and may not mature before a killing frost (Scott, pp. 52-53). However, delayed planting is advisable if soil temperatures are below 50°F, the threshold temperature necessary for germination.

Yield responses of adapted varieites vary little for May planting dates (Caldwell, p. 212). This is an advantage of a soybean crop in that it allows more efficient use of the operator's time and machinery on other crops.

Depth of planting influences the number of seedlings that emerge and the length of time from planting to emergence (Hanway). Temperatures are cooler at greater depths and growth is slower. In addition, deeper planted soybeans have more difficulty penetrating a surface crust. When emergence is slowed, the danger of insect, disease, and herbicide damage increases. For these reasons, the maximum depth from which soybeans can successfully emerge is about two inches.

The seeding rate primarily depends upon varietal characteristics. Generally, the tall, large-leafed varieties produce optimal yields in lower populations than the shorter, small-leafed types (Caldwell, p. 215). Those varieties susceptible to lodging or that tend to branch may do better at lower populations as well (Scott, p. 53). The soybean has a tremendous ability to compensate for population variations, however. Therefore, Scott (p. 53) says, "the penalty for over or underplanting is relatively small".

Row width influences the seeding rate as well. Results indicate that yields are higher when soybeans are planted in narrow rows with higher plant populations as compared to wider rows regardless of the planting rate (Scott, p. 55-56; Thompson). These yield differences are probably due to the larger number of plants, more uniformly distributed per acre, resulting in greater light interception and photosynthesis. Consequently, more beans develop.

Solid seeding soybeans is receiving more attention. Thompson suggests that a narrow-leafed, upright variety planted with a grain drill may give highest yields provided weeds are not a problem.

Weed Control

The slow early growth of soybeans increases weed competition for nutrients, water, and light. This may lead to a substantial decrease in soybean yields. However, with the proper use of mechanical and chemical tools, weeds can be controlled.

Mechanical means of weed control consist primarily of the tandem disk or harrow, the rotary hoe, and the cultivator. The disk or harrow can effectively be used prior to planting to kill weeds. However, this operation brings to the surface ungerminated weed seed and causes soil moisture losses (Scott, p. 115).

The effectiveness of the rotary hoe in controlling weeds is dependent upon timeliness and speed of operation (Scott, pp. 115, 117). Germinated weeds which have yet to emerge or are small are thrown out of the ground, provided the ground speed is sufficient. Some of the soybean seedlings will be damaged as well. However, Thompson indicates that unless ten percent of the soybeans are killed, the hoeing operation has not been effective in killing weeds. The soybean seedling losses can be alleviated by increasing the planting rate.

The cultivator does a good job of controlling larger weeds between the rows. When used it should be set to run shallow to avoid damage to the soybean roots. Soybeans should not be hilled or ridged when cultivated. It is difficult to harvest the branches close to the soil in the "valleys".

Chemical tools may substitute for or complement the mechanical weed control methods. Pre-emergence and post-emergence herbicides have been developed to control weeds in soybean fields. However, each herbicide kills some weeds better than others.

Normally pre-emergence herbicides are broadcast and worked into the soil. Incorporation is required because the herbicides are lost to the air or damaged by the sun if left on the surface.

The soybean plant can withstand direct contact with some herbicides, but only on the base of the stem and not on the leaves. For this reason, post-emergence herbicides must be applied carefully.

Diseases and Insects

The prevalence of soybean diseases and insect pests depends upon environmental conditions and host plant reaction (Caldwell, p. 459). Therefore, some diseases and insects are geographically limited while others are widespread. Scott (pp. 128-144) and Caldwell (pp. 459-572) describe the different diseases and insects which affect soybeans and offer some suggestions in interpreting the plant symptoms to identify the specific culprit.

Cultural methods are generally applicable to control most diseases. Removal or destruction of crop residue, proper soil preparation and drainage, good fertility, crop rotation, and use of disease-resistant varieties help to prevent and control diseases (Caldwell, p. 459).

Generally, insect control is corrective rather than preventative in nature. Chemical insecticides are used to suppress insect outbreaks that otherwise could result in economic losses (Caldwell, p. 564).

Harvesting

Harvesting soybeans in an important factor in profitable soybean production. Studies indicate that an average of ten percent of the soybean crop is left in the field (Kansas State University Cooperative Extension). Most of these losses are caused by the cutterbar and reel mechanisms of the combine.

Cutterbar and reel position should be coordinated with ground speed for minimum disturbance to standing plants. In this way shatter losses are minimized as well as the number of pods left on uncut or lodged stalks.

Special attachments have been engineered to help limit harvesting losses. Floating cutterbars and reels and headers specific for harvesting soybeans are examples.

Soybeans are most efficiently harvested at about 12 percent moisture content (Martin, p. 702). At this moisture level, soybeans can be safely stored without drying. If harvested at a lower moisture content, shatter losses and cracking of the seed increase.

Soybeans can be harvested at up to a 19 percent moisture content without excessive damage to the seed (Kansas State University Cooperative Extension Service). However, high moisture beans are not safe for storage unless they are dried.

Summary

Soybeans, the "Golden Bean of Asian Antiquity", are a warm-season crop adapted to many geographic areas, soil types, and climates. However, adequate water, appropriately distributed throughout the growing season, is essential.

Tillage requirements for soybeans are similar to other row crops. Preparing a level seedbed promotes uniform seedling emergence and aids in reducing harvesting losses.

Soybeans do respond to applied fertilizer when the soil cannot meet the nutritional requirements. Nitrogen fertilizer is essential in uninoculated soybeans. However, if inoculated seed is used and nodule development and nitrogen fixation are adequate, only a relatively small amount of starter nitrogen may be required.

Shallow, narrow-row planting of adapted varieties around the middle of May should result in highest yields. Narrow rows may also help limit the competition from weeds; however, mechanical and/or chemical weed control methods are usually required. Soybeans should be harvested carefully with well adjusted equipment at about a 12 percent moisture content.

CHAPTER 3

THE AGRONOMIC FEASIBILITY OF SOYBEAN PRODUCTION IN OREGON

Soybeans are not new to Oregon. Experiments involving soybean production date back to 1938 in the Ontario area ("Soybeans: New-Old Crop for Oregon", p. 3). Intermittent experiments have been conducted in every decade since in either the Ontario, Hermiston or Willamette Valley areas.

Two major problems emerged from these investigations. Some of the varieties grown did not fully mature and the lack of effective weed control limited yields.

These problems may not be as serious today. The development of new varieties and herbicides hold some promise. However, interest in the possibility of producing soybeans in the state has arisen primarily for the reasons mentioned in Chapter One.

Environmental factors determine where soybeans can be grown while economic factors determine where they will be grown. Before looking at the economic issues involved, the potential for soybean production in Oregon is evaluated from a purely agronomic standpoint.

Oregon's Climate

The single most important factor influencing the climate of Western Oregon and possibly the entire state is the Pacific Ocean (Sternes, p. 1). The maritime winds prevail out of the west, moderating winter and summer temperatures while bringing moisture laden air inland.

The mountains which form the Coast and Cascade ranges in Western Oregon act as barriers to the marine air masses. Consequently, the air rises and cools resulting in some of the heaviest annual rainfalls in the

United States to the west of the Cascade range while substantially limiting the moisture available for distribution east of the Cascades (Sternes, p. 1).

Latitude and elevation are two other factors which influence Oregon's climate and hence, the agronomic feasibility of soybean production. Length of the growing season, day length, and temperatures are affected by these geographic elements and influence the crops and crop varieties which can be grown.

Potential Soybean Producing Regions in Oregon

Region Identification

Six regions have been identified as potential soybean producing areas (Fitch). The regions are depicted in Figure 8 and assigned the following names for identification purposes: (1) Medford; (2) Willamette Valley; (3) The Dalles; (4) Columbia Basin; (5) Union; and (6) Ontario. Other Oregon areas may possess the potential for soybean production as well (e.g., Roseburg vicinity), however, they are not considered because of the limited acreage involved.

Climatic Elements

Some of the major climatic elements for each of the identified regions are listed in Table 1. Those reporting stations selected were assumed to be most representative of the regions.

The length of the growing seasons (Table 1) was estimated from Eichhorn, et al. The length of the growing season is not simply the summation of days from the last spring frost to the first fall frost. Some crops can withstand temperatures lower than 32°F, thus the effective growing season is longer. On the other hand, rainfall distribution, soil moisture, and soil temperature can shorten the growing season even though

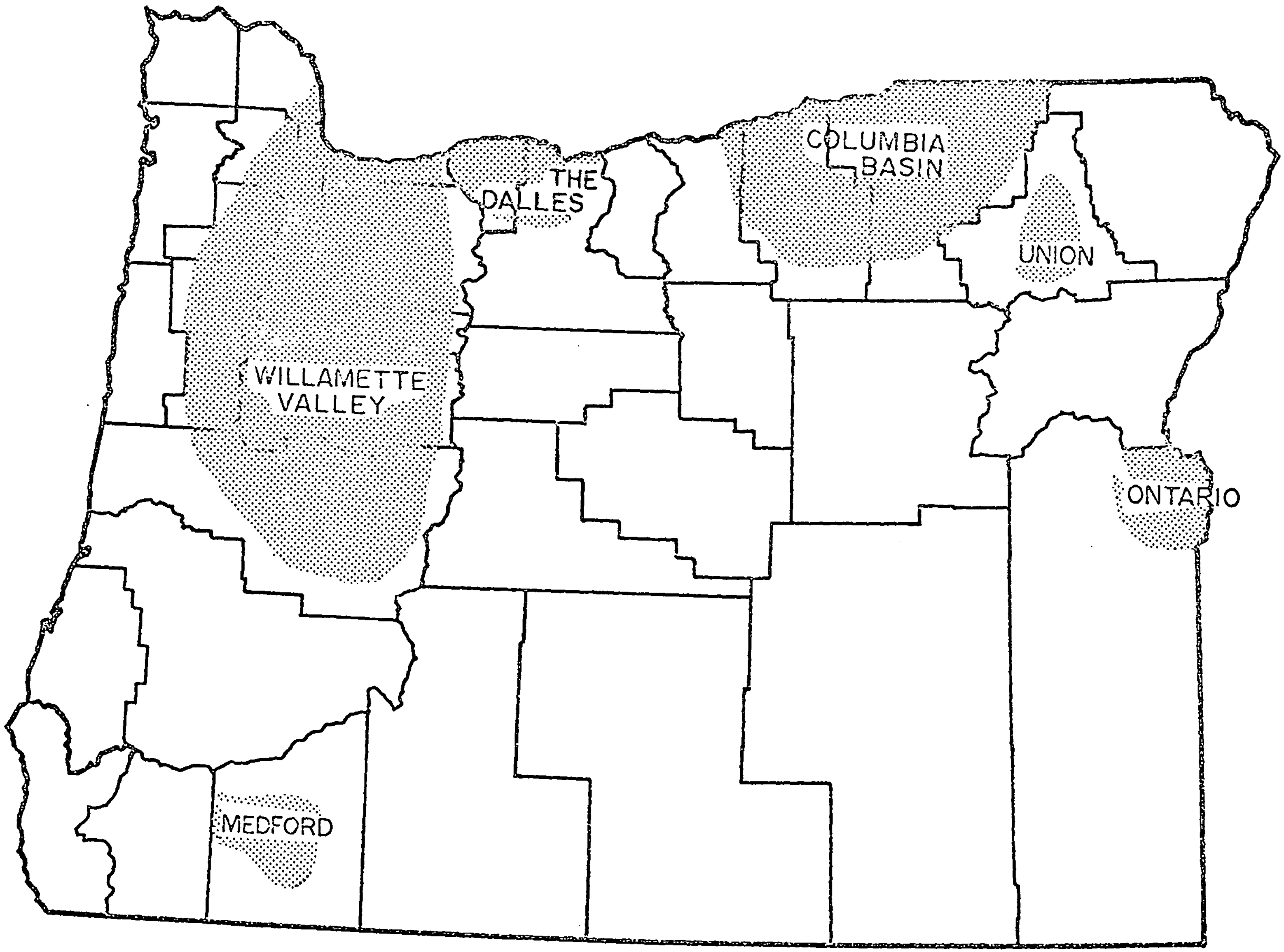

Figure 8. Potential soybean producing regions in Oregon

Table 1. Climatic and Agronomic Characteristics of Potential Soybean Producing Regions in Oregon[a/].

Region	Reporting station	Growing season (days)	Average annual rainfall (inches)	Growing season average rainfall (inches)	Growing season average high temperature (°F)	Growing season average low temperature (°F)	Growing season average temperature (°F)	Growing season average growth degree days (GDD)	1974-1976 average annual row crop acreage (acres)
Willamette Valley	Salem airport	160-220	39.1	7.8	72.3	45.9	59.1	2,008	132,371
The Dalles	Hood River Exp. Sta.	100-190	31.1	4.4	73.5	47.4	60.4	1,900	142
Columbia Basin	Hermiston	130-180	9.4	2.3	80.1	51.1	65.6	2,705	123,549
Union	LaGrande	120-170	20.2	5.3	79.5	49.3	64.4	1,546[b/]	13,800
Ontario	Malheur Exp. Sta.	130-170	10.4	3.2	80.2	50.4	65.3	2,443[c/]	72,333
Medford	Medford airport	150-200	21.3	4.9	78.3	46.7	62.5	2,588	1,096

[a/] Sources: Eichhorn, et. al.; Pacific Northwest River Basin Commission, Meteorology Committee; Oregon State University Extension Service, County Statistics Program. A growing season of average duration was used to measure the growing season averages presented.

[b/] The Union reporting station was used to calculate the GDD for the Union region.

[c/] The Vale reporting station was used to calculate the GDD for the Ontario region.

the temperature may never drop to the freezing level. Further, on any given date there is some probability of frost occurring on or after that date. The amount of risk a farmer is willing to take as related to the probability of frost damage also influences the length of the growing season. For these reasons, as well as accounting for the effects of elevation and latitude differences within each region, the growing season is given as a range of days.

The length of the growing season is an important consideration in soybean variety selection. The variety grown should mature soon enough to avoid possible adverse fall weather conditions yet be full-season for highest yields (Thompson).

The annual rainfalls appear to indicate that the Willamette Valley and The Dalles regions receive sufficient total precipitation to produce soybeans. However, the growing season rainfall levels indicate that irrigation would be required for soybean production in all regions. Soybean production then, would be restricted to areas within each region having soil types conducive to and water available for irrigation.

Temperature is also an important climatic factor affecting the growth and development of soybeans. The minimum, optimum, and maximum temperatures for growth are 50°, 75° to 77°, and 90°F respectively (Chapman, p. 346; Martin, p. 693). Growth, yield and seed quality are reduced when temperatures are either too high or too low.

Soybeans require about 4,300 growth-degree days (or heat units) during the growing season to mature (Martin, p. 693). The degree-days are calculated by subtracting the minimum growing temperature (50°F for soybeans) from the average daily temperature and summing the positive daily differences throughout the growing season.

The 4,300 degree-days required for soybeans to mature is probably an average figure for the major soybean producing areas. It is higher than any of those reported in Table 1. However, Martin (p. 37) indicates that the number of degree-days required to mature a particular crop differs by region. Fewer degree-days are required in a cool region where high temperatures do not retard plant growth.

Most of the literature does not talk about degree-day requirements for soybeans. In fact, Martin was the only author reviewed which even mentioned the subject, and then only briefly. About all that can be said about the degree-day data reported in Table 1 is that those regions receiving more heat units probably have an advantage over the others relative to soybean maturation.

Another important climatic aspect which is not listed in Table 1 but should be addressed is humidity. During the growing season, the relative humidity is generally low throughout Oregon. Low humidity increases the likelihood of shattering losses. Varieties selected should probably have a high degree of shattering resistance to avoid harvesting losses.

The three year average annual row crop acreages reported in the last column of Table 1 were taken from the Oregon State University Extension Service County Statistics Program. A three year average was used to account for those years in which non-row crops such as small grains and hay were grown in rotation with row crops. These figures measure row crop adaptability within each region.

The Willamette Valley

The Willamette Valley, in northwestern Oregon, is bounded on the north by the Columbia River and extends southward to the Eugene-Springfield area. The Coast and Cascade mountain ranges form the western and eastern boundaries respectively.

This area includes nearly five million acres of which about two million are suited for cultivated crops or improved pasture (Oregon's Long-Range Requirement for Water-Willamette Drainage Basin, p. 1). The number of acres suited to soybean production is substantially less when cultivation, topography, drainage, irrigation suitability, and irrigation water characteristics are considered. The lands appearing to be best suited for soybeans are the deep, well drained soils which are close to a source of irrigation water on the Valley floor (Hickerson). Considering these soil and water factors, a more realistic estimate of the acreage on which soybeans could feasibly be grown is probably the average annual row crop figure (about 130,000 acres) reported in Table 1.

The climate of the Willamette Valley is cool and temperate. Influenced strongly by marine air, summers are warm and dry while winters are cool and wet. The growing season ranges from 160 to 220 days. During this time about 20 percent (7.8 inches) of the average annual precipitation falls. The average growing season temperature is about 59°F with the average growing season high and low temperatures being about 72°F and 46°F respectively. Precipitation and temperature vary with elevation and location. Soils are generally dry for a prolonged summer period.

The potential for soybean production in the Willamette Valley could be limited for two reasons. First, the effective growing season is probably lower than the range indicated in Table 1 because the distribution of the annual rainfall is such that late spring and early fall rains are not uncommon. Soybeans would have to be planted after the spring rains and harvested before the fall rains to avoid poor seedling emergence and harvesting losses. Second, a longer growing season may be required in order for soybeans to mature because of the cool climate. However, because of the apparent ease with which soybeans fit into existing cropping rotations, the generally suitable soils, and the importance of this area to Oregon's agriculture, the Willamette Valley is evaluated in this study as a potential soybean producing region.

The Dalles Area

The Dalles Area in northcentral Oregon includes most of Hood River County and the northern part of Wasco County. The area is bounded on the north by the Columbia River, on the west by the Cascade mountains, and on the south and east by roughly Fifteen Mile Creek (Oregon's Long-Range Requirements for Water - Hood Drainage Basin, pp. 2, 5).

The area includes about 654,500 acres. Major land uses include small grain production, forestry, livestock grazing and orchards. About one-fourth of the region is in cropland (Oregon's Long-Range Requirements for Water - Hood Drainage Basin, p. 2). The lands appearing to be suited to soybean production contain deep, level, well-drained soils close to a source of irrigation water.

The climate of The Dalles Area varies substantially from location to location. Both marine and continential air masses as well as elevation are influential. The growing season ranges from 100 to 190 days, decreasing with rising elevations. Annual rainfall ranges from 130 inches in the Cascades to ten inches at the eastern edge of the region. The Hood River Experiment Station receives about 31 inches annually with only 4.4 inches falling during the growing season. The average growing season temperature is about 60°F while the average growing season low and high temperatures are about 47°F and 74°F respectively.

The potential of soybean production in The Dalles Area appears to be very limited. The average of 142 row crop acres grown annually is a good indication that soybeans would not fair well. The combination of the generally steep slopes with soybean's mellowing effect on soils could lead to serious erosion problems. The relatively cool climate and short growing season could make it difficult for soybeans to mature. Although there may be some areas in which soybean production is agronomically feasible, they probably amount to only a small number of acres. Thus, The Dalles Area is not considered as a potential soybean producing region in the present study.

The Columbia Basin

The Columbia Basin, in northcentral Oregon consists primarily of lands in the northern portions of Morrow and Umatilla Counties. Northeastern Gilliam and minor sections of Wallowa and Union Counties are also included.

The area includes about 2.9 million acres of which about one million are cultivated, mostly for dryland wheat (Oregon's Long-Range Requirements for Water - Umatilla Drainage Basin, pp. 1, 3). Approximately 180,000 acres may be suited for soybean production considering soil and water characteristics. Wind erosion on the sandy soils could be a problem. However, managerial practices involving irrigation scheduling and cover crops would help limit the hazard of wind erosion.

The climate of the Columbia Basin is generally cool and temperate with cold winters and hot, dry summers. The growing season ranges from 130 to 180 days. Precipitation is as low as seven inches annually in the northwest portion increasing up to 15 to 20 inches at higher elevations to the south and east. Approximately one-fourth of the annual precipitation falls during the growing season. The growing season average low and high temperatures are within the limits for soybean production.

The potential for soybean production in the Columbia Basin appears to be quite good. Cool night-time temperatures and wind erosion could be minor, but not serious, problems. Soils appearing to be suited for soybeans exist close to a source of irrigation water. A relatively large acreage of row-crops already grown implies that the adaptation of soybeans into existing rotations may be easily handled. Therefore, the Columbia Basin is considered as a potential soybean producing region in this study.

The Union Area

The Union Area in northeastern Oregon primarily consists of the Grande Ronde Valley in Union County. The area includes approximately 470,000 acres. Most of the Valley is used for dryland small grain production and mixed farming. Irrigation is becoming more popular with about 120,000 acres being well suited for irrigation (Oregon's Long-Range Requirements for Water - Grande Ronde Drainage Basin, pp. 14-16, 29-30).

The climate of Union Area is characterized by warm, dry summers, and cold, wet winters. The growing season ranges from 120 to 170 days with 140 days being typical for the main valley. About 20 inches of precipitation falls annually, a fourth of which occurs during the growing season. The average growing season temperature is about 64°F with the low and high growing season averages being about 49°F and 80°F respectively.

The occurrence of saline-sodic soils, the somewhat short growing season and cool temperatures, along with wind erosion potential probably limits the potential for soybean production. Although there undoubtedly exist some parts of the area in which soybean production is agronomically feasible, they are a limited acreage. Thus, the Union Area is not evaluated as a potential soybean producing region.

The Ontario Area

The Ontario Area, in east-central Oregon, consists of the northeast corner of Malheur County. It includes more than 500,000 acres, of which approximately 120,000 are suited to soybean production considering soil and climate factors (Oregon's Long-Range Requirements for Water - Malheur River Drainage Basin, pp. 17-20, 34-36).

The climate of the Ontario Area is characterized by hot summers, cold winters, and low precipitation. The growing season ranges from 130 to 170 days. Annual precipitation averages about ten inches, a third of which falls during the growing season. The average temperature during the growing season is about 65°F with the average low and high growing season temperatures being about 50°F and 80°F respectively.

The potential for producing soybeans in this area appears to be quite good. Soybeans could fit well into existing cropping rotations which primarily consist of row-crops. The growing season temperatures, although somewhat cool, seem to be adequate. Hence, the Ontario Area is evaluated as a potential soybean producing region in the study.

The Medford Area

The Medford Area, in southwestern Oregon, consists of the west-central part of Jackson County. Over 450,000 acres make up the entire area but because of the slope and lack of source of irrigation water, only about 33,000 acres are suited to soybean production (Oregon's Long-Range Requirements for Water - Rogue Drainage Basin, pp. 21-22, 34-35).

The Medford Area climate is characterized by cloudy, wet winters and warm, dry summers. The growing season ranges from 150-200 days. The average annual rainfall is about 21 inches. Only about five inches of precipitation fall during the growing season. The average temperature throughout the growing season is about 63°F. The growing season's average low and high temperatures are about 47°F and 78°F respectively.

The generally cool night-time temperatures, lack of irrigation water, and relatively steep slopes appear to limit the potential for soybean production in this area to only a small acreage. The Medford Area is not considered as a potential soybean producing region.

Conclusion

A detailed agronomic feasibility study involving field trails in each of the six identified Oregon regions would be needed for a thorough assessment of their potential for soybean production. Climatic, soil, and water characteristics, other than those mentioned above, may be influential and probably would be accounted for in such trials. However, based on the agronomic and climatic data presented, it appears that the Willamette Valley, the Columbia Basin, and the Ontario Area are the most likely candidates for soybean production in Oregon. Whether or not soybeans will be grown in these regions depends upon the economic feasibility of soybean production. This is the topic of the next chapter.

CHAPTER 4

THE COMPETITIVE POSITION OF SOYBEANS IN OREGON

Demonstrated below are the conditions under which soybeans are able to compete with existing crops in the Willamette Valley, the Columbia Basin, and the Ontario Area. Two approaches are taken. First, the competitive position of soybeans is determined on a regional basis. This involves: (1) identifying those crops with which soybeans would be in competition; (2) estimating the returns to land for these competing crops and soybeans; and (3) projecting crop rotations which would maximize the returns to land assuming various soybean price levels. The second approach is a break-even analysis that compares soybeans with selected alternate crops.

Selection of Competing Crops

The price required for soybeans to become a part of existing cropping patterns is related to other crop alternatives. Soybeans would be competing with these alternate crops for the farmer's cropland. To effect a shift in resources to soybean production, the economic returns to land generated from cropping patterns including soybeans must at least equal the returns to land from existing cropping patterns. This assumes that farmers are profit motivated and ignores any change in risk due to changes in the crops grown.

The first step in this analysis is to identify those crops most likely to be in competition with soybeans in the Willamette Valley, the Columbia Basin, and the Ontario Area. Specific criteria were established in order to make this selection. The competing crops had to:

(1) be the major irrigated crops presently grown;

(2) be grown in areas within each region having soils and climates suited to soybean production; and

(3) make use of machinery and equipment similar to that required for soybean production.

Using these criteria and consulting various Extension agents located within the study areas, the competing crops were identified. For the Willamette Valley the crops included wheat, alfalfa, silage corn, sweet corn, and bush beans. Wheat, alfalfa, field corn, sugarbeets, potatoes, and drybeans were the competing crops selected for the Columbia Basin. For the Ontario Area, wheat, alfalfa, field corn, sweet corn, sugarbeets, potatoes, and onions were selected. Other crops may be competitors for some individual farming situations.[1/] For a general analysis within each region, however, the above crops are probably the principal competitors given the aforementioned criteria.

Budgeting Net Returns for the Competing Crops and Soybeans

Budgeting Procedures and General Assumptions

Typical costs and returns were estimated for the competing crops identified based on 1976 costs and normal prices and yields. Cost data were also developed for establishing alfalfa in each of the regions and planting cover crops in the Columbia Basin. A cost for land investment was not included in these budgets. The result is that the net returns

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1/ The technique which can be adapted to the individual situation is described in "The Competitive Position of Soybeans: A Break-Even Approach" which follows.

estimated for each crop represents what is left to provide the owner with a return to his investment in land after all other costs of production are paid.

The basic information regarding cultural operations was determined from existing enterprise cost studies prepared by the Oregon State University Cooperative Extension Service. Additional information regarding machinery, irrigation, and production input costs and requirements were obtained from local suppliers, machinery dealers, various Extension agents, and others familiar with irrigated crop production in each of the regions.[2/]

Certain general assumptions were made in the development of these data. A commercially viable farm consisting of 600 to 700 acres of irrigated cropland was chosen to be representative for each of the three regions. The owner/operator of this farm uses above average management efficiency and sound agronomic practices. He also has the necessary resources with which to grow soybeans, as well as any of the competing crops within each region.

These data developed are representative of presently irrigated crops grown in the three regions, however, they do not necessarily represent any one farm situation. Therefore, caution must be used by the individual farmer in using these data for his particular operation.

Price and Yield Assumptions

Given the variability in prices over the years (and even within a single year) it is indeed difficult to determine what on-farm prices to

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2/ Production practices, yields, prices, and cost data were developed and reviewed in cooperation with Linn County Extension Agent Hugh Hickerson, Umatilla County Extension Agent Luther Fitch, Malheur County Extension Agent Oris Rudd, and Extension Farm Management Specialist Dr. A. Gene Nelson.

use for the competing crops in this analysis. Recent prices, yields, and acreages of the competing crops are presented in Table 2. The price assumptions used in the budgets, consistent with 1976 costs, were based on these observed price data. The assumed prices, presented in Table 3, represent normal prices that might be expected over the next three to five years measured in 1976 dollars.

Crop yields are also subject to a degree of variability. However, given a better than average manager of a commercially viable farming enterprise, the yield assumptions in Table 4 can be considered normal. In determining these yields, no distinction has been made between the productivities of the various soil types within each region. Adequate irrigation water was assumed to be available.

Production Cost Assumptions

Production input and machinery cost assumptions are listed in Appendix Tables B-1 and B-2. Fertilizer, seed, chemicals, etc. were charged at 1976 prices. Machinery costs were averaged over the lives of the machines assuming they were purchased in 1976. With a few exceptions, all machinery was assumed to be owned by the operator. The fertilizer applicator and land plane were rented. Chemical applications and delivery of the harvested products were custom hired. Interest on machinery, equipment, and operating capital was charged at nine percent. Regional differences and economies of size associated with the production input and machinery costs were ignored.

Labor was charged at rates comparable to wages paid for farm labor. A separate charge was included for the managerial input of the operator.

Irrigation systems were chosen considering those that are technically feasible and typically used. A hand-move system, a center-pivot system,

Table 2. Yields, Prices, and Acreages for Selected Competing Crops in the Willamette Valley, the Columbia Basin, and the Ontario Area, 1973-1976[a]

	Year	Alfalfa Hay Yield (T./a.)	Alfalfa Hay Price ($/T.)	Alfalfa Hay Acreage (1000 a.)	Bush Beans Yield (T./a.)	Bush Beans Price ($/T.)	Bush Beans Acreage (1000 a.)	Sweet Corn Yield (T./a.)	Sweet Corn Price ($/T.)	Sweet Corn Acreage (1000 a.)
Willamette Valley	1973	3.8	51.11	34.27	4.4	110.08	39.02	6.9	38.77	35.46
	1974	4.1	62.78	30.20	4.6	196.37	41.55	7.1	75.91	33.55
	1975	4.1	61.67	31.15	4.2	160.26	34.33	7.7	69.33	34.65
	1976	4.5	68.23	29.90	4.8	126.73	24.53	8.0	59.00	31.95
Columbia Basin	1973	3.4	48.67	47.00						
	1974	4.5	62.67	49.30						
	1975	5.1	55.67	52.70						
	1976	5.7	66.00	47.00						
Ontario	1973	4.2	50.00	63.00				6.8	28.50	5.50
	1974	4.5	50.00	60.00				6.8	42.00	5.35
	1975	4.5	50.00	61.00				7.3	54.00	4.60
	1976	4.5	55.00	61.00				8.0	42.00	3.50

	Year	Corn[b] Yield (T.or bu/a.)	Corn[b] Price ($/T.or bu.)	Corn[b] Acreage (1000 a.)	Wheat[c] Yield (bu./a.)	Wheat[c] Price ($/bu.)	Wheat[c] Acreage (1000 a.)	Drybeans Yield (cwt./a.)	Drybeans Price ($/cwt.)	Drybeans Acreage (1000 a.)
Willamette Valley	1973	22.1	11.50	8.48	84.1	3.96	143.00			
	1974	21.9	15.71	11.40	72.0	4.83	203.50			
	1975	20.8	17.69	13.38	67.7	3.84	231.90			
	1976	21.3	19.25	14.40	63.8	2.72	251.55			
Columbia Basin	1973			0.00	22.3	4.05	533.50	17.0	17.00	.66
	1974	100	3.90	1.10	34.3	4.67	593.70	16.7	35.00	1.84
	1975	115	3.50	2.00	33.2	4.28	508.90	18.3	22.00	1.90
	1976	135	2.90	2.50	47.7	2.88	658.50	17.2	15.33	.65
Ontario	1973	86.0	3.30	5.00	60.0	4.10	20.00			
	1974	85.0	3.90	5.00	55.0	4.50	30.00			
	1975	95.0	3.60	5.00	80.0	3.60	32.00			
	1976	80.0	2.60	6.00	75.0	2.40	34.00			

	Year	Potatoes Yield (cwt.a.)	Potatoes Price ($/cwt.)	Potatoes Acreage (1000 a.)	Sugarbeets Yield (T./a.)	Sugarbeets Price ($/T.)	Sugarbeets Acreage (1000 a.)	Onions Yield (cwt./a.)	Onions Price ($/cwt.)	Onions Acreage (1000 a.)
Willamette Valley	1973									
	1974									
	1975									
	1976									
Columbia Basin	1973	420.0	3.08	11.13	21.6	16.00	1.75			
	1974	370.0	4.20	19.07	25.0	40.00	1.00			
	1975	480.0	3.64	28.53	25.0	40.00	1.20			
	1976	493.5	2.28	35.76	25.0	20.00	1.15			
Ontario	1973	340.0	1.65	14.90	25.0	17.80	17.25	480	4.00	5.50
	1974	330.0	4.00	13.50	25.0	40.00	10.60	460	3.50	5.74
	1975	320.0	3.25	10.30	24.0	30.00	16.60	420	4.50	5.65
	1976	370.0	2.97	10.80	25.5	20.00	13.30	420	2.00	6.30

a/ Source: Original County Extension Agents estimates, County Statistics Program, Oregon State University Extension Service. Yield and price data are simple averages of the data for those counties within each region.

b/ Silage corn data presented for the Willamette Valley, grain corn data for the Columbia Basin and the Ontario area.

c/ Includes irrigated and dryland wheat production.

Table 3. Price Assumptions for the Competing Crops in the Willamette Valley, the Columbia Basin, and the Ontario Area.

Crop	Unit	Price ($/unit) Willamette Valley	Columbia Basin	Ontario Area
Wheat	bu.	3.25	3.25	3.25
Silage corn	Ton	19.00	-	-
Sweet corn	Ton	60.00	-	55.00
Bush beans	Ton	140.00	-	-
Alfalfa	Ton	65.00	65.00	60.00
Sugarbeets	Ton	-	25.00	25.00
Potatoes	Ton	-	55.00	55.00
Grain corn	bu.	-	3.00	3.00
Drybeans	cwt.	-	18.00	-
Onions	cwt.	-	-	3.75

Table 4. Yield Assumptions for the Competing Crops in the Willamette Valley, the Columbia Basin, and the Ontario Area.

Crop	Unit	Yield (units/acre)		
		Willamette Valley	Columbia Basin	Ontario Area
Wheat	bu.	100	90	100
Silage corn	Ton	25	-	-
Sweet corn	Ton	8.6	-	8
Bush beans	Ton	4.6	-	-
Alfalfa	Ton	6	7	6
Sugarbeets	Ton	-	28	27
Potatoes	Ton	-	25	17.5
Grain corn	bu.	-	155	130
Drybeans	cwt.	-	18	-
Onions	cwt.	-	-	450

and a siphon system were selected to irrigate the crops under consideration in the Willamette Valley, the Columbia Basin, and the Ontario Area, respectively. Investment requirements and ownership costs were calculated assuming these irrigation systems were purchased at 1976 prices (Reed; "Enterprise Cost Studies"; Nelson and Holst).

Irrigation water was assumed available through irrigation districts in the Columbia Basin and the Ontario Area and from wells in the Willamette Valley. The cost of water and the associated costs of its on-farm distribution were explicitly included.

Soybean Budget Data

The cost of producing soybeans was estimated for each region using the same assumptions as for the competing crops. The results are presented in Tables 5 through 7.

Soybeans were assumed to be grown as a row crop. In this context, the cultural operations required would be similar to those performed in the production of other row crops presently grown in each region. The general agronomic aspects of soybean production were consulted to verify that these cultural operations conformed to the general guidelines presented in Chapter Two.

Considering the limited commercial production of soybeans within each region, it is difficult to determine the production input requirements. General guidelines were again consulted. The fertilizer and herbicide rates used in these budgets should provide adequate nutrients and weed control, respectively. However, the individual farmer may need to adjust these data to his particular operation. The seeding rate may also need to be adjusted depending on the variety grown and whether soybeans are drilled or planted in rows (Fitch; Thompson, p. 4).

Table 5. Estimated Cost of Producing Soybeans in the Willamette Valley

Item	Labor Hrs.	Labor Cost ($)	Machinery & Equipment Operating ($)	Machinery & Equipment Ownership ($)	Other Item	Other Cost ($)	Total cost ($)
Cultural Operations							
Lime[a]					Custom	6.79	6.79
Fertilize	.171	.77	.27	.49	Spreader rental	.75	
					20#N	5.00	
					35#P	16.80	
					20#K	1.80	
					20#S	3.60	29.48
Disc	.143	.64	.99	1.48			3.11
Plow	.209	.95	1.34	3.84			6.13
Disc & pack (2X)	.286	1.28	2.20	3.55			7.03
Herbicide					½# Lorox	2.13	
					1½ qt.Lasso	6.00	
					Custom Appl.	2.25	10.38
Disc & pack (2X)	.286	1.28	2.20	3.55			7.03
Plant	.183	.82	.70	1.80	1 bu. seed	18.00	21.32
Cultivate	.172	.77	.70	1.51			2.98
Irrigate	8.0	28.00	29.16	35.00			92.16
Harvest							
Combine	.402	1.81	5.07	11.44			18.32
Haul (30 bu. @ 8¢/bu.)					Custom	2.40	2.40
Other Charges							
Land taxes[b]						11.00	11.00
Operating capital interest[c]						6.50	6.50
Management [d]						8.99	8.99
Overhead [e]						6.74	6.74
Total Non-Land Costs Per Acre		36.32	42.63	62.66		98.75	240.36

a/ Lime charge amortized over 4 years @ 9%.

b/ Farm use value.

c/ Cash expenses were assumed outstanding for half a year with a 9% annual interest charge.

d/ Estimated at 4% of all costs except land investment and overhead.

e/ Estimated at 3% of all costs except land investment and management.

Table 6. Estimated Cost of Producing Soybeans in the Columbia Basin

Item	Labor Hrs.	Labor Cost ($)	Machinery & Equipment Operating ($)	Machinery & Equipment Ownership ($)	Other Item	Other Cost ($)	Total cost ($)
Cultural Operations							
Fertilize	.171	.77	.27	.49	Spreader rental	.75	
					50#N	12.50	
					50#P	24.00	
					50#K	4.50	43.28
Disc	.143	.64	.99	1.48			3.11
Chisel plow (2X)	.230	1.04	1.39	3.15			5.58
Disc & pack	.143	.64	1.10	1.77			3.51
Herbicide					1 qt. Treflan	7.75	
					2 qt. Eptan 7E	12.50	
					Custom Appl.	2.25	22.50
Disc and pack	.143	.64	1.10	1.77			3.51
Plant	.183	.82	.70	1.80	1-1/3bu. seed	24.00	27.32
Cultivate (3X)	.516	2.31	2.10	4.53			8.94
Irrigate	1.584	5.54	13.73	43.55	Water	12.00	74.82
Harvest							
Combine	.402	1.81	5.07	11.44			18.32
Haul (40 bu. @ 8¢/bu.)					Custom	3.20	3.20
Other Charges							
Misc. labor	.300	1.05					1.05
Truck (2-ton)	.300	1.35	1.31	3.12			5.78
Pickup	.400	1.40	1.23	1.69			4.32
Land taxes a/						10.00	10.00
Operating capital interest b/						6.77	6.77
Management c/						9.68	9.68
Overhead d/						7.26	7.26
Total Non-Land Cost Per Acre		18.01	28.99	74.79		137.16	258.95

a/ Farm use value.

b/ Cash expenses were assumed outstanding for half a year with a 9% annual interest charge.

c/ Estimated at 4% of all costs except land investment and overhead.

d/ Estimated at 3% of all costs except land investment and management.

Table 7. Estimated Cost of Producing Soybeans in the Ontario Area

Item	Labor Hrs.	Labor Cost ($)	Machinery & Equipment Operating ($)	Machinery & Equipment Ownership ($)	Other Item	Other Cost ($)	Total cost ($)
Cultural Operations							
Fertilize	.171	.77	.27	.49	Spreader rental	.75	
					35#N	8.75	
					45#P	21.60	
					43#K	3.87	36.50
Disc	.143	.64	.99	1.48			3.11
Chisel	.115	.52	.69	1.57			2.78
Plow	.209	.95	1.34	3.84			6.13
Disc & pack	.143	.64	1.10	1.77			3.51
Herbicide					1 qt. Treflan	7.75	
					2 qt. Eptam 7E	12.50	
					Custom Appl.	2.25	22.50
Disc & pack	.143	.64	1.10	1.77			3.51
Plant	.183	.82	.70	1.80	1-1/3 bu.seed	24.00	27.32
Cultivate (3X)	.516	2.31	2.10	4.53			8.94
Irrigate	4.5	15.75	.45	4.20	Water	10.80	31.20
Harvest							
Combine	.402	1.81	5.07	11.44			18.32
Haul (40 bu. @ 8¢/bu.)					Custom	3.20	3.20
Other Charges							
Land taxes a/						23.00	23.00
Operating capital interest b/						6.02	6.02
Management c/						7.84	7.84
Overhead d/						5.88	5.88
Total Non-Land Costs Per Acre		24.85	13.81	32.89		138.21	209.76

a/ Farm use value.

b/ Cash expenses were assumed outstanding for half a year with a 9% annual interest charge.

c/ Estimated at 4% of all costs except land investment and overhead.

d/ Estimated at 3% of all costs except land investment and management.

The irrigation systems selected for use to irrigate the regional competing crops were also used for soybeans. Irrigation requirements for soybeans and the competing crops were compared to estimate the irrigation costs presented in these soybean budgets.

Since commercial soybean production in Oregon has been limited thus far, historical production data could not be consulted to determine the normal soybean yield in each of the regions. Expected yields were developed considering: (1) experimental yield trials (Appendix C); (2) the discussion of the agronomic potential of soybean production in each of the regions (Chapter 3); and (3) the above average management and competing crop yield assumptions. Reasonable soybean yields were determined to be 30 bushels per acre in the Willamette Valley and 40 bushels per acre in the Columbia Basin and the Ontario Area (Fitch; Calhoun; Goetze; Rudd; Hickerson).

Net Returns to Land by Crop

Net returns to land based on the assumed prices, yields, and costs are presented in Tables 8 through 10. (Detailed budget breakdowns are listed in Appendix Tables B-3 through B-5.) The price per bushel of soybeans is not indicated, and hence, neither are the returns to land. The other information contained in these tables provides the basis for the following analysis of the competitive position of soybeans.

Analysis of the Competitive Position of Soybeans by Region

Rotations to Maximize Returns to Land

Crop rotations are determined in part by sound agronomic practices and the profitability of alternate crops. Agronomically acceptable crop rotations were developed for the competing crops in the Willamette Valley,

Table 8. Yield, Price, Cost, and Return Assumptions for the Competing Crops and Soybeans in the Willamette Valley

Crop	Unit	Yield per acre	Price per unit ($)	Gross returns per acre ($)	Total variable costs per acre ($)	Returns over variable costs per acre ($)	Total fixed costs per acre ($)	Total costs per acre[a] ($)	Returns to land per acre ($)
Wheat	bu.	100	3.25	325.00	145.98	179.02	82.72	228.70	96.30
Silage corn	T.	25	19.00	475.00	307.37	167.63	97.73	405.10	69.90
Sweet corn	T.	8.6	60.00	516.00	224.08	291.92	100.54	324.62	191.38
Bush beans	T.	4.6	140.00	644.00	329.93	314.07	112.81	442.74	201.26
Alfalfa prod.	T.	6	65.00	390.00	178.52	211.48	120.79	299.31	90.69
Alfalfa est.[b]	-	0	--	0	174.89	-174.89	35.80	210.69	-210.69
Soybeans	bu.	30	?	?	150.97	?	89.39	240.36	?

[a] Excludes a charge for land investment.

[b] One acre of the alfalfa establishment enterprise is required for every four acres of alfalfa production, assuming a stand life of four years. See rotation sequences listed in Table 12.

Table 9. Yield, Price, Cost, and Return Assumptions for the Competing Crops and Soybeans in the Columbia Basin

Crop	Unit	Yield per acre	Price per unit ($)	Gross returns per acre ($)	Total variable costs per acre ($)	Returns over variable costs per acre ($)	Total fixed costs per acre ($)	Total costs per acre[a/] ($)	Returns to land per acre ($)
Wheat	bu.	90	3.25	292.50	148.33	144.17	88.56	236.89	55.61
Sugarbeets	T.	28	25.00	700.00	392.35	307.65	128.79	521.14	178.86
Potatoes	T.	25	55.00	1375.00	751.93	623.07	172.39	924.32	450.68
Alfalfa prod.	T.	7	65.00	455.00	172.01	282.99	148.04	320.05	134.95
Alfalfa est.[b/]	-	0	--	0	86.56	-86.56	35.42	121.98	-121.98
Corn[c/]	bu.	155	3.00	465.00	286.94	178.06	109.93	396.87	68.13
Drybeans	cwt.	18	18.00	324.00	146.64	177.36	108.63	255.27	68.73
Soybeans	bu.	40	?	?	157.22	?	101.73	258.95	?
Cover crop	-	0	0	0	33.03	-33.03	12.68	45.71	-45.71

a/ Excludes a charge for land investment

b/ One acre of the alfalfa establishment enterprise is required for every four acres of alfalfa production, assuming a stand life of four years.

c/ Similar costs and returns could be expected for silage corn.

Table 10. Yield, Price, Cost, and Return Assumptions for the Competing Crops and Soybeans in the Ontario Area

Crop	Unit	Yield per acre	Price per unit ($)	Gross returns per acre ($)	Total variable costs per acre ($)	Returns over variable costs per acre ($)	Total Fixed costs per acre ($)	Total costs per acre[a] ($)	Returns to land per acre ($)
Wheat	bu.	100	3.25	325.00	130.02	194.98	63.75	193.77	131.23
Sugarbeets	T.	27	25.00	675.00	444.10	230.90	110.99	555.09	119.91
Potatoes	T.	17.5	55.00	962.50	581.35	381.15	130.61	711.96	250.54
Alfalfa prod.	T.	6	60.00	360.00	127.59	232.41	116.74	244.33	115.67
Alfalfa est.[b]	-	0	--	0	84.94	-84.94	19.16	104.10	-104.10
Corn[c]	bu.	130	3.00	390.00	198.39	191.61	75.79	274.18	115.82
Sweet corn	T.	8	55.00	440.00	216.66	223.34	77.14	293.80	146.20
Onions	cwt.	450	3.75	1687.50	1006.03	681.47	126.83	1132.86	554.64
Soybeans	bu.	40	?	?	140.15	?	69.61	209.76	?

a/ Excludes a charge for land investment.

b/ One acre of the alfalfa establishment enterprise is required for every four acres of alfalfa production, assuming a stand life of four years. See rotation sequences listed in Table 16.

c/ Similar costs and returns could be expected for silage corn.

the Columbia Basin, and the Ontario Area. In addition, rotations combining the alternate crops with soybeans were developed for each region (Hickerson; Fitch; Rudd; Nelson).

The number of acres which could be devoted to any one crop was restricted to a specified range. In this way prevailing crop production patterns were accounted for within each region. The maximum and minimum acreage assumption in Table 11 were based on the acreage figures presented in Table 2. The minimum restrictions on wheat and alfalfa are also justified by the need for erosion control and maintaining soil fertility.

Using the price, yield, total cost, and acreage restriction assumptions presented in Tables 8 through 11 and the crop rotations listed in the following sections, linear programming models were developed for each region to determine the combination of crop rotations which would maximize the returns to land.[3/] The soybean price was varied from low to high levels to determine its effect on the optimum combination of crop rotations. Results obtained are elaborated below by region.

The Willamette Valley Results

The crop rotations which were considered for the Willamette Valley are presented in Table 12.[4/] These rotations, along with the price, yield, and total cost assumptions in Table 8 and the acreage restrictions in

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3/ "Linear programming is a planning method that is often helpful in decisions requiring a choice among a large number of alternatives." (Beneke, p. 3). In farm management, linear programming is usually used to maximize profits for given levels of resources (e.g., land, labor, and capital). A brief discussion of the assumptions of linear programming and an example of the models used are presented in Appendix D.

4/ Developed in consultation with Linn County Extension Agent Hugh Hickerson.

Table 11. Maximum and Minimum Acreage Restrictions for the Competing Crops by Region.

Crop	Willamette Valley		Columbia Basin		Ontario Area	
	(max.%)	(min.%)	(max.%)	(min.%)	(max.%)	(min.%)
Wheat	35	10	40	0	30	10
Alfalfa	25	0	35	15	45	20
Field corn[a/]	15	0	10	0	15	0
Sweet corn	35	0	-	-	10	0
Sugarbeets	-	-	18	0	20	0
Potatoes	-	-	40	0	25	0
Bush beans	35	0	-	-	-	-
Drybeans	-	-	5	0	-	-
Onions	-	-	-	-	10	0

[a/] Harvested either for grain or silage.

Table 12. Willamette Valley Crop Rotations.

Rotation	Crop Sequence
(1)	Two years wheat, silage corn
(2)	Two years wheat, sweet corn
(3)	Two years wheat, bush beans
(4)	Two years wheat, soybeans
(5)	Four years alfalfa production, two years wheat, silage corn (alfalfa establishment)[a]
(6)	Four years alfalfa production, two years wheat, sweet corn (alfalfa establishment)
(7)	Four years alfalfa production, two years wheat, bush beans (alfalfa establishment)
(8)	Four years alfalfa production, two years wheat, soybeans (alfalfa establishment)
(9)	Sweet corn, soybeans
(10)	Silage corn, soybeans
(11)	Sweet corn, bush beans
(12)	Silage corn, bush beans
(13)	Silage corn, wheat
(14)	Sweet corn, wheat
(15)	Bush beans, wheat
(16)	Soybeans, wheat

[a] The establishment of alfalfa is indicated in parentheses because the operations for this enterprise were assumed to be performed in the fall; thus additional land was not required.

Table 11, were analyzed using a linear programming model. The results are presented in Table 13.

Using a low soybean price, the first farm plan resulted in a combination of three rotations which would maximize the returns to land. The optimum farm plan consisted of 30 percent wheat, 35 percent sweet corn, and 35 percent bush beans.[5/] With this crop mix, the returns to land amounted to an average of $166.31 per acre.

The minimum price required for soybeans to become a part of the farm plan was $11.22 per bushel. Using that price, a new farm plan was determined. Soybeans substituted for some of the wheat while sweet corn and bush beans remained constant.

The price per bushel of soybeans was increased to $14.73 before the next change in the farm plan resulted. At that price, soybeans replaced all of the bush beans. Raising the price of soybeans further had no effect on the crop mix due to rotation limitations.

Reviewing the net returns for the individual crops in Table 8, bush beans have the highest return to land; however, bush beans were not a part of the farm plan when the price of soybeans was $14.73 per bushel or higher. The explanation can be seen by reviewing the crop rotations in Table 11. None of the crop sequences have bush beans and soybeans together. The contribution to the returns to land would therefore be greater by dropping bush beans and substituting more soybeans.

The Columbia Basin Results

The crop rotations considered for the Columbia Basin are presented in Table 14.[6/] Cover crops were planted between successive row crops to

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5/ Sweet corn and bush beans were at the maximum permissable acreage.

6/ Developed in consultation with Umatilla County Extension Agent Luther Fitch.

Table 13. Projected Cropping Pattern in the Willamette Valley at Various Soybean Price Levels

	Soybean Price Levels ($/bu.)		
	0.00 - 11.21	11.22 - 14.72	14.73 and above
Rotations:[a]	2 yrs. wheat, sweet corn (2)	Sweet corn, soybeans (9)	Sweet corn, soybeans (9)
	Sweet corn, bush beans (11)	Sweet corn, bush beans (11)	
	Bush beans, wheat (15)	Bush beans, wheat (15)	Soybeans, wheat (16)
Crops (%):			
Wheat	30	15	15
Silage corn	0	0	0
Sweet corn	35[b]	35	35
Bush beans	35[b]	35	0
Alfalfa prod.	0	0	0
Alfalfa est.	(0)	(0)	(0)
Soybeans	0	15	50
Total	100	100	100
Returns to land ($/a.)[c]	166.31	166.31 - 182.06	182.20 and above

[a] Refers to the corresponding numbered rotations in Table 12.

[b] This number is the maximum permissible percent of land that could be in this particular crop.

[c] Calculated from yield, price, and total cost assumptions for crops presented in Table 8 and the soybean price levels above.

Table 14. Columbia Basin Crop Rotations.

Rotation	Crop Sequence
(1)	Wheat, sugarbeets
(2)	Wheat, potatoes
(3)	Wheat, corn
(4)	Wheat, drybeans
(5)	Wheat, soybeans
(6)	Wheat (alfalfa establishment), four years alfalfa production, wheat, sugarbeets. a/
(7)	Wheat (alfalfa establishment), four years alfalfa production, wheat, potatoes.
(8)	Wheat (alfalfa establishment), four years alfalfa production, wheat, corn.
(9)	Wheat (alfalfa establishment), four years alfalfa production, wheat, drybeans.
(10)	Wheat (alfalfa establishment), four years alfalfa production, wheat, soybeans.
(11)	Wheat, sugarbeets (cover crop), potatoes a/
(12)	Wheat, sugarbeets (cover crop), corn
(13)	Wheat, sugarbeets (cover crop), drybeans
(14)	Wheat, sugarbeets (cover crop), soybeans
(15)	Wheat, potatoes (cover crop), corn
(16)	Wheat, potatoes (cover crop), drybeans
(17)	Wheat, potatoes (cover crop), soybeans
(18)	Wheat, corn (cover crop), drybeans
(19)	Wheat, corn (cover crop), soybeans
(20)	Wheat, drybeans (cover crop), soybeans
(21)	Sugarbeets (cover crop), potatoes (cover crop), drybeans (cover crop)
(22)	Sugarbeets (cover crop), potatoes (cover crop), soybeans (cover crop)
(23)	Potatoes (cover crop), corn (cover crop), drybeans (cover crop)
(24)	Potatoes (cover crop), corn (cover crop), soybeans (cover crop)
(25)	Sugarbeets (cover crop), drybeans (cover crop), soybeans (cover crop)
(26)	Potatoes (cover crop), drybeans (cover crop), soybeans (cover crop)
(27)	Corn (cover crop), drybeans (cover crop), soybeans (cover crop)
(28)	Sugarbeets (cover crop), potatoes (cover crop)
(29)	Sugarbeets (cover crop), drybeans (cover crop)
(30)	Sugarbeets (cover crop), soybeans (cover crop)
(31)	Potatoes (cover crop), drybeans (cover crop)
(32)	Potatoes (cover crop), soybeans (cover crop)
(33)	Corn (cover crop), drybeans (cover crop)
(34)	Corn (cover crop), soybeans (cover crop)
(35)	Drybeans (cover crop), soybeans (cover crop)

a/ The establishment of alfalfa and the planting of cover crops are indicated in parentheses because the operations for these enterprises were assumed to be performed in the fall; thus additional land was not required.

control wind erosion. These rotations along with the price, yield, and total cost assumption (Table 9) and the acreage restrictions (Table 11) were analyzed using a linear programming model.

Using a low soybean price, the first farm plan resulted in a combination of four rotations which maximized the returns to land (Table 15). The optimum farm plan consisted of 27 percent wheat, 18 percent sugarbeets, 40 percent potatoes, and 15 percent alfalfa.[7/] This crop mix resulted in an average return to land per acre of $227.27.

The minimum price at which soybeans became a part of the farm plan was $10.15 per bushel. At that price soybeans comprised 19.5 percent of the acreage, substituting for some of the wheat. Sugarbeets, potatoes, and alfalfa remained at the same levels.

The rotation which included soybeans was potatoes (cover crop), soybeans (cover crop). Although there were other changes, this rotation primarily substituted for a wheat, potatoes rotation. Since potatoes are included in both of these rotations, the cost of planting cover crops <u>and</u> soybeans had to be offset by the price of soybeans before soybeans would substitute for wheat. If the cover crops could be omitted and a potatoes, soybean crop sequence constituted an agronomically sound rotation, the minimum price at which soybeans would become a part of the farm plan would be $7.86 per bushel instead of $10.15 per bushel.[8/]

[7/] Sugarbeets and potatoes were at the maximum permissible acreage while alfalfa was at the minimum.

[8/] A total cost of $91.42 is required to grow the cover crops in a potatoes (cover crop), soybeans (cover crop) rotation (from Table 9). Dividing $91.42 by 40 bushels of soybeans per acre implies that the $10.15 price per bushel of soybeans is inflated by $2.29 to cover the cost of the cover crops. The difference between $10.15 and $2.29 is $7.86. Assuming the cover crops were <u>not</u> required, the minimum price at which soybeans would become a part of the farm plan is $7.86 per bushel given that the rotations and crop acreages remain constant at this lower price.

Table 15. Projected Cropping Pattern in the Columbia Basin at Various Soybean Price Levels.

	Soybean Price Levels ($/bu.)			
	0.00 - 10.14	10.15 - 10.94	10.95 - 17.74	17.75 and above
Rotations:[a]	Wheat, sugarbeets (1) Wheat, potatoes (2) Wheat, 4 yrs. alfalfa prod., wheat, potatoes (7) Sugarbeets, potatoes (28)	Wheat, 4 yrs. (6) alfalfa prod., wheat, sugarbeets Potatoes, soy-beans (32) Wheat, 4 yrs. (7) alfalfa prod., wheat, potatoes Sugarbeets, (28) potatoes	Wheat, 4 yrs. (10) alfalfa prod., wheat, soybeans Potatoes, soybeans (32) Wheat 4 yrs. (7) alfalfa prod., wheat, potatoes	Wheat, 4 yrs. (10) alfalfa prod., wheat, soybeans Potatoes, soybeans (32)
Crops (%):				
Wheat	27	7.5	7.5	7.5
Sugarbeets	18[b]	18	0	0
Potatoes	40[b]	40	40	36.875
Alfalfa prod.	15[c]	15	15	15
Alfalfa est.[d]	(3.75)	(3.75)	(3.75)	(3.75)
Corn	0	0	0	0
Drybeans	0	0	0	0
Soybeans	0	19.5	37.5	40.625
Cover crop[d]	(34.75)	(73.75)	(73.75)	(73.75)
Total	100	100	100	100
Returns to land ($/a.)[e]	227.27	227.27 - 233.43	233.54 - 355.39	335.56 and above

a/ Refers to the corresponding numbered rotations in Table 14.

b/ This number is the maximum permissible percent of land that could be in this particular crop.

c/ At least 15 percent of the land was required to be in alfalfa production.

d/ The establishment of alfalfa and cover crops was assumed to be performed in the fall after the prior crop was harvested, thus no additional land was required.

e/ Calculated from yield, price, and total cost assumptions for the crops presented in Table 9 and the soybean price levels above.

The price per bushel of soybeans was increased to $10.95 before the next change in the farm plan occurred. At that price, soybeans with a return to land of $179.05 per acre became more profitable than sugarbeets with a return to land of $178.86 per acre. Thus, soybeans substituted for all of the sugarbeets. Even though soybeans are more profitable than wheat or alfalfa at the price of $10.95 per bushel, rotation and acreage restrictions caused these two crops to remain in the farm plan at minimal levels.

The next change in the farm plan occurred when the price of soybeans reached $17.75 per bushel. Over 40 percent of the acreage was in soybeans. A slight decrease in the potato acreage was observed. Raising the price of soybeans further had no effect on the farm plan due to rotation and acreage restrictions.

The Ontario Area Results

The rotations listed in Table 16, the price, yield, and total cost assumption in Table 10, and the acreage restrictions in Table 11 were analyzed for the Ontario Area.[9/] The results from the linear programming model are presented in Table 17.

A low soybean price was utilized to determine the first farm plan. A combination of five rotations resulted in the maximum return to land. The optimal farm plan consisted of 30 percent wheat, 5 percent sugarbeets, 25 percent potatoes, 20 percent alfalfa, 10 percent sweet corn, and 10 percent onions.[10/]

9/ Rotations were developed in consultation with Malheur County Extension Agent Oris Rudd.

10/ Wheat, potatoes, sweet corn, and onions were at the maximum permissible acreage while alfalfa was at the minimum.

Table 16. Ontario Area Crop Rotations.

Rotation	Crop Sequence
(1)	Wheat (alfalfa establishment), four years alfalfa production, potatoes[a]
(2)	Wheat (alfalfa establishment), four years alfalfa production, corn
(3)	Wheat (alfalfa establishment), four years alfalfa production, sweet corn
(4)	Wheat (alfalfa establishment), four years alfalfa production, soybeans
(5)	Wheat, sugarbeets
(6)	Wheat, potatoes
(7)	Wheat, corn
(8)	Wheat, sweet corn
(9)	Wheat, onions
(10)	Wheat, soybeans
(11)	Sugarbeets, potatoes, onions
(12)	Sugarbeets, potatoes, soybeans
(13)	Potatoes, corn, soybeans
(14)	Onions, soybeans, sugarbeets
(15)	Onions, soybeans, potatoes
(16)	Soybeans, sugarbeets, corn
(17)	Soybeans, sugarbeets, sweet corn
(18)	Soybeans, potatoes, sweet corn
(19)	Wheat, sugarbeets, potatoes
(20)	Wheat, sugarbeets, corn
(21)	Wheat, sugarbeets, sweet corn
(22)	Wheat, sugarbeets, onions
(23)	Wheat, sugarbeets, soybeans
(24)	Wheat, potatoes, corn
(25)	Wheat, potatoes, sweet corn
(26)	Wheat, potatoes, onions
(27)	Wheat, potatoes, soybeans
(28)	Wheat, corn, soybeans
(29)	Wheat, sweet corn, soybeans
(30)	Wheat, onions, soybeans
(31)	Sugarbeets, potatoes
(32)	Sugarbeets, onions
(33)	Sugarbeets, soybeans
(34)	Potatoes, onions
(35)	Potatoes, soybeans
(36)	Corn, soybeans
(37)	Sweet corn, soybeans
(38)	Onions, soybeans

[a] The establishment of alfalfa is indicated in parenthesis because the operations for this enterprise were assumed to be performed in the fall; thus additional land was not required.

Table 17. Projected Cropping Pattern in the Ontario Area at Various Soybean Price Levels.

	← Soybean Price Levels ($/bu.) →				
	0.00-8.24	8.25-8.52	8.53-8.89	8.90-11.50	11.51&above
Rotations:[a]	Wheat, 4 yrs. alfalfa prod. potatoes (1) Wheat, onions (9) Wheat, sugarbeets, potatoes (19) Wheat, potatoes, sweet corn (25) Wheat, potatoes, onions (26)	Wheat, 4 yrs. alfalfa prod., potatoes (1) Wheat, onions (9) Wheat, potatoes, soybeans (27) Wheat, potatoes, sweet corn (25) Onions, soybeans, potatoes (15) Wheat, potatoes (6)	Wheat, 4 yrs. alfalfa prod., potatoes (1) Wheat, 4 yrs. alfalfa prod., sweet corn (3) Wheat, potatoes, soybeans (27) Soybeans, potatoes, sweet corn (18) Onions, soybeans, potatoes (15) Wheat, 4 yrs. alfalfa prod., soybeans (4)	Wheat, onions, soybeans (30) Potatoes, soybeans (35) Onions, soybeans, potatoes (15) Wheat, 4 yrs. alfalfa prod., soybeans (4)	Wheat, soybeans (10) Potatoes, soybeans (35) Onions, soybeans (38) Wheat, 4 yrs. alfalfa prod. soybeans (4)
Crops (%):					
Wheat	30[b]	30	10[c]	10	10
Sugarbeets	5	0	0	0	0
Potatoes	25[b]	25	25	25	20
Alfalfa prod.	20[c]	20	20	20	20
Alfalfa est.[d]	(5)	(5)	(5)	(5)	(5)
Corn	0	0	0	0	0
Sweet corn	10[b]	10	10	0	0
Onions	10[b]	10	10	10	10
Soybeans	0	5	25	35	40
Total	100	100	100	100	100
Returns to land ($/a.)[c]	196.01	196.03-196.57	196.63-200.23	200.34-236.74	236.88 &above

a/ Refers to the corresponding numbered notations in Table 16.

b/ This number is the maximum permissible percent of land that could be in this particular group.

c/ At least 20 percent and 10 percent of the land was required to be in alfalfa and wheat respectively.

d/ The establishment of alfalfa was assumed to be performed in the fall after the prior crop was harvested, thus no additional land was required.

e/ Calculated from yield, price, and total cost assumptions for the crops presented in Table 10 and the soybean price levels above.

The minimum price at which soybeans became a part of the farm plan was $8.25 per bushel. At that price soybeans constituted five percent of the acreage eliminating sugarbeets. When the soybean price was increased to $8.53, the wheat acreage dropped to the minimum permissible and the soybean acreage increased to 25 percent.

The next change in the farm plan occurred when the price of soybeans was increased to $8.90 per bushel. At this price level, sweet corn dropped out of the farm plan in lieu of soybeans.

Increasing the price of soybeans further resulted in another change in the farm plan. At a price of $11.51 per bushel of soybeans, a slight decrease in the potato acreage resulted while the soybean acreage increased. Additional increases in the soybean price had no effect on the farm plan due to rotation and acreage restrictions.

Conclusions of the Regional Analyses

To measure the ability of soybeans to compete for resources, the primary competing crops were identified in the Willamette Valley, the Columbia Basin, and the Ontario Area. Typical costs and returns were estimated for each of the competing crops based on 1976 costs and normal yields and prices. Expected costs and returns were estimated for soybean production in each of the regions identified above. These data, along with agronomically sound crop rotations, were analyzed using a linear programming model for each region to determine the combination of crop rotations which maximize the returns to land. The price of soybeans was varied from low to high levels to determine its effect on the optimum combination of crop rotations. The results of these analyses indicated that soybeans were able to compete with the alternate crops provided the price of soybeans was $11.22, $10.15, and $8.25 per bushel in the Willamette Valley, the Columbia Basin, and the Ontario Area respectively.

The Competitive Position of Soybeans: A Break-Even Approach

The decision of what crop to grow is primarily dependent upon the individual farmer's perception of anticipated prices, yields, and costs of alternate enterprises which could be undertaken. The break-even analysis allows the individual farmer to use his own expectations in making annual planting decisions. In this context, only variable costs (seed, fertilizer, fuel, etc.) are considered. (The preceding linear programming analysis assumed a long-run planning horizon, considering total costs.)

Price Equations Yielding Equal Returns

To show the competitive position of soybeans relative to the alternate crops, the returns over variable costs were calculated using the following equations:

(1) $NR_{sb} = P_{sb} \times Y_{sb} - VC_{sb}$

(2) $NR_x = P_x \times Y_x - VC_x$

where

NR_{sb}, NR_x = Net returns over variable costs per acre for soybeans and competing crop "x" respectively.

P_{sb}, P_x = Price per bushel of soybeans and price per unit of competing crop "x" respectively.

Y_{sb}, Y_x = Yields per acre of soybeans and competing crop "x" respectively.

VC_{sb}, VC_x = Variable costs per acre of soybeans and com- competing crop "x" respectively.

By setting the net returns of soybeans equal to the net returns of competing crop "x", the price of soybeans required to yield equal returns between an individual crop alternative and soybeans can be specified in terms of the other variables. Equations (3), (4), and (5) demonstrate the procedure.

$$(3) \quad NR_{sb} = NR_{x}$$

or

$$(4) \quad P_{sb} \times Y_{sb} - VC_{sb} = P_{x} \times Y_{x} - VC_{x}$$

and solving for the price of soybeans gives

$$(5) \quad P_{sb} = (P_{x} \times Y_{x} - VC_{x} + VC_{sb})/Y_{sb}$$

From this equation, the break-even soybean price for any level of alternate crop "x" price can be obtained given costs and yields.

Results of the Break-Even Analysis

The variable cost and yield assumptions for selected competing crops in Tables 8 through 10 were used in developing the break-even analysis. The soybean yield was varied to demonstrate the effect of a yield change on the break-even soybean price.[11/]

The results of the break-even analysis are presented in Figures 9 through 21 below. The approach can be individualized by substituting the producer's expectations of prices, yields, and costs into Equation 5.

11/ Variable costs per acre for soybeans may vary slightly with a change in yield. However, the change in variable costs was not considered significant enough to account for in this analysis of break-even prices.

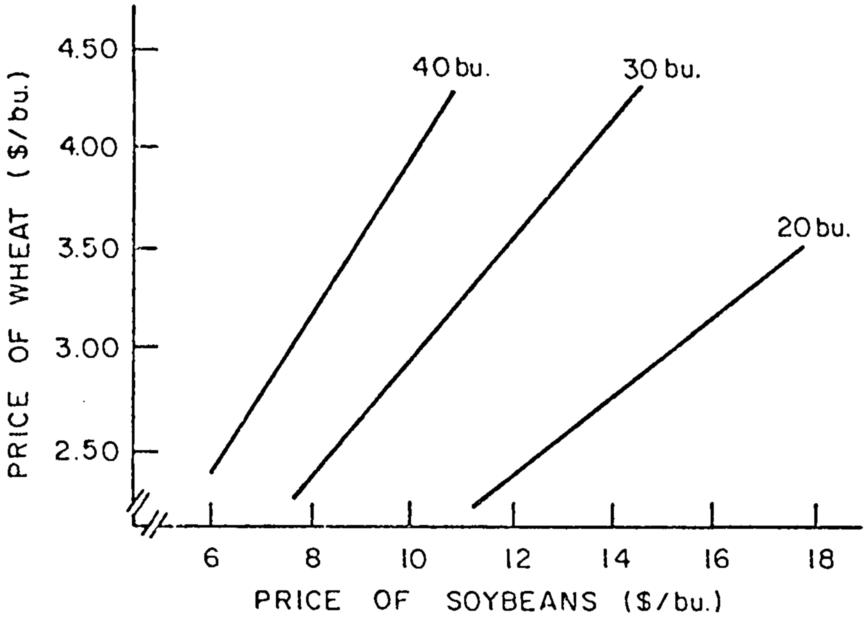

Figure 9. Wheat and soybean prices yielding equal returns per acre above variable costs for three soybean yields, Willamette Valley.

Assumptions: (1) variable costs of wheat = $145.98/a.

(2) variable costs of soybeans = $150.97/a.

(3) wheat yield = 100 bu./a.

	Price of Wheat ($/bu.)								
	2.50	2.75	3.00	3.25	3.50	3.75	4.00	4.25	4.50
Soybean yield (Bu./a.)	Price of soybeans ($/bu.)								
20	12.75	14.00	15.25	16.50	17.75	19.00	20.25	21.50	22.75
30	8.50	9.33	10.17	11.00	11.83	12.67	13.50	14.33	15.17
40	6.37	7.00	7.62	8.25	8.87	9.50	10.12	10.75	11.37

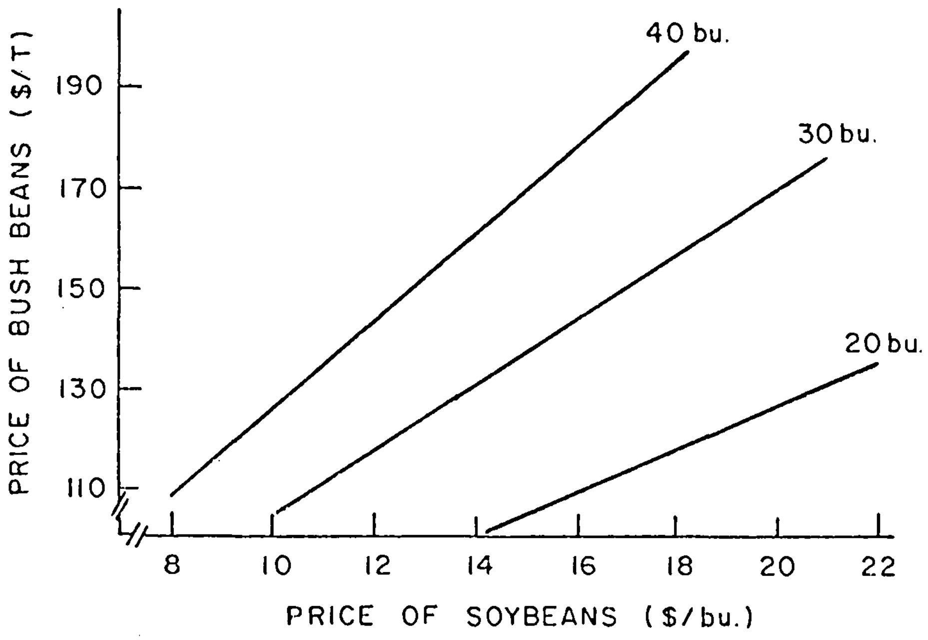

Figure 10. Bush bean and soybean prices yielding equal returns per acre above variable costs for three soybean yields, Willamette Valley.

Assumptions: (1) variable costs of bushbeans = $329.93/a.

(2) variable costs of soybeans = $150.97/a.

(3) bush bean yield = 4.6 T./a.

	Price of Bush Beans ($/T.)								
	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90
Soybean yield (bu./a.)	Price of soybeans ($/bu.)								
20	16.35	18.65	20.95	23.25	25.55	27.85	30.15	30.45	34.75
30	10.90	12.43	13.97	15.50	17.03	18.57	20.10	21.63	23.17
40	8.18	9.33	10.48	11.63	12.78	13.93	15.08	16.23	17.38

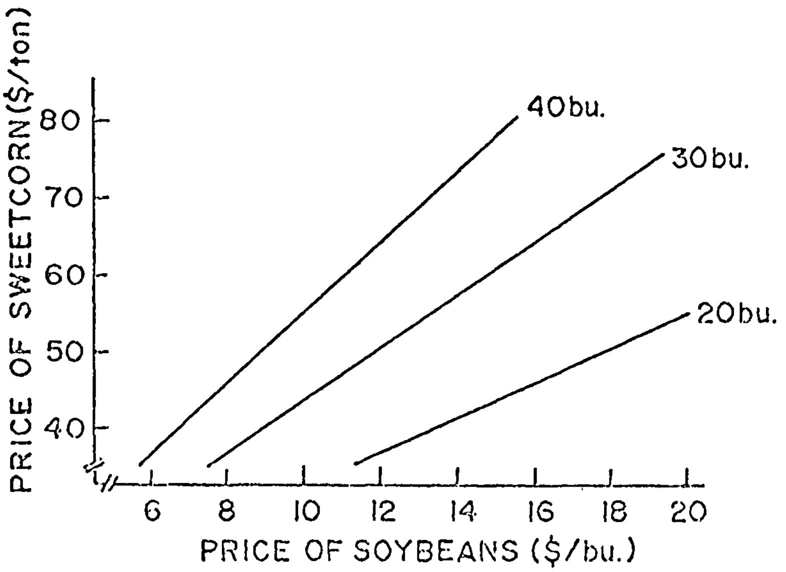

Figure 11. Sweet corn and soybean prices yielding equal returns per acre above variable costs for three soybean yields, Willamette Valley.

Assumptions: (1) variable costs of sweet corn = $224.08/a.

(2) variable costs of soybeans = $150.97/a.

(3) sweet corn yield = 8.6 T./a.

Soybean Yield (bu./a.)	Price of Sweet Corn ($/T.)									
	35.00	40.00	45.00	50.00	55.00	60.00	65.00	70.00	75.00	80.00
	Price of Soybeans ($/bu.)									
20	11.39	13.54	15.69	17.84	19.99	22.14	24.29	26.44	28.59	30.74
30	7.60	9.03	10.46	11.90	13.33	14.76	16.20	17.63	19.06	20.50
40	5.70	6.77	7.85	8.92	10.00	11.07	12.15	13.22	14.30	15.37

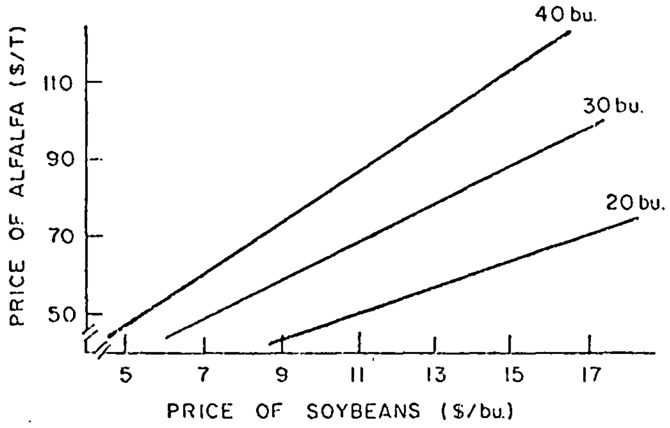

Figure 12. Alfalfa and soybean prices yielding equal returns per acre above variable costs for three soybean yields, Willamette Valley.

Assumptions: (1) variable costs of alfalfa = $178.52/a.

(2) variable costs of alfalfa establishment (amortized over 4 yrs. @ 9%) = $53.99/a.

(3) variable costs of soybeans = $150.97/a.

(4) alfalfa yield = 6 T./a.

Soybean Yield (bu./a.)	Price of Alfalfa ($/T.)												
	50	55	60	65	70	75	80	85	90	95	100	105	110
	Price of Soybeans ($/bu.)												
20	10.92	12.42	13.92	15.42	16.92	18.42	19.92	21.42	22.92	24.42	25.92	27.42	28.92
30	7.28	8.28	9.28	10.28	11.28	12.28	13.28	14.28	15.28	16.28	17.28	18.28	19.28
40	5.46	6.21	6.96	7.71	8.46	9.21	9.96	10.71	11.46	12.21	12.96	13.71	14.46

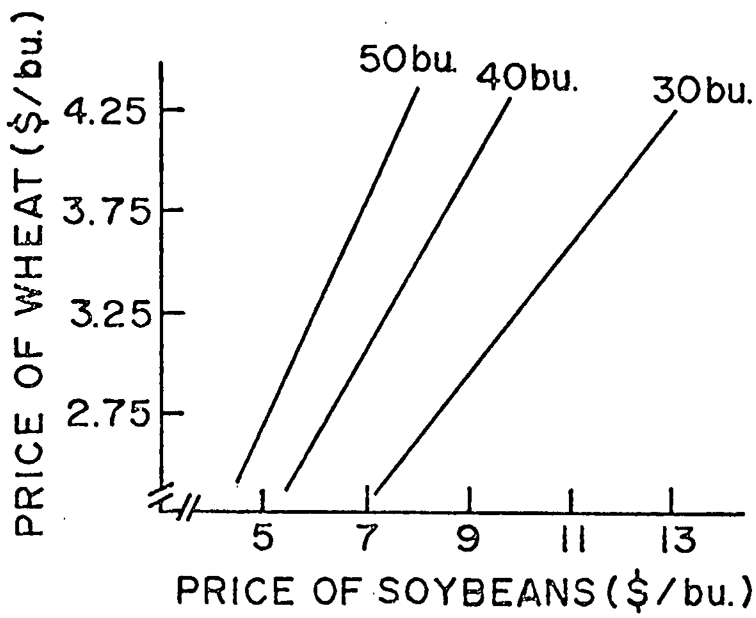

Figure 13. Wheat and soybean prices yielding equal returns per acre above variable costs for three soybean yields, Columbia Basin.

Assumptions: (1) variable costs of wheat = $148.33/a.

(2) variable costs of soybeans = $157.22/a.

(3) wheat yield = 90 bu./a.

Soybean Yield (bu./a.)	Price of Wheat ($/bu.)							
	2.50	2.75	3.00	3.25	3.50	3.75	4.00	4.25
	Price of Soybeans ($/bu.)							
30	7.80	8.55	9.30	10.05	10.80	11.55	12.30	13.05
40	5.85	6.41	6.97	7.53	8.10	8.66	9.22	9.78
50	4.68	5.13	5.58	6.03	6.48	6.93	7.38	7.83

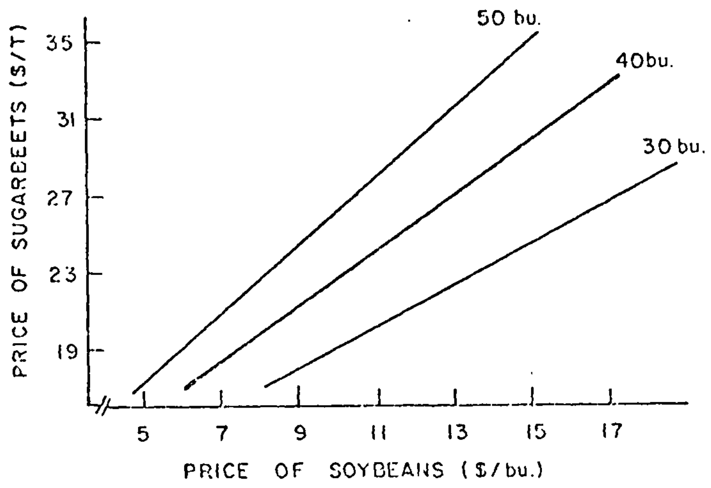

Figure 14. Sugarbeet and soybean prices yielding equal returns per acre above variable costs for three soybean yields, Columbia Basin.

Assumptions: (1) variable costs of sugarbeets = $392.35/a.

(2) variable costs of soybeans = $157.22/a.

(3) sugarbeet yield = 28 T./a.

	Price of Sugarbeets ($/T.)									
	17	19	21	23	25	27	29	31	33	35
Soybean Yield (bu./a.)	Price of soybeans ($/bu.)									
30	8.03	9.90	11.76	13.63	15.50	17.36	19.23	21.10	22.96	24.83
40	6.02	7.42	8.82	10.22	11.62	13.02	14.42	15.82	17.22	18.62
50	4.82	5.94	7.06	8.18	9.30	10.42	11.54	12.66	13.78	14.90

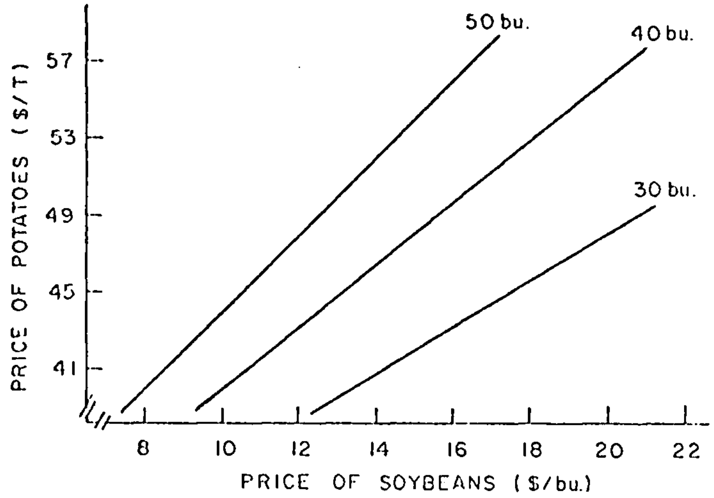

Figure 15. Potato and soybean prices yielding equal returns per acre above variable costs for three soybean yields, Columbia Basin.

Assumptions: (1) variable costs of potatoes = $751.93

(2) variable costs of soybeans = $157.22

(3) potato yield = 25 T./a.

	Price of Potatoes ($/T.)									
	39	41	43	45	47	49	51	53	55	57
Soybean Yield (bu./a.)	Price of soybeans ($/bu.)									
30	12.68	14.34	16.01	17.68	19.34	21.01	22.68	24.34	26.01	27.68
40	9.51	10.76	12.01	13.26	14.51	15.76	17.01	18.26	19.51	20.76
50	7.61	8.61	9.61	10.61	11.61	12.61	13.61	14.61	15.61	16.61

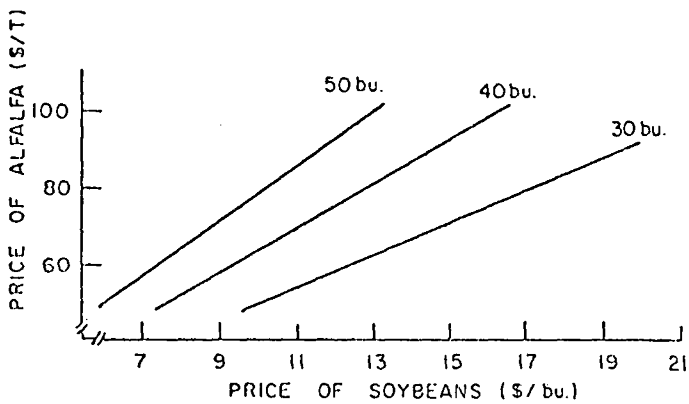

Figure 16. Alfalfa and soybean prices yielding equal returns per acre above variable costs for three soybean yields, Columbia Basin.

Assumptions: (1) variable costs of alfalfa = $172.01/a.

(2) variable costs of alfalfa establishment (amortized over 4 years @ 9%) = $26.72/a.

(3) variable costs of soybeans = $157.22/a.

(4) alfalfa yield = 7 T./a.

	Price of Alfalfa ($/T.)										
	50	55	60	65	70	75	80	85	90	95	100
Soybean Yield (bu./a.)	Price of soybeans ($/bu.)										
30	10.28	11.45	12.62	13.78	14.95	16.12	17.28	18.45	19.62	20.78	21.95
40	7.71	8.59	9.46	10.34	11.21	12.09	12.96	13.84	14.71	15.59	16.46
50	6.17	6.87	7.57	8.27	8.97	9.67	10.37	11.07	11.77	12.47	13.17

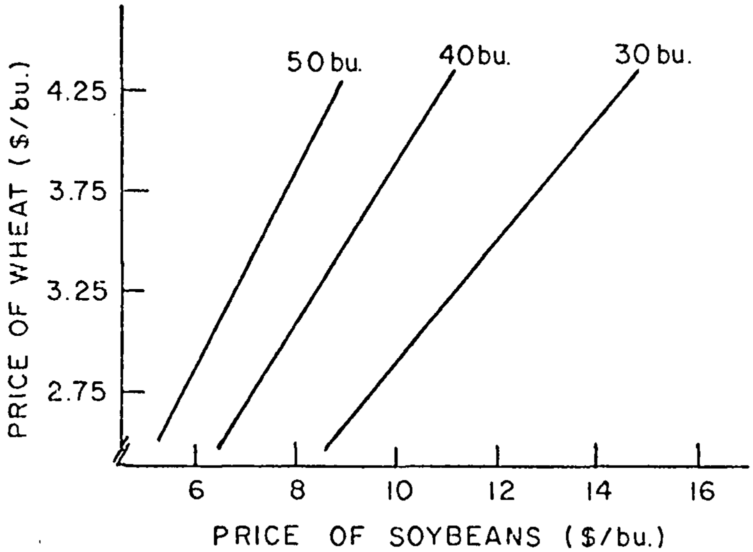

Figure 17. Wheat and soybean prices yielding equal returns per acre above variable costs for three soybean yields, Ontario Area.

Assumptions: (1) variable costs of wheat = \$130.02/a.

(2) variable costs of soybeans = \$140.15/a.

(3) wheat yield = 100 bu./a.

	Price of Wheat (\$/bu.)							
	2.50	2.75	3.00	3.25	3.50	3.75	4.00	4.25
Soybean Yield (bu./a.)	Price of soybeans (\$/bu.)							
30	8.67	9.50	10.34	11.17	12.00	12.84	13.67	14.50
40	6.50	7.13	7.75	8.38	9.00	9.63	10.25	10.89
50	5.20	5.70	6.20	6.70	7.20	7.70	8.20	8.70

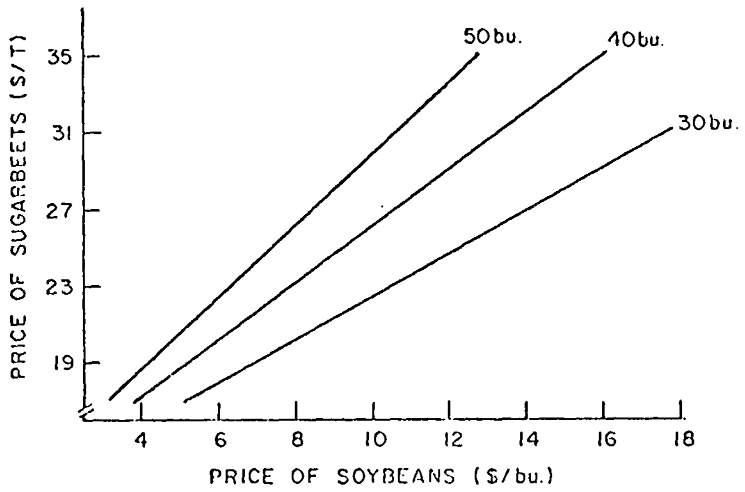

Figure 18. Sugarbeet and soybeen prices yielding equal returns per acre above variable costs for three soybean yields, Ontario Area.

Assumptions: (1) variable costs of sugarbeets = $144.10/a.

(2) variable costs of soybeans = $140.15/a.

(3) sugarbeet yield = 27 T./a.

	Price of Sugarbeets ($/T.)									
	17	19	21	23	25	27	29	31	33	35
Soybean Yield (bu./a.)	Price of soybeans ($/bu.)									
30	5.17	6.97	8.77	10.57	12.37	14.17	15.97	17.77	19.57	21.37
40	3.88	5.23	6.58	7.93	9.28	10.63	11.98	13.33	14.68	16.03
50	3.10	4.18	5.26	6.34	7.42	8.50	9.58	10.66	11.74	12.82

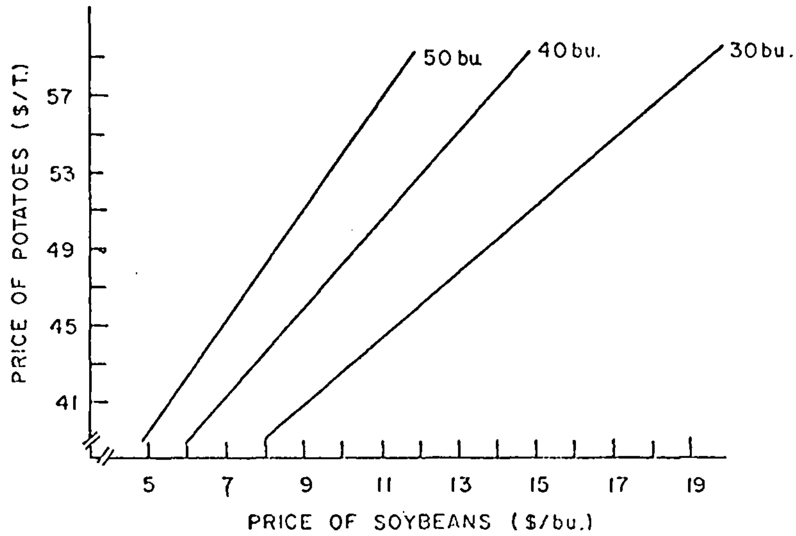

Figure 19. Potato and soybean prices yielding equal returns per acre above variable costs for three soybean yields, Ontario Area.

Assumptions: (1) variable costs of potatoes = $581.35/a.
(2) variable costs of soybeans = $140.15/a.
(3) potato yield = 17.5 T./a.

	Price of Potatoes ($/T.)										
	39	41	43	45	47	49	51	53	55	57	59
Soybean Yield (bu./a.)	Price of soybeans ($/bu.)										
30	8.04	9.21	10.38	11.54	12.71	13.88	15.04	16.21	17.38	18.54	19.71
40	6.03	6.91	7.78	8.66	9.53	10.41	11.28	12.16	13.03	13.91	14.78
50	4.83	5.53	6.23	6.93	7.63	8.33	9.03	9.73	10.43	11.13	11.83

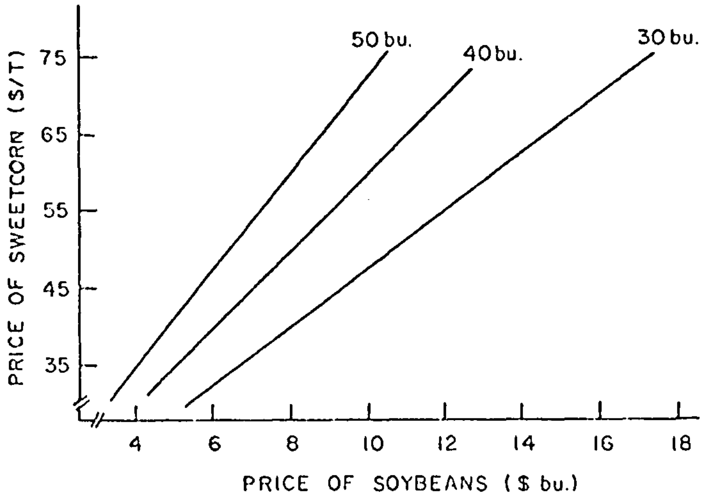

Figure 20. Sweetcorn and soybean prices yielding equal returns per acre above variable costs for three soybean yields, Ontario Area.

Assumptions: (1) variable costs of sweetcorn = $216.66/a.

(2) variable costs of soybeans = $140.15/a.

(3) sweetcorn yield = 8 T./a.

	Price of Sweetcorn ($/T.)									
	30	35	40	45	50	55	60	65	70	75
Soybean Yield (bu./a.)	Price of soybeans ($/bu.)									
30	5.45	6.78	8.12	9.45	10.78	12.12	13.45	14.78	16.12	17.45
40	4.09	5.09	6.09	7.09	8.09	9.09	10.09	11.09	12.09	13.09
50	3.27	4.07	4.87	5.67	6.47	7.27	8.07	8.87	9.67	10.47

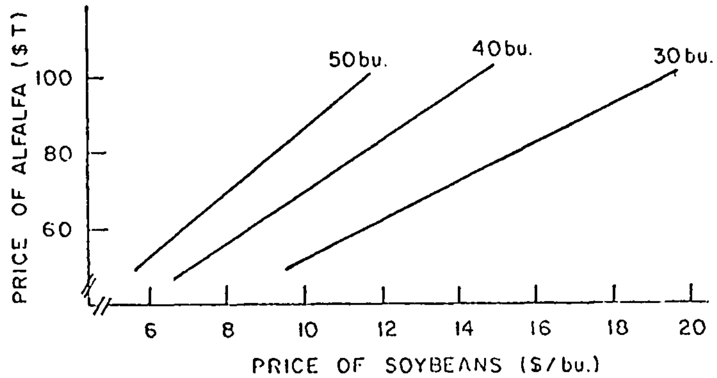

Figure 21. Alfalfa and soybean prices yielding equal returns per acre above variable costs for three soybean yields, Ontario Area.

Assumptions: (1) variable costs of alfalfa = $127.59/a.

(2) variable costs of alfalfa establishment (amortized over 4 years @ 9%) = $26.22/a.

(3) alfalfa yield = 6 T./a.

	Price of Alfalfa ($/T.)										
	50	55	60	65	70	75	80	85	90	95	100
Soybean Yield (bu./a.)	Price of soybeans ($/bu.)										
30	9.54	10.54	11.54	12.54	13.54	14.54	15.54	16.54	17.54	18.54	19.54
40	7.16	7.91	8.66	9.41	10.16	10.91	11.66	12.41	13.16	13.91	14.66
50	5.73	6.33	6.93	7.53	8.13	8.73	9.33	9.93	10.53	11.13	11.73

CHAPTER 5

MARKETING ALTERNATIVES FOR OREGON-GROWN SOYBEANS

The linear programming and break-even analyses presented in Chapter Four evaluated the competitive position of soybeans compared to other crops produced in Oregon. The minimum price required for soybeans to successfully compete with the major alternate crops was determined. However, these prices may differ from what farmers could expect to receive in the Oregon market-place. Therefore, the marketing alternatives which may exist for Oregon soybeans are identified below. The more promising are analyzed to estimate the maximum price which could be offered for Oregon-produced soybeans. These results are compared in the following chapter with the results of the linear programming analyses presented in Chapter Four.

Overview of the United States Market for Soybeans

The demand for United States' soybeans arises almost entirely out of the two soybean products jointly produced through processing - meal and oil (Ryan, p. 3). The use of whole soybeans as a food is an increasing, but still a small component of total consumption. The primary use of soybean oil is in food products as margarine, salad oil, shortening, and cooking oil. Soybean meal is a high protein supplement containing 44 to 50 percent protein for use in livestock and poultry feeds.

Table 18 summarizes the utilization of United States soybeans. The numbers reported are percentages of the total disposition for the marketing years 1972 to 1975.

Over 90 percent of the United States' utilization of soybeans occurs as meal and oil. Meal is primarily a high protein supplement in livestock and poultry rations. Dairy cows, beef cattle, and broilers consume over half of the meal (Caldwell, p. 620). More than two-thirds of the oil utilized is in the form of shortening and salad oil. Seed and feed constitute small percentages of the domestic utilization of raw soybeans.

Nearly half of the United States' soybean disposition ends up in over-seas markets. Exports of soybeans occur as beans, meal, or oil, with beans being the dominant form. Foreign buyers purchase about two of every five bushels of raw soybeans which enter the marketplace. In addition, about 27 percent of the meal and 13 percent of the oil produced in the United States is exported.

The Western European countries and Japan are the primary markets for United States' soybeans (Ryan, pp. 5, 6). The European community is also the dominant meal importer. The lesser developed nations of Latin America, Asia, and Africa are the major oil importers.

Identification of Potential Marketing Alternatives

Potential marketing alternatives which may exist for Oregon-grown soybeans are based on two different assumptions. The first assumption represents the existing condition, that a soybean processing plant does not exist in the Pacific Northwest. Three marketing alternatives are identified given this assumption. Soybeans produced in Oregon could be (1) exported to Japan; (2) exported to a United States processor in another region; or (3) utilized on the farm. The second assumption is futuristic in that it assumes that a soybean processing plant is built in the Pacific Northwest. Three similar marketing alternatives are identified given this assumption. Oregon soybeans could be processed and the resulting meal and oil could (1) be used to help meet the Pacific Northwest's demand for these products; (2) be exported to other regions of the United States; or (3) be

Table 18. Soybeans; United States Disposition, 1972-1975

Marketing Year[a]	Domestic Use					Exports				Other[b]	Total Disposition
	Meal	Oil	Seed	Feed	Total	Soybeans	Meal	Oil	Total		
	(expressed as a percent of total disposition)										
1972-73	20.2	24.4	4.8	.1	49.5	38.3	8.1	3.9	50.3	.2	100
1973-74	20.7	24.3	3.9	.1	49.0	37.7	8.3	4.8	50.8	.2	100
1974-75	22.1	25.5	4.8	.1	52.5	35.6	7.5	4.0	47.1	.4	100
1975-76[c]	21.9	26.0	--- 4.4---		52.3	37.1	7.3	3.0	47.4	.3	100

Source: United States Department of Agriculture, Economic Research Service, Fats and Oils Situation, August 1976 and Fats and Oils Statistics, 1961-1976, June 1977.

a/ Begins in September for soybeans; October for meal and oil.

b/ Includes shipments of meal and oil under the Food for Peace programs.

c/ Preliminary.

exported to Japan. Combinations and variations of the six alternatives identified probably would exist. However, for the purpose of this analysis, each of the six alternatives above are evaluated individually.

Evaluation of Potential Marketing Alternatives

Decatur, Illinois, is typically used by the soybean industry as the "base-point" for pricing soybeans, meal, and oil in the United States (Bell). Suppliers price their products at the Decatur price plus freight from Decatur, whether or not the seller actually ships from Decatur. All buyers at one location pay the same price regardless of where the product originates (Carman and Uhl, p. 581).

The potential marketing alternatives of (1) exporting soybeans to Japan; (2) exporting soybeans to a United States processor in another region; (3) meeting the Pacific Northwest's demand for meal and oil; and (4) exporting meal and oil to other regions of the United States are evaluated below using a Decatur base-point pricing scheme. (The lack of data and current experience limited the evaluation of (1) on-farm use of raw soybeans and (2) exporting meal and oil to Japan.) This approach leads to an estimate of the price which could be offered Oregon soybeans.

Export Oregon Soybeans to Japan

The Japanese demand for United States' soybeans is primarily met by shipments from Gulf of Mexico ports through the Panama Canal (Holz). Using the Decatur base-point pricing scheme and accounting for transportation cost differentials, the value of soybeans in Portland is determined by analyzing the data using the following steps:

(1) Decatur soybean price; plus

(2) Transportation cost, Decatur to Japan; equals

(3) Value of soybeans in Japan; minus

(4) Transportation cost, Portland to Japan; equals

(5) Value of soybeans in Portland.

The results of this approach are presented in Table 19. The average Decatur soybean prices for the marketing years 1971 to 1976 are inflated to 1976 marketing year dollars to (1) account for the change in the value of the dollar; (2) be consistent with the time frame of the linear programming analyses in Chapter Four; and (3) provide an indication of the variability in soybean prices. Transportation costs (column 4) which would be incurred if soybeans were railed from Decatur to New Orleans, transferred to a ship, and delivered to Japan via the Panama Canal are added. In this way, the value of soybeans in Japan is determined (column 5). Subtracting the cost of loading soybeans on a ship in Portland and transporting them to Japan leaves the value of soybeans in Portland.

The results of this analysis are listed in column 7. The value of soybeans in Portland is estimated to range from $4.87 to $8.63 per bushel in 1976-77 marketing year dollars.

Export Oregon Soybeans to Other Regions of the United States

Oregon soybeans could be transported to other regions of the United States for processing. The base-point pricing scheme would be applied with the processor buying an input instead of selling a product. In this case, it is assumed that the processor would offer the Decatur prices less transportation costs, Portland to Decatur.

Table 20 summarizes the results. The 1971 to 1976 marketing years' average Decatur soybean prices are again inflated to 1976 marketing year

Table 19. Estimate of the Portland Soybean Price Based on Exporting Oregon Soybeans to Japan

Marketing Year[a/]	(1) Decatur Soybean Price[b/]	(2) Price Index[c/]	(3) (1) x (2) Value of Soybeans[d/]	(4) Transportation Cost[e/]	(5) (3) + (4) Value of Soybeans in Japan	(6) Transportation Cost[f/]	(7) (5) - (6) Value of Soybeans in Portland
	($/bu.)		($/bu.)	($/bu.)	($/bu.)	($/bu.)	($/bu.)
1971-72	3.24	1.3938	4.52	.70	5.22	.35	4.87
1972-73	6.21	1.3329	8.28	.70	8.98	.35	8.63
1973-74	6.12	1.2007	7.35	.70	8.05	.35	7.70
1974-75	6.33	1.0993	6.96	.70	7.66	.35	7.31
1975-76	5.26[g/]	1.0462	5.50	.70	6.20	.35	5.85
1976-77	6.76[h/]	1.0000	6.76	.70	7.46	.35	7.11

a/ Begins in September.
b/ Source: United States Department of Agriculture, Economic Research Serivce, "Fats and Oils Situation," July 1977 and June 1974.
c/ Adapted for each marketing year from the quarterly Implicit Price Deflators for Gross National Product in "Economic Indicators" by the Council of Economic Advisors.
d/ Column one adjusted to 1976 marketing year dollars.
e/ Source: Baumel, et al.; Bell; and "The Journal of Commerce and Commercial," includes transportation and and transfer costs and canal toll from Decatur to Japan via the Panama Canal for the fall of 1976.
f/ Source: Baumel, et al.; Bell; and "The Journal of Commerce and Commercial," includes transportation and transfer costs from Portland to Japan for the fall of 1976.
g/ Preliminary.
h/ Estimate.

Table 20. Estimate of the Portland Soybean Price Based on Exporting Oregon Soybeans to Other Regions of the United States

	(1)	(2)	(3) (1) x (2)	(4)	(5) (3) - (4)
Marketing Year[a/]	Decatur Soybean Price[b/]	Price Index[c/]	Value of Soybeans[d/]	Transportation Cost[e/]	Value of Soybeans in Portland
	($/bu.)		($/bu.)	($/bu.)	($/bu.)
1971-72	3.24	1.3938	4.52	1.31	3.21
1972-73	6.21	1.3329	8.28	1.31	6.97
1973-74	6.12	1.2007	7.35	1.31	6.04
1974-75	6.33	1.0993	6.96	1.31	5.65
1975-76	5.26[f/]	1.0462	5.50	1.31	4.19
1976-77	6.76[g/]	1.0000	6.76	1.31	5.45

a/ Begins in September.

b/ Source: United States Department of Agriculture, Economic Research Service, "Fats and Oils Situation," July 1977 and June 1974.

c/ Adapted for each marketing year from the quarterly Implicit Price Deflators for Gross National Product in "Economic Indicators" by the Council of Economic Advisors.

d/ Column one adjusted to 1976 marketing year dollars.

e/ Source: Bell; the fall 1976 cost of transporting soybeans from Decatur to Portland.

f/ Preliminary.

g/ Estimate.

dollars. The cost of transporting soybeans from Decatur to Portland is subtracted. The results (column 5) indicate a range on the value of soybeans in Portland from $3.21 to $6.97 per bushel in 1976-77 marketing year dollars.

On-Farm Use of Oregon Soybeans

Whole or ground soybeans could be utilized on the farm. However, raw soybeans contain an enzyme which inhibits normal protein digestion in non-ruminant animals such as swine and poultry (Caldwell, p. 646). The enzyme does not pose a problem to ruminants like cattle and sheep.

A relatively inexpensive on-farm roaster develops enough heat to destroy the enzyme and a cooked full-fat product can be fed. However, feeding cooked soybeans to swine during the finishing period results in "soft" or oily pork (Scott, p. 170). No feed problems are encountered when a full-fat product is fed to poultry, cattle, or sheep.

By comparing the nutritional values and costs of soybeans and substitute ingredients like alfalfa and urea in feed rations, a price which could be offered for Oregon soybeans could be estimated. There is limited research concerning the nutritional value of Oregon soybeans in feed rations, "Feeding Value of Pacific Northwest Grown Soybeans for Replacement and Laying Pullets" by Harry Nakaue. However, because (1) soybeans are usually more valuable for human food than as a source of fat for feeds (Caldwell, p. 647); and (2) national disposition trends indicate less than one-tenth of one percent of the raw soybeans utilized is fed (Table 18), it appears that on-farm use of Oregon soybeans would be limited. Therefore, this alternative is not examined further.

Meet the Pacific Northwest's Demand for Meal and Oil

For the years 1973 through 1975, the estimated average annual soybean meal and oil consumption in the Pacific Northwest was about 92,000 and 75,800 tons, respectively.[1/] Assuming (1) a bushel of soybeans (60 pounds in weight) will yield 46.8 pounds of meal and 10.8 pounds of crude oil and (2) an average yield of 40 bushels per acre, about 98,000 acres of soybeans would be required to meet the Pacific Northwest's demand for soybean meal. An additional 253,000 acres would be required to meet the soybean oil demand. The oil would have to be refined before it could be utilized in cooking oils, salad oils, margarine, etc.

A plant does exist in the Pacific Northwest which would be capable of refining crude soybean oil to the point where it could be used in salad oils (Salvatori). However, further refinement (a hardening process) would be required before products like shortening and margarine could be produced and utilized in potato processing and human foods.

If a processing plant existed in the Portland area for example, Oregon soybeans could be processed, the crude oil refined, and the resulting meal and oil products used to meet part or all of the demand for these products in the Pacific Northwest. Using the Decatur base-point pricing scheme, the value of soybeans in Portland is determined in the following manner:

(1) Decatur meal and oil prices; plus

(2) Transportation costs, Decatur to Portland; equals

(3) Value of meal and oil in Portland.

[1/] These estimates were made by Divine, et al. in "Research on the Potential Impact of Advanced Oilseeds Processing Technology on Pacific Northwest Agriculture," by projecting a one percent sample of carload waybill statistics to total volume.

By converting the Portland meal and oil prices to a soybean equivalent and subtracting the processing costs, a price the Portland processor would be willing to offer for Oregon soybeans is determined.

Table 21 summarizes this approach. Six marketing years are again examined. The average Decatur meal and oil prices for the marketing years indicated are inflated to the 1976 marketing year value of the dollar. The cost of transporting meal and oil (columns 6 and 7) are added to determine the value of these products in Portland. By weighting these summations (columns 8 and 9) by the meal and oil yields above, the value of processed soybeans in Portland (column 10) is determined. Subtracting the processing costs results in a price the processor could offer Oregon soybean growers. However, this price would be no higher than the price the Portland processor could pay for midwest soybeans (the Decatur price) and transport them to the Portland plant.

Table 22 shows the costs to the Portland processor for purchasing, transporting, and processing midwest soybeans. Comparing column 12, Table 21 with column 4, Table 22, an upper limit is found to exist on the value of meal and oil per bushel in the marketing years 1972-73 and 1973-74. Thus, the price the processor would be willing to offer Oregon soybeans ranges from \$5.65 to \$10.07 per bushel in 1976-77 marketing year dollars.

Export Meal and Oil to Other Regions of the United States

Oregon soybeans could be processed in the Portland area plant and the resulting meal and oil could be transported and sold to other regions of the United States. In this case, buyers of meal and oil would be willing to pay no more than the Decatur price. The Portland processor would have to sell meal and oil at a price equivalent to the Decatur price less transportation. Then, by subtracting the processor's costs, a price the processor would be willing to offer Oregon soybeans in Portland is determined.

Table 21. Estimate of the Portland Soybean Price Based on Processing Oregon Soybeans in Portland

	(1)	(2)	(3)	(4) (1) x (3)	(5) (2) x (3)	(6)	(7)	(8) (4) + (6)	(9) (5) + (7)	(10)	(11)	(12) (10) - (11)
Marketing Year a/	Decatur Meal Price b/	Decatur Crude Oil Price b/	Price Index c/	Value of Meal d/	Value of Crude Oil d/	Meal Transportation Cost e/	Crude oil Transportation Cost e/	Value of Meal in Portland	Value of Oil in Portland	Value of Processed Soybeans in Portland f/	Processing Costs g/	Price Portland Processing Willing to Offer
	($/T.)	(¢/lb.)		($/T.)	(¢/lb.)	($/T.)	(¢/lb.)	($/T.)	(¢/lb.)	($/bu.)	($/bu.)	($/bu.)
1971-72	90.20	11.3	1.3938	125.72	15.7	43.60	4.2	169.32	19.9	6.13	.48	5.65
1972-73	228.99	16.5	1.3329	305.22	22.0	43.60	4.2	348.82	26.2	10.97	.48	10.49
1973-74	146.35	31.5	1.2007	175.72	37.8	43.60	4.2	219.32	42.0	9.68	.48	9.20
1974-75	130.85	30.7	1.0993	143.84	33.7	43.60	4.2	187.44	37.9	8.49	.48	8.01
1975-76	147.77 h/	18.3 h/	1.0462	154.60	19.1	43.60	4.2	198.20	23.3	7.15	.48	6.67
1976-77	205.00 i/	24.0 i/	1.0000	205.00	24.0	43.60	4.2	248.60	28.2	8.85	.48	8.37

a/ Begins in October.

b/ "Fats and Oils Situation," July 1977 and June 1974.

c/ Adapted from the Implicit Price Deflators for Gross National Product in "Economic Indicators" by the Council of Economic Advisors.

d/ Columns (1) and (2) adjusted to 1976 marketing year dollars.

e/ Source: Bell; transportation costs for the fall of 1976 from Decatur to Portland.

f/ Assumes that 60 pounds of soybeans per bushel will yield 46.8 pounds of 44% protein meal and 10.8 pounds of crude oil.

g/ Includes the cost of processing an allowance for the processor's taxes, and a 7% return on investment before taxes assuming a 650 ton of soybeans per day plant with a 300-day crushing season adapted from Helgeson. Does not includes costs for refining crude oil.

h/ Preliminary.

i/ Estimated.

Table 22. Estimate of the Portland Soybean Price Based on Importing Midwest Soybeans for Processing

	(1)	(2)	(3)	(4) (1) + (2) + (3)
Marketing Year[a/]	Value of Decatur Soybeans[b/]	Transportation Cost[c/]	Processing Costs[d/]	Value of Soybeans Delivered to and Processed at the Portland Plant
	($/bu.)	($/bu.)	($/bu.)	($/bu.)
1971-72	4.52	1.31	.48	6.31
1972-73	8.28	1.31	.48	10.07
1973-74	7.35	1.31	.48	9.14
1974-75	6.96	1.31	.48	8.75
1975-76	5.50	1.31	.48	7.29
1976-77	6.76	1.31	.48	8.55

a/ Begins in September.

b/ From column 3, Table 19. The prices have already been inflated to 1976 marketing year dollars.

c/ Source: Bell, fall 1976 cost.

d/ From column 11, Table 21.

Table 23 summarizes this approach. By subtracting the transportation costs from Portland to Decatur from the Decatur meal and oil prices for the marketing years 1971-72 to 1976-77 inflated to the value of the dollar in the 1976-77 marketing year, the Portland processor's selling price of meal and oil is obtained (columns 5 and 6). By weighting these prices by the meal and oil yields mentioned early and subtracting the cost of processing, the maximum price the processor is willing to offer Oregon soybeans ranges from $2.69 to $7.56 per bushel in 1976-77 marketing year dollars.

Export Meal and Oil to Japan

Japan imports about three percent of the United States meal exports and no oil (Ryan, p. 6; Holz). Most of the Japanese demands for meal and oil are met by their own processors. Thus, the potential market demand for processed Oregon soybeans appears to be limited and will not be evaluated further.

Summary and Conclusions

Six marketing alternatives which may exist for Oregon soybeans are identified and evaluated above. On-farm use of soybeans and exporting soybean meal and oil to Japan appeared to be limited, if not impractical, marketing alternatives. The remaining four alternatives are evaluated using the Decatur base-point pricing scheme to estimate the maximum Portland price of soybeans. The results are summarized in Table 24. The Portland soybean price could be expected to range from $2.69 to $10.07 per bushel based on the data presented for the past six years inflated to the value of the dollar in the 1976-77 marketing year.

Table 23. Estimate of the Portland Soybean Price Based on Exporting Processed Oregon Soybeans to Other Regions of the United States

	(1)	(2)	(3)	(4)	(5) (1) - (3)	(6) (2) - (4)	(7)	(8)	(9) (7) - (8)
Marketing Year[a]	Value of Decatur Meal[b]	Value of Decatur Oil[b]	Meal Transportation Cost[c]	Oil Transportation Cost[c]	Processor's Meal Selling Price	Processor's Oil Selling Price	Value of Processed Soybeans Sold	Processing Costs	Price Portland Processing Willing to Offer
	($/T.)	(¢/lb.)	($/T.)	(¢/lb.)	($/T.)	(¢/lb.)	($/bu.)	($/bu.)	($/bu.)
1971-72	125.72	15.7	43.60	4.2	82.12	11.5	3.17	.48	2.69
1972-73	305.22	22.0	43.60	4.2	261.62	17.8	8.04	.48	7.56
1973-74	175.72	37.8	43.60	4.2	132.12	33.6	6.72	.48	6.24
1974-75	143.84	33.7	43.60	4.2	100.24	29.5	5.53	.48	5.05
1975-76	154.60	19.1	43.60	4.2	111.00	14.9	4.21	.48	3.73
1976-77	205.00	24.0	43.60	4.2	161.40	19.8	5.92	.48	5.44

a/ Begins in October.

b/ From columns 4 and 5, Table 21. The prices have already been inflated to the 1976 marketing year value of the dollar.

c/ Source: Bell, fall 1976 transportation costs.

Table 24. Summary of Maximum Portland Soybean Prices by Marketing Alternatives in 1976-1977 Dollars

Marketing Year[a]	Without Processing Plant: Export to Japan[b]	Without Processing Plant: Ship to Other States[c]	With Processing Plant: Use Meal and Oil[d] in PNW	With Processing Plant: Ship Meal and Oil to Other[e] States
	($/bu.)	($/bu.)	($/bu.)	($/bu.)
1971-72	4.87	3.21	5.65	2.69
1972-73	8.63	6.97	10.07	7.56
1973-74	7.70	6.04	9.14	6.24
1974-75	7.31	5.65	8.01	5.05
1975-76	5.85	4.19	6.67	3.73
1976-77	7.11	5.45	8.37	5.44
Average[f]	6.91	5.25	7.99	5.12

[a] Begins in September for beans, October for meal and oil.

[b] From Table 19.

[c] From Table 20.

[d] From Tables 21 and 22.

[e] From Table 23.

[f] Simple average of the data presented for the marketing years analyzed.

CHAPTER 6

CONCLUSIONS

The economic feasibility of soybean production in Oregon is evaluated below. The approach used is to compare (1) the minimum price required for soybeans to successfully compete with the alternate crops in the Willamette Valley, the Columbia Basin, and the Ontario Area (estimated by the linear programming analyses of Chapter Four) with (2) the maximum Portland soybean price range resulting from the analyses of the marketing alternatives.

Willamette Valley

To assess the economic feasibility of soybean production in the Willamette Valley, the transportation costs which would be involved in getting soybeans from the farm to Portland must be subtracted from the Portland soybean price range. Assuming an average length of haul, transportation costs would be about thirteen cents per bushel (Hickerson). The maximum on-farm soybean price a Willamette Valley farmer may anticipate would range from \$2.56 to \$9.94 per bushel (represented by the vertical dashed lines in Figure 22). The solid line in Figure 22 represents the percent of the Willamette Valley acreage in soybeans as the price of soybeans increases (the linear programming results). The minimum price required for soybeans to successfully compete with the alternate crops in the Willamette Valley is \$11.22 per bushel, \$1.28 per bushel higher than the highest maximum price farmers may anticipate based on the analysis of the marketing alternatives for the past six years (Table 24). The average maximum price for the six years analyzed, assuming a processing plant at Portland with the resulting meal and oil used in the Pacific Northwest, is \$7.86 per bushel after subtracting transportation costs to Portland

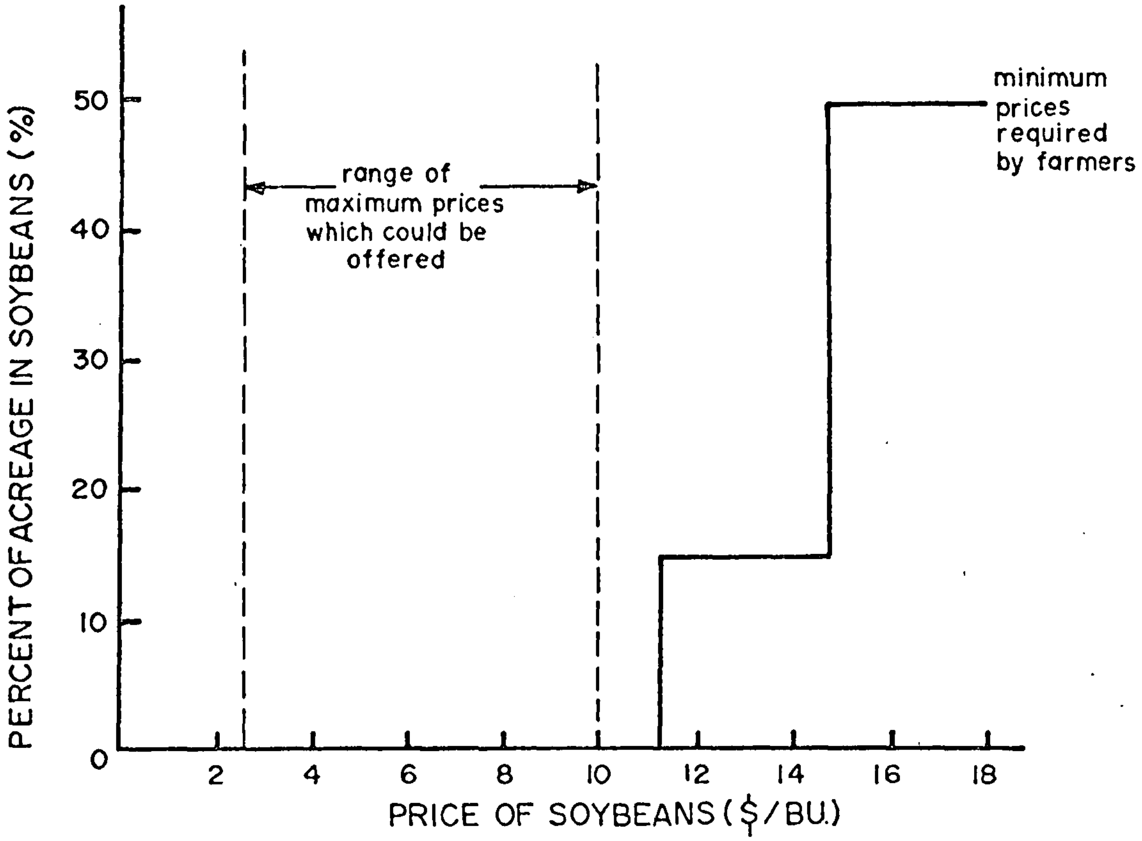

Figure 22. Comparison of the maximum prices which could be offered and the minimum prices required by farmers, Willamette Valley.

($7.99 - $0.13 = $7.86). With Willamette Valley farmers requiring $11.22 per bushel, it appears that soybean production in this area is not economically feasible based on the assumptions and data used in this analysis.

Columbia Basin

Transportation costs involved with getting soybeans from the Columbia Basin to Portland would average about 28 cents per bushel (Fitch). Subtracting the transportation costs from the Portland soybean price range (as estimated in Chapter Five) results in a range on the soybean price Columbia Basin farmers may anticipate of $2.41 to $9.79 per bushel (the vertical dashed lines in Figure 23). The average maximum price, assuming a processing plant in Portland with the resulting meal and oil used in the Pacific Northwest, is $7.71 per bushel after subtracting transportation costs to Portland (Table 24). The minimum price required for soybeans to successfully compete with the alternate crops in the Columbia Basin is $10.15 per bushel, $2.44 higher than the average maximum price farmers may anticipate.[1/]

1/ The processor could locate in Hermiston, for example, instead of Portland. The Hermiston processor would be closer to (1) soybeans grown in the Columbia Basin and (2) the source of demand for meal in livestock rations. Some transportation costs could be saved, vis-a-vis the Portland location, and might result in a higher on-farm soybean price for Columbia Basin farmers. However, the Hermiston processor would be farther away from the Willamette Valley, the center of the demand for meal in poultry rations. Unless a refinery also were to be located in Hermiston, crude oil produced at the Hermiston processing plant would have to be transported to Portland, refined, and transported back to the Columbia Basin before it could be utilized by the potato processing industry. The saving in transportation costs could be offset by these other factors and thus have no effect on the soybean price Columbia Basin farmers might anticipate.

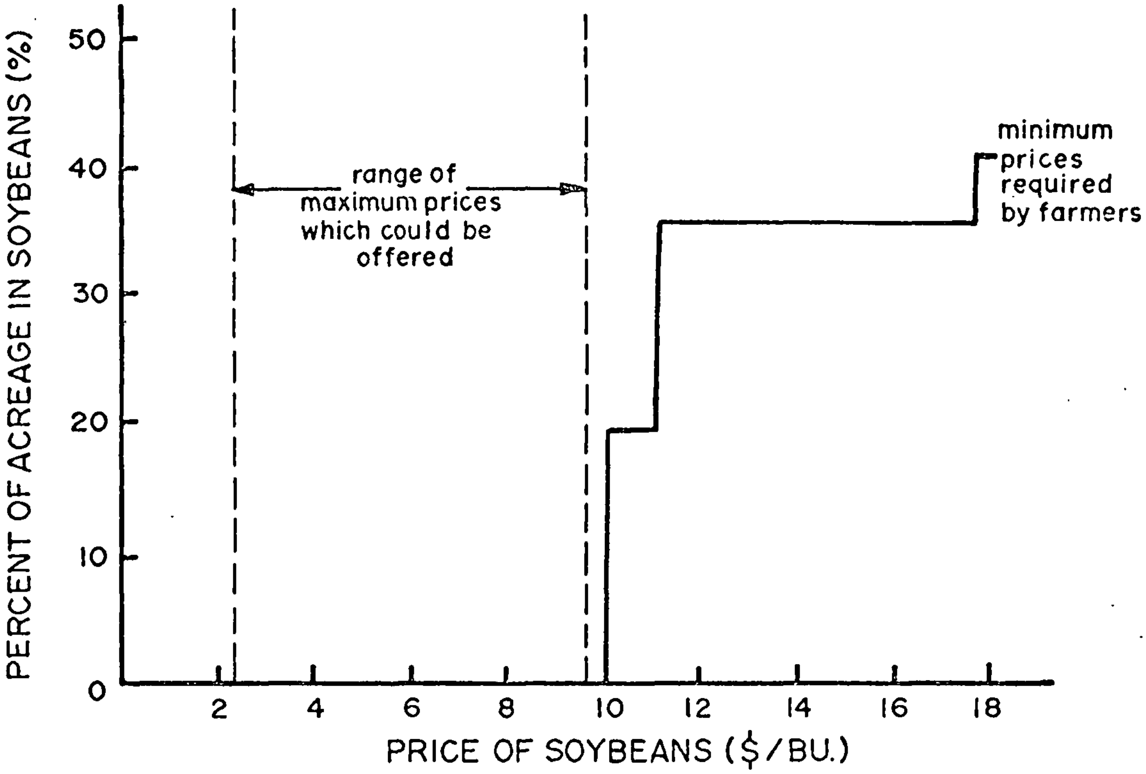

Figure 23. Comparison of the maximum prices which could be offered and the minimum prices required by farmers, Columbia Basin.

If soybeans could be grown in the Columbia Basin without a cover crop to curb wind erosion, the minimum price required for soybeans to successfully compete with the alternate crops becomes $7.86 per bushel (Chapter Four). However, the average maximum soybean price Columbia Basin farmers may expect ($7.71 per bushel) is still lower. Therefore, based on the assumptions and data used in this analysis, it appears that soybean production in the Columbia Basin is not economically feasible.

Ontario Area

The average transportation costs involved in getting soybeans from the Ontario Area to Portland would be about 39 cents per bushel (Burr). Subtracting the transportation costs from the maximum Portland soybean price range (Chapter Five) indicates that the on-farm price Ontario Area farmers may anticipate would range from $2.30 to $9.68 per bushel (indicated by the vertical dashed lines in Figure 24). The solid line in Figure 24 represents the percent of the Ontario Area acreage in soybeans as the price of soybeans increases. The minimum price necessary for soybeans to successfully compete with the alternate crops in the Ontario Area is $8.25 per bushel. The highest maximum price which could be offered for Ontario Area soybeans in $1.43 per bushel higher than the minimum price required by farmers to grow soybeans. At this price, 35 percent of the Ontario Area acreage would be in soybeans. However, only two of the 24 estimates of the maximum Portland price (Table 24) result in a price higher than that required by Ontario Area farmers after subtracting transportation costs to Portland. The average maximum price for the six years analyzed, assuming a processing plant at Portland and the resulting meal and oil used in the Pacific Northwest, is $7.60 per bushel after sub-

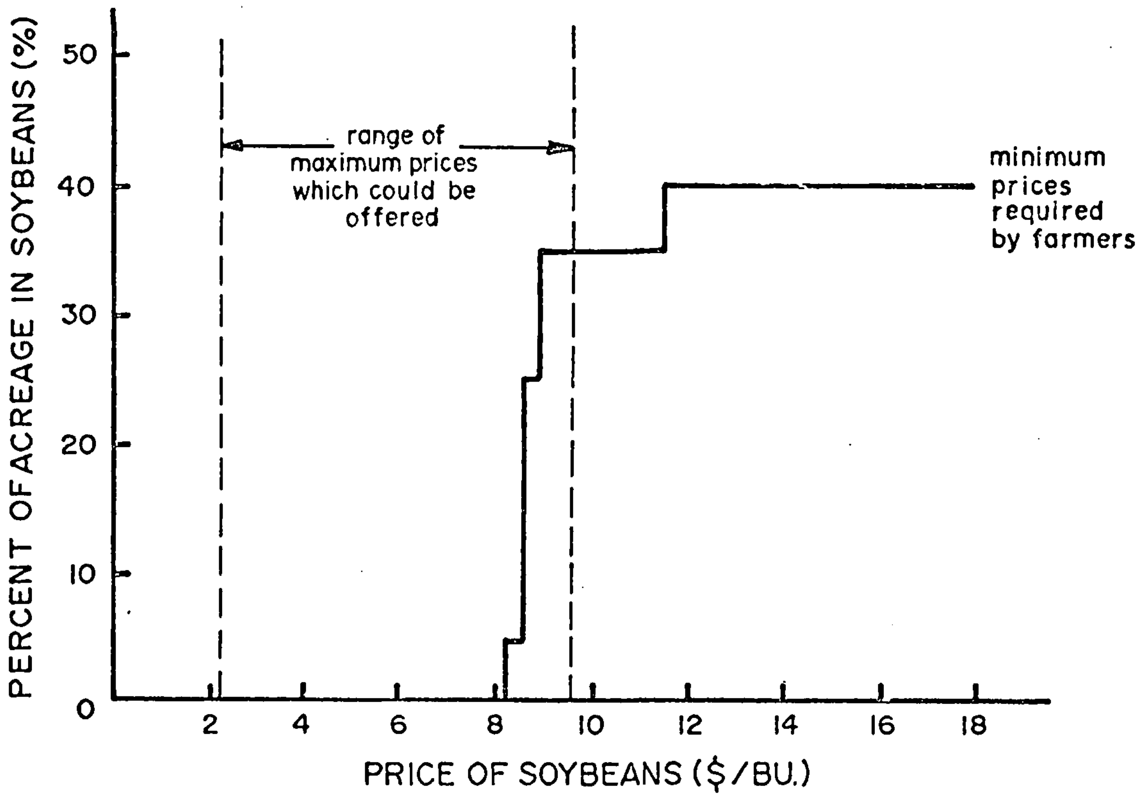

Figure 24. Comparison of the maximum prices which could be offered and the minimum prices required by farmers, Ontario Area.

tracting transportation costs to Portland. With the minimum price required by Ontario Area farmers being $8.25 per bushel, the economic feasibility of soybean production in the Ontario Area appears marginal.

Other Considerations

This analysis indicates that the economic feasibility of soybean production in Oregon is limited. However, other factors, beyond the scope of this study, may improve soybeans' position.

The energy issue as it relates to crop production may favor soybeans. As the cost of electrical energy increases, so do the costs of irrigation. It appears that irrigation pumping requirements are less for soybeans then for other row crops and alfalfa if grown at the same elevation. Accounting for future increases in pumping energy costs in the linear programming analyses (Chapter Four) would result in a lower minimum price necessary for soybeans to compete with the alternate crops which require more pumping energy.

Increases in energy costs would also increase transportation costs. Accounting for the transportation cost changes in the Decatur base-point pricing scheme of Chapter Five may result in a higher maximum Portland soybean price which could be offered.

A third energy related issue is fertilizer. As energy costs increase, fertilizer costs may also increase. Since soybeans require less nitrogen fertilizer than the other crops analyzed in this study, future increases in nitrogen fertilizer costs may result in a lower minimum price required for soybeans to compete with the alternate crops. Therefore, it appears that increases in energy costs may increase the economic feasibility of soybean production in Oregon.

The competitive position of soybeans compared to the alternate crops in this analysis may be improved in other ways. Soybean yields used in the linear programming analyses were 40 bushels per acre in the Columbia Basin and Ontario Area and 30 bushels per acre in the Willamette Valley. If a variety of soybeans better adapted to the climatic conditions and soil types which exist in Oregon were to be developed, yields could be increased. A lower minimum price required for soybeans to successfully compete with the alternate crops would result.

For soybeans to become an economically viable crop alternative in Oregon, further research should be undertaken. Soybean research in Oregon is needed to:

(1) determine what yields would be required for soybeans to become an economically viable crop alternative in Oregon and determine if these yields are attainable through plant breeding;

(2) determine the economic feasibility of a soybean processing plant in the Pacific Northwest;

(3) economically evaluate improvements in soil fertility resulting from nitrogen fixation and carryover; and

(4) determine and evaluate other marketing alternatives which may exist for Oregon-grown soybeans.

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A P P E N D I X A

United States Soybean Acreages, Yields, and Prices

Tables A-1 to A-5

Table A-1. U. S. Soybean Acreage Harvested for Beans and Average Yield, 1960-1976

Year	Acres harvested	Average yield per acre harvested
	(Thousand)	(Bushels)
1960	23,655	23.5
1961	27,003	25.1
1962	27,608	24.2
1963	28,615	24.4
1964	30,793	22.8
1965	34,449	24.5
1966	36,546	25.4
1967	39,805	24.5
1968	41,391	26.7
1969	41,337	27.4
1970	42,249	26.7
1971	42,701	27.5
1972	45,698	27.8
1973	55,796	27.7
1974	52,368	23.2
1975	53,761	28.8
1976	49,443	25.6

Source: U. S. Department of Agriculture. Crop Production Annual Summaries: 1961, 1966, 1969, 1972, 1973, 1975 and 1976. Crop Reporting Board, Statistical Reporting Service.

Table A-2. U. S. Soybean Acreage Harvested for Beans by Regions and States

Region	States	1960	1965	1970	1971	1972	1973	1974	1975	1976
		Year								
		(1,000 acres)								
Corn Belt:										
	Illinois	4,973	6,021	6,800	7,150	7,520	8,930	8,440	8,220	7,560
	Iowa	2,599	4,850	5,680	5,500	6,000	7,750	7,110	6,970	6,590
	Missouri	2,344	3,051	3,465	3,605	3,960	4,700	4,350	4,470	4,200
	Indiana	2,415	2,871	3,278	3,377	3,688	4,290	3,890	3,630	3,280
	Ohio	1,499	2,044	2,550	2,634	3,010	3,590	3,190	3,100	2,880
	Total	13,830	18,837	21,773	22,266	24,178	29,260	26,980	26,390	24,510
Delta:										
	Arkansas	2,409	3,550	4,400	4,300	4,050	4,650	4,300	4,700	4,320
	Mississippi	916	1,461	2,580	2,632	2,464	2,750	2,500	3,120	3,250
	Louisiana	216	622	1,688	1,644	1,667	1,580	1,760	1,920	2,120
	Total	3,541	5,633	8,668	8,566	8,181	8,980	8,560	9,740	9,690
Lake States:										
	Minnesota	2,090	3,166	3,030	2,780	3,225	4,390	4,000	3,650	3,020
	Michigan	221	440	500	500	524	693	630	610	565
	Wisconsin	96	160	153	128	145	241	217	191	152
	Total	2,407	3,766	3,683	3,408	3,894	5,324	4,847	4,451	3,737
Atlantic:										
	So.Carolina	499	806	1,010	1,070	1,080	1,250	1,250	1,380	1,190
	No.Carolina	545	776	867	990	1,165	1,450	1,420	1,420	1,100
	Virginia	320	345	339	353	350	413	430	433	398
	Maryland	225	202	213	220	253	275	310	318	285
	Delaware	189	139	156	152	161	178	198	204	182
	Total	1,778	2,268	2,585	2,785	3,009	3,566	3,608	3,755	3,155
Plains States:										
	Nebraska	164	696	812	609	707	1,210	1,190	1,200	1,030
	Kansas	586	873	930	871	875	1,200	1,030	1,080	865
	So. Dakota	100	333	247	232	253	396	368	342	271
	No. Dakota	176	211	181	208	190	218	179	149	147
	Total	1,026	2,113	2,170	1,920	2,025	3,024	2,767	2,771	2,313
Others:										
	Tennessee	394	732	1,150	1,219	1,298	1,570	1,520	1,850	1,800
	Alabama	133	228	600	655	800	970	1,020	1,310	1,220
	Kentuckey	199	295	530	705	924	1,140	1,170	1,200	1,070
	Georgia	75	209	475	600	670	950	1,010	1,260	940
	Texas	75	82	158	103	210	425	261	370	347
	Florida	30	78	184	207	232	254	279	295	265
	Oklahoma	124	152	185	163	170	200	219	237	240
	New Jersey	33	37	54	55	58	67	72	79	102
	Pennsylvania	7	16	28	32	41	55	44	43	42
	New York	3	3	6	7	8	11	11	10	12
	Total	1,073	1,832	3,370	3,746	4,411	5,642	5,606	6,654	6,038
TOTAL U. S.		23,655	34,449	42,249	42,701	45,698	55,796	52,368	53,761	49,443

Source: U. S. Department of Agriculture. Crop Production Annual Summaries: 1961, 1966, 1969, 1972, 1973, 1975 and 1976. Crop Reporting Board, Statistical Reporting Service.

Table A-1. Average Soybean Yields by Regions and States

Region	States	1960	1965	1970	1971	1972	1973	1974	1975	1976
		Year								
		(Bushels per Acre)								
Corn Belt:										
	Illinois	26.0	29.5	31.0	33.0	34.5	31.5	24.0	36.0	32.0
	Iowa	25.5	26.0	32.5	32.5	36.0	34.0	28.0	34.0	31.0
	Missouri	21.5	26.0	25.5	27.0	27.5	27.0	21.5	26.0	20.0
	Indiana	27.0	28.0	31.0	33.0	29.5	31.5	25.0	33.5	33.0
	Ohio	24.5	24.5	28.5	30.5	26.5	25.0	25.0	33.0	32.5
	Average	25.2	27.3	30.2	31.6	32.0	30.6	24.9	33.1	29.9
Delta:										
	Arkansas	21.0	21.5	22.5	21.5	20.0	25.0	19.0	24.5	18.0
	Mississippi	22.0	22.5	22.5	21.5	19.5	22.0	18.5	22.5	22.0
	Louisiana	24.0	21.5	24.0	24.0	23.0	22.0	25.0	24.5	26.0
	Average	21.4	21.8	22.8	22.0	20.5	23.6	20.1	23.9	21.1
Lake States:										
	Minnesota	19.5	18.5	26.0	23.0	28.0	29.0	21.0	26.5	21.0
	Michigan	20.0	22.0	26.5	20.5	26.0	24.0	21.0	26.0	20.5
	Wisconsin	16.0	19.0	24.0	23.5	28.0	25.0	20.0	25.5	22.0
	Average	19.4	18.9	26.0	22.7	27.7	28.2	21.0	26.4	21.0
Atlantic:										
	So. Carolina	19.5	21.0	20.0	21.5	18.5	19.0	18.5	22.0	18.0
	No. Carolina	22.5	25.0	24.0	24.0	25.0	24.0	21.5	23.5	21.5
	Virginia	22.5	20.5	20.0	24.0	23.0	27.0	23.5	25.0	20.5
	Maryland	26.0	27.0	24.0	30.0	27.0	31.0	28.5	28.0	25.0
	Delaware	24.0	25.0	21.0	28.0	25.0	28.0	26.0	25.0	24.0
	Average	22.3	23.1	21.7	23.7	22.6	23.3	21.5	23.6	20.5
Plains States:										
	Nebraska	28.0	23.5	22.0	25.0	32.5	30.0	23.5	27.0	20.0
	Kansas	21.5	21.0	15.0	20.5	28.0	22.0	19.5	21.0	15.0
	So. Dakota	17.0	17.0	17.5	21.0	29.0	24.0	20.0	25.0	17.0
	No. Dakota	13.0	19.0	15.0	14.0	20.5	23.5	16.0	19.5	12.5
	Average	20.6	21.0	17.9	21.3	29.0	25.6	21.1	24.0	17.3
Others:										
	Tennessee	22.5	23.5	23.0	26.0	22.0	23.5	21.0	25.0	22.5
	Alabama	24.0	22.0	23.0	26.0	20.0	21.0	23.0	24.5	24.0
	Kentucky	22.0	24.0	27.0	29.5	27.0	25.5	24.0	27.0	26.5
	Georgia	17.0	20.5	23.0	25.5	15.0	21.0	25.5	25.5	23.5
	Texas	27.0	26.0	28.0	27.0	26.0	20.0	30.0	25.0	26.0
	Florida	26.0	26.0	28.0	28.0	21.0	24.0	27.0	24.0	26.0
	Oklahoma	20.0	16.5	18.0	21.5	21.0	23.0	23.0	23.0	22.0
	New Jersey	24.5	23.5	25.0	28.0	17.0	21.0	29.0	26.0	24.0
	Pennsylvania	23.0	24.0	32.0	29.0	25.0	26.0	26.0	28.0	29.0
	New York	17.0	15.0	20.0	22.0	21.0	23.0	23.0	24.0	24.0
	Average	22.4	22.7	24.0	26.5	21.7	22.8	23.7	25.3	24.1
AVERAGE U. S.		23.5	24.5	26.7	27.5	27.8	27.7	23.2	28.8	25.6

Source: U. S. Department of Agriculture. _Crop Production Annual Summaries: 1961, 1966, 1969, 1972, 1973, 1975 and 1976._ Crop Reporting Board, Statistical Reporting Service.

Table A-4. Average Annual Prices Received by U. S. Farmers for Soybeans, 1960 to 1976

Marketing Year	Price per bushel
1960	2.13
1961	2.28
1962	2.34
1963	2.51
1964	2.62
1965	2.54
1966	2.75
1967	2.49
1968	2.43
1969	2.35
1970	2.85
1971	3.03
1972	4.37
1973	5.68
1974	6.64
1975	4.90
1976	7.02[a/]

Source: U. S. Department of Agriculture, 1976. U.S. Fats and Oils Statistics 1960-75. Economic Research Service. (Statistical Bulletin No. 560).

[a/] Preliminary.

Table A-5. Average Monthly Prices Received by U. S. Farmers for Soybeans, 1972 to 1976

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
						Month						
1972	2.92	3.00	3.20	3.37	3.35	3.32	3.34	3.36	3.26	3.13	3.38	3.95
1973	4.11	5.49	6.04	6.14	8.27	10.00	6.69	8.99	5.81	5.63	5.14	5.65
1974	5.87	6.07	5.96	5.15	5.21	5.13	6.11	7.55	7.32	8.17	7.44	7.03
1975	6.30	5.72	5.31	5.61	5.00	4.90	5.28	5.80	5.32	4.92	4.45	4.28
1976	4.46	4.50	4.46	4.52	4.87	6.16	6.73	6.07	6.65	5.90	6.11	6.56

Sources: U. S. Department of Agriculture. Agricultural Prices Annual Summaries: 1970 and 1975. Crop Reporting Board, Statistical Reporting Service.

U. S. Department of Agriculture. Agricultural Prices: March, June, September, December 1975, and March, June, September, December, 1976. Crop Reporting Board, Statistical Reporting Service.

A P P E N D I X B

Production Input and Machinery Cost Assumptions and Crop Budgets

Tables B-1 to B-5

Table B-1. Production Input Price Assumptions

Item	Unit	Price ($)
Alfalfa seed	lb.	1.75
Wheat seed	lb.	.10
Potato seed	cwt.	8.50
Sugarbeet seed	lb.	5.35
Seed corn	bu.	65.00
Sweet corn seed	bu.	54.00
Drybean seed	lb.	.25
Bushbean seed	lb.	.80
Soybean seed (inoculated)	bu.	18.00
Onion seed	a.	35.00
Sudan seed	lb.	1.00
Nitrogen	lb.	.25
Phosphorus	lb.	.48
Potassium	lb.	.09
Sulfur	lb.	.18
Zinc	lb.	.53
Boron	lb.	.90
Fertilizer spreader rental	a.	.75
Lime (applied)	T.	22.00
Kerb	lb.	7.90
Simazine	lb.	3.75
Sencor	lb.	14.92
Banvel-D	oz.	.27
2, 4-D	pt.	1.10
Treflar	gal.	31.00
Atrazine	lb.	2.95
Eptam-7E	gal.	25.00
Ro-Neet	lb.	6.00
Betanex	gal.	30.00
Lasso	qt.	4.00
Dyfonate	lb.	.62
Di-Syston	lb.	.49
Monitor	qt.	10.00
Nudrin	qt.	4.00
Difolatan	gal.	9.75
Sulfur Dust	lb.	.17
Di-Nitro	qt.	2.75
Custom chemical application	a.	2.25
Fumigant-applied	a.	90.00
Sprout-inhibitor-applied	a.	20.00
Rodent control	a.	2.00
Bale wire	T.	3.00
Crop insurance (wheat)	bu.	.04
Land plane rental	a.	2.00
Custom wheat hauling	bu.	.08
Custom potato hauling	cwt.	.20
Custom sugarbeet hauling	T.	1.50
Custom corn hauling	bu.	.08
Custom sweet corn hauling	T.	5.00
Custom drybean hauling	cwt.	.30
Custom bushbean hauling	T.	5.00
Custom soybean hauling	bu.	.08
Custom onion hauling	cwt.	.14
Custom harvest onions (piece-basis)	cwt.	.39
Custom handling onions	cwt.	.20
Onion box rental	cwt.	.18
Custom thinning (sugarbeets)	a.	25.00
Custom hoeing (sugarbeets)	a.	20.00
Custom topping (sweetcorn)	a.	5.00
Machinery labor	hr.	4.50
Irrigation labor	hr.	3.50
Miscellaneous labor	hr.	3.50
Operating capital interest	%	9.00
Lorox	lb.	4.25

Table B-2. Machinery Inventory, Costs, and Capacity Assumptions

Machine	Size	Width	Ownership costs a/	Repair cost	Fuel & lube	Field capacity
	(hp.)	(ft.)	($/hr.)	($/hr.)	($/hr.)	(hrs./a.)
Wheel tractor	40		2.89	.66	.94	
Wheel tractor	100		6.19	1.16	2.11	
Wheel tractor, 4WD	130		7.20	1.83	2.80	
Plow		9.3	11.09	1.74		.209
Chisel plow		18.0	6.49	1.41		.115
Tandem disk		15.0	3.17	2.30		.143
Cultipacker		15.0	1.99	.76		.143
Drill		12.0	6.62	3.08		.281
Planter, gen. purpose		12.0	3.67	.54		.183
Potato planter		12.0	19.05	3.52		.393
Cultivator		12.0	2.58	.81		.172
Combine w/o head	125		24.80	10.05	1.97	
Cutter-bar head		18.0	3.65	.59		.402
Corn head		12.0	7.61	1.34		.423
Beet topper		11.0	12.53	1.74		.510
Beet digger		5.5	14.54	3.40		.612
Potato digger		6.0	12.84	9.09		1.511
Self-propelled swather	50	12.0	17.10	4.80	.26	.327
PTO baler		6.0	14.84	1.09		.344
PTO bale wagon		12.0	20.69	2.60		.430
Accumulator		8.0	2.71	2.34		.344
Loader-balefork		12.0	3.28	1.27		.430
Picker		6.0	12.18	2.05		.750
Snap bean harvester		6.0	31.20	3.37		.500
Onion lifter		6.0	1.18	.52		.300
Truck			10.40	4.37		
Pickup			4.23	3.08		

Table B-3. Estimated per Acre Costs and Returns for Selected Crop Enterprises: Willamette Valley

Crop	Wheat	Silage corn	Sweet corn	Bush beans	Alfalfa production	Alfalfa establishment	Soybeans
Income:							
Price	$3.25/bu.	$19.00/T.	$60.00/T.	$140.00/T.	$65.00/T.		?
Yield	100 bu.	25 T.	8.6 T.	4.6 T.	6 T.		30 bu.
Gross income	$325.00	$475.00	$516.00	$644.00	$390.00	0	?
Costs:							
Seed	10.59	16.25	13.50	64.00	0	35.00	18.00
Fertilizer & spreader	61.17	73.93	77.37	54.41	46.28	111.53	34.74
Chemicals & application	22.16	11.10	11.79	75.51	11.55	0	10.38
Other direct expenses a/	8.75	125.00	48.00	34.50	24.00	0	2.40
Machinery operating b/	9.55	11.52	14.73	12.83	15.19	11.01	13.47
Irrigation pumping	7.00	14.00	10.50	17.50	17.50	0 j/	17.50
Irrigation repairs	4.67	9.33	7.00	11.66	11.66	0 j/	11.66
Irrigation labor c/	10.50	21.00	15.75	28.00	28.00	0 j/	28.00
Other labor	5.30	11.96	15.79	17.31	16.65	9.82	8.32
Operating capital interest d/	6.29	13.24	9.65	14.21	7.69	7.53	6.50
Machinery ownership e/	21.76	25.23	33.30	37.85	55.21	22.01	27.66
Irrigation ownership f/	35.00	35.00	35.00	35.00	35.00	0 j/	35.00
Land taxes g/	11.00	11.00	11.00	11.00	11.00	0 j/	11.00
Management h/	8.55	15.14	12.14	16.55	11.19	7.88	8.99
Overhead i/	6.41	11.36	9.10	12.41	8.39	5.91	6.74
TOTAL COSTS	$228.70	$405.10	$324.62	$442.74	$299.31	$210.69	$240.36
RETURN TO LAND	$ 96.30	$ 69.90	$191.38	$201.26	$ 90.69	-$210.69	$?

a/ Includes such items as baling wire, rodent control, custom hauling, and custom topping of sweet corn.

b/ Includes fuel lubrication and repairs.

c/ Hired labor

d/ Assumed that the cash expenses are outstanding for half a year with a 9% interest charge.

e/ Includes depreciation, interest on average investment at 9%, property taxes at 1.1% of purchase price, and insurance at 0.7% of average investment.

f/ Based on one hand-move system per 80 acres with an initial investment of $350 per acre.

g/ Based on farm use value.

h/ Estimated at 4% of all costa except land investment and overhead.

i/ Estimated at 3% of all costs except land investment and management.

j/ Since alfalfa is assumed to be established in the fall, no irrigation costs are incurred and the land taxes have been charged to the prior crop.

Table B-4. Estimated per Acre Costs and Returns for Selected Crop Enterprises: Columbia Basin

Crop	Wheat	Sugarbeets	Potatoes	Alfalfa production	Alfalfa establishment	Corn	Drybeans	Soybeans	Cover crop
Income:									
Price	$3.25/bu.	$25/T.	$55/T.	$65/T.		$3/bu.	$18/cwt.	$?/bu.	
Yield	90 bu.	28 T.	25 T.	7 T.		155 bu.	18 cwt.	40 bu.	
Gross income	$292.50	$700.00	$1375.00	$455.00	0	$465.00	$324.00	$?	0
Costs:									
Seed	9.98	16.05	187.00	0	35.00	21.45	22.50	24.00	15.00
Fertilizer & spreader	64.34	77.63	232.94	37.14	7.95	151.80	45.05	41.75	0
Chemicals & application	4.85	92.28	100.27	10.15	0	23.35	5.61	22.50	0
Other direct expenses a/	10.80	107.00	100.00	22.00	2.00	12.40	5.40	3.20	0
Machinery operating b/	9.41	16.13	32.73	22.35	14.69	14.07	17.13	15.26	5.41
Irrigation pumping c/	22.21	28.77	26.88	28.42	2.62k/	23.84	20.45	20.45	2.62k/
Irrigation repairs	6.38	10.48	9.30	10.26	1.64	7.40	5.28	5.28	1.64
Irrigation labor d/	6.70	11.00	9.76	10.77	1.72	7.77	5.54	5.54	1.72
Other labor	7.27	16.11	20.67	23.51	17.21	12.50	13.37	12.47	5.22
Operating capital interest e/	6.39	16.90	32.38	7.41	3.73	12.36	6.31	6.77	1.42
Machinery ownership f/	19.51	41.15	58.37	73.56	27.44	30.41	38.38	31.24	9.69
Irrigation ownership g/	43.55	43.55	43.55	43.55	0 k/	43.55	43.55	43.55	0 k/
Land taxes h/	10.00	10.00	10.00	10.00	0 k/	10.00	10.00	10.00	0 k/
Management i/	8.86	19.48	34.55	11.96	4.56	14.84	9.54	9.68	1.71
Overhead j/	6.64	14.61	25.92	8.97	3.42	11.13	7.16	7.26	1.28
TOTAL COSTS	$236.89	$521.14	$924.32	$320.05	$121.98	$396.87	$255.27	$258.95	$45.71
RETURN TO LAND	$ 55.61	$178.86	$450.68	$134.95	-$121.98	$ 68.13 l/	$ 68.73	$?	-$45.71

a/ Includes such items as land plane rental, bale wire, and rodent control for alfalfa, fire insurance for wheat, custom thinning and hoeing for sugarbeets, and custom hauling.

b/ Includes fuel, lubrication, and repairs.

c/ Includes electricity and water district charges.

d/ Hired labor.

e/ Assumed that the cash expenses are outstanding for half a year with a 9% interest charge.

f/ Includes depreciation, interest on average investment at 9%, property taxes at 1.1% of purchase price, and insurance at 0.7% of average investment.

g/ Based on one center-pivot irrigation system per 130 acres with $35,620 initial investment in one sprinkler unit (1/4 mile), pumps, and miscellaneous. Additional investment for mainlines equals $87.50 per acre.

h/ Based on farm use value.

i/ Estimated at 4% of all costs except land investment and overhead.

j/ Estimated at 3% of all costs except land investment and management.

k/ The operations for these alternatives are performed in the fall following other crop enterprises thus, irrigation district charges, irrigation equipment ownership charges, and land taxes have been charged to the prior crop.

l/ This net return would be similar for a 25 ton per acre silage yield at a price of $19.00 per ton.

B-5. Estimated per Acre Costs and Returns for Selected Crop Enterprises: Ontario Area

Crop	Wheat	Sugarbeets	Potatoes	Alfalfa production	Alfalfa establishment	Corn	Sweet corn	Onions	Soybeans
Income:									
Price	$3.25/bu.	$25/T.	$55/T.	$60/T.		$3/bu.	$55/T.	$3.75	$?
Yield	100 bu.	27 T.	17.5T.	6 T.		130 bu.	8 T.	450 cwt.	40 bu.
Gross income	$325.00	$675.00	$962.50	$360.00	0	$390.00	$440.00	$1687.50	$?
Costs:									
Seed	10.50	21.40	160.00	0	32.30	21.45	12.94	35.00	24.00
Fertilizer & spreader	63.65	112.35	103.24	11.31	24.41	82.59	70.58	172.07	34.97
Chemicals & application	4.85	100.50	120.25	12.03	10.00	23.35	30.53	123.25	22.50
Other direct expenses a/	6.00	105.50	78.00	20.50	0	10.40	45.00	410.00	3.20
Machinery operating b/	10.83	18.75	31.44	22.35	6.06	13.28	11.62	11.70	13.36
Irrigation pumping	10.80	10.80	10.80	10.80	0 i/	10.80	10.80	10.80	10.80
Irrigation repairs	.44	1.05	.99	.60	.10	.50	.40	.60	.45
Irrigation labor	8.75	37.00	35.00	21.00	3.50	17.50	14.00	21.00	15.75
Other labor	6.60	17.63	16.60	23.51	4.91	9.98	11.46	188.29	9.10
Operating capital interest c/	5.60	19.12	25.03	5.49	3.66	8.54	9.33	43.32	6.02
Machinery ownership d/	23.88	47.48	56.83	73.56	12.35	30.65	30.72	25.52	28.69
Irrigation ownership e/	4.20	4.20	4.20	4.20	0 i/	4.20	4.20	4.20	4.20
Land taxes f/	23.00	23.00	23.00	23.00	0 i/	23.00	23.00	23.00	23.00
Management g/	7.24	20.75	26.62	9.13	3.89	10.25	10.98	42.35	7.84
Overhead h/	5.43	15.56	19.96	6.85	2.92	7.69	8.24	31.76	5.88
TOTAL COSTS	$193.77	$555.09	$711.96	$244.33	$104.10	$293.80	$274.18	$1132.86	$209.76
RETURN TO LAND	$131.23	$119.91	$250.54	$115.67 j/	-$104.10 j/	$146.20 k/	$115.82	$ 554.64	$?

a/ Includes such items as custom hauling, custom thinning and hoeing sugarbeets, bale wire, handling, harvesting, and weeding onions, and custom topping of sweet corn.

b/ Includes fuel, lubrication, and repairs.

c/ Assumes that the cash expenses are outstanding for half a year at 9%.

d/ Includes depreciation, interest on average investment at 9%, property taxes at 1.1% of purchase price, and insurance at 0.7% of average investment.

e/ Based on a siphon irrigation system.

f/ Based on farm use value.

g/ Estimated at 4% of all costs except land investment and overhead.

h/ Estimated at 3% of all costs except land investment and management.

i/ Since alfalfa is assumed to be established in the fall, water district charges, irrigation ownership costs, and land taxes have been charged to the prior crop.

j/ This net return per acre is assumed to be similar for alfalfa seed production and establishment.

k/ This net return per acre would be similar for a 20 ton per acre silage yield at a price of $19.00/ton.

A P P E N D I X C

Experimental Soybean Variety Trials

Tables C-1 and C-2

Table C-1. Soybean Variety Trials, Hermiston, Oregon

Variety	1973 Yield bu./A.	1972 Yield bu./A.
Merit	59.5	63.5
Grant	57.9	58.5
Dunn	56.5	
Clay	56.5	61.7
Wirth	56.5	
Hark	52.6	
Norman	51.0	53.0
M63-173	50.3	
Rampage	49.9	53.1
FFR 955-053	49.0	
Anoka	47.1	
0-4323	45.1	61.0
FFR 950-108	44.7	
FFR 950-18 Buff	43.8	
OR Sel 10	40.0	
FFR 955-048	35.4	
FFR 950-021	31.1	
FFR 950-18 Black	0.0 (Did not mature)	

Source: New Crops Annual Report, Oregon State University, Crop Science Department, 1973.

Table C-2. Seed Yield, Maturity and Plant Height of Soybean Varieties Grown on Sandy Soil, Corvallis, Oregon, 1973

Variety	Days to 50% Flower	Days to Maturity	Ht. cm. 9/28/73	Yield in bu./A.		
				I	II	Avg.
Wirth	69	139	100	41.9	35.0	38.5
Rampage	68	150	101	37.2	35.4	36.3
Anoka	70	145	102	32.5	37.2	34.9
0-4323	58	132	98	34.0	35.9	34.8
Dunn	68	140	111	29.4	34.8	32.1
Merit	67	134	89	32.9	30.8	31.9
M63-173	59	126	75	40.2	-	40.2

Source: New Crops Annual Report, Oregon State University, Crop Science Department, 1973.

A P P E N D I X D

Linear Programming: A Brief Discussion and Example

APPENDIX D

Linear Programming: A Brief Discussion and Example

The purpose of this appendix is twofold. First, the assumptions of linear programming are briefly discussed. This is followed by an example of the use of linear programming within the framework of this thesis.

Linear Programming

Linear programming is a mathematical tool typically used by agricultural economists to determine the optimum organization of production resources and activities in a farm planning context. The standard form of a linear programming model consists of three parts: (1) a linear objective function; (2) a set of linear constraints; and (3) non-negativity requirements on the activities.

The objective function consists of costs, prices, or net returns associated with the alternate activities (or farm enterprises) under consideration. The objective function is maximized (in a profit-problem context) or minimized (in a cost-analysis context) subject to a set of constraints. These constraints indicate (1) the amount of each resource required by each activity and (2) the amount of each resource available. Restrictions on the level of activities may also be included in the set of constraints. The non-negativity condition on the activities stipulates the physical fact that no negative amount of real activities or products can be produced.

Linear programming models embody five basic assumptions. These are: linearity, additivity, divisibility, finiteness, and single-valued expectations.

The objective function and constraints must be linear. That is, no term may comprise more than one variable and that variable must appear in the first degree. The additivity assumption states that the total amount of resources used by two or more activities must equal the sum of the resources used by each individual activity. The resources and products are assumed to be infinitely divisible, that is, inputs and outputs can be utilized or produced in fractional units. There exists a finite limit to the number of alternate activities and resource constraints under consideration. The single-valued expectation assumption applies to the resource supplies, the relationship between inputs and outputs, and the prices, costs, or net returns. It is assumed that these values are known with certainty. For more detailed information on the assumptions and use of linear programming see Beneke and Winterboer.

The Structure of the Model

A simplified example of the linear programming models used in this study is presented in Table D-1. The models are static, long-run models which maximize returns to land. The models are long-run in the sense that fixed as well as variable costs for machinery and irrigation equipment are included for the crop production alternatives.

Model Activities

Three distinct, but interrelated sets of activities are defined to ensure the agronomics of crop production and determine the impact of various soybean price assumptions on the acreage of soybeans produced. The three sets of activities are (1) crop rotations, (2) crop acreages, and (3) production sales.

The Crop Rotation Activities. These activities use available land acreage and are restricted by individual crop acreage constraints. For ex-

Table D-1. A Simplified Example of the Linear Programming Models Used in this Study

Description of equation or inequality	Activities: Crop Rotations[1/] WPOT	WPOS	POTS	WAWS	Crop Acreages AWHT	APOT	ASOY	AALF	AAFE	ACVC	Production Sales BWHT	TPOT	BSOY	TALF		Right-hand side
Objective function[2/]					-236.89	-924.32	-258.95	-320.05	-121.98	-45.71	+3.25	+55.00	+?	+65.00	=	Returns to land
Land acreage constraint	+2	+3	+2	+7											≤	100
Wheat acreage constraint	+1	+1		+2											≤	40
Potato acreage constraint	+1	+1	+1												≤	40
Alfalfa acreage constraint				+4											≤	35
Alfalfa acreage constraint				+4											≥	15
Wheat acreage transfer	+1	+1		+2	-1										=	0
Potato acreage transfer	+1	+1	+1			-1									=	0
Soybean acreage transfer		+1	+1	+1			-1								=	0
Alfalfa acreage transfer				+4				-1							=	0
Alfalfa Estab. acreage transfer				+1					-1						=	0
Cover crop acreage transfer		+1	+2							-1					=	0
Wheat production transfer					-90						+1				=	0
Potato production transfer						-25						+1			=	0
Soybean production transfer							-40						+1		=	0
Alfalfa production transfer								-7						+1	=	0

1/ Selected from the list of crop rotations in Table 14.

2/ Production costs per acre and prices per unit taken from Table 9.

where:

WPOT = wheat, potato rotation
WPOS = wheat, potato (cover crop), soybean rotation
POTS = potato (cover crop), soybean (crover crop) rotation
WAWS = wheat (alfalfa establishment), four years alfalfa production, wheat, soybean rotation
AWHT = wheat acreage
APOT = potato acreage
ASOY = soybean acreage
AALF = alfalfa production acreage
AAFE = alfalfa establishment acreage
ACVC = cover crop acreage
BWHT = wheat production (bu.)
TPOT = potato production (T.)
BSOY = soybean production (bu.)
TALF = alfalfa production (T.)

ample, the first rotation listed in Table D-1 (wheat, potatoes) requires two acres of land; one acre of wheat and one in potatoes. The last rotation listed (wheat, alfalfa establishment, four years alfalfa production, wheat, soybean) requires seven acres of land; two wheat, four alfalfa, and one soybean. The establishment of alfalfa, as well as the planting of cover crops, is assumed to be performed in the fall of the year, after the prior crop (wheat in this case) is harvested. Hence, additional land acreage is not required. The crop rotation activities contribute individual crop acreages at no cost or benefit.

The Crop Acreages Activities. These activities sum the individual crop acreages resulting from the mix of crop rotations. Per acre costs of production are specified in the objective function. They contribute total crop production based on their respective per acre yields.

The Production Sales Activities. These activities require the individual crop production levels as determined above. These production levels are taken times their respective per unit product prices to obtain total gross sales of each crop produced. The price of soybeans is initially set at a low level. It is systematically increased (based on the range over which it can vary without changing the optimal farm plan) until further increases result in no change in the optimal plan (see Table 15 for example).

Model Constraints

Production resource availabilities are assumed to be unrestrictive with the exception that one hundred acres of land are available for crop production. The one hundred acres is viewed as representing one hundred percent of the land suited to crop production in each region.

A set of constraints which restrict the levels of each of the crops presently grown to a specified range were developed. These constraints place an upper and, in some cases, lower limit on individual crop acreages consistent with historical trends in each region. The example presented indicates that wheat and potatoes could not exceed forty percent of the acreage respectively. Alfalfa is required to be grown on at least fifteen percent of the acreage but could be grown on no more than thirty-five percent.

A series of balancing constraints are then developed. These constraints transfer individual crop acreages and yields to account for the appropriate costs of production and product prices.