Strawberries in the Northwest: Present Situation and Future Prospects

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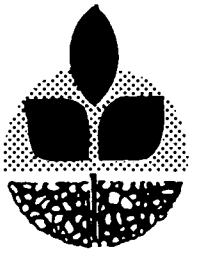

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CONTENTS

SUMMARY

Production of strawberries is worth more than $13 million annually to Pacific Northwest (PNW) growers who produce on 5000 acres of sandy loam soils in Oregon's Willamette Valley and on 3000 acres in southwest central Washington. A typical grower produces strawberries for processing on 10 to 15 acres and grows other crops. The costs of production and resource requirements are high; it costs about $1200 per acre in non-land costs to establish strawberries and about $1900 per acre to produce them, including harvest costs. Rootstock and agri-chemicals account for more than half of establishment costs. Most of the production costs are for hired labor to move irrigation lines and to pick fruit. The uncertain availability of pickers has been a major impetus in the drive to develop a mechanical harvester. Its economic feasibility is uncertain.

The PNW's major competitor in strawberry production is California which produces up to 80 percent of the U.S. crop. Their yields are 40,000 pounds per acre compared to about 6,900 pounds per acre in the PNW. The major competitive advantage enjoyed by the PNW is a more flavorful, higher quality berry.

There is considerable strawberry breeding activity going on. Consequently yields are expected to increase dramatically by the end of the century. Prospects for an Integrated Pest Management program are fair but little research in that area is currently ongoing.

Although the PNW market share is shrinking maintaining acreages and increasing yields could increase the volume of production. The possibility of increased local and fresh market could be explored.

STRAWBERRIES IN THE NORTHWEST: PRESENT SITUATION AND FUTURE PROSPECTS

Shepard C. Buchanan, James K. Whittaker, A. Gene Nelson

INTRODUCTION

The strawberry is one of America's most popular and versatile small fruits. Strawberries are grown in nearly every state, but over 80 percent of the commercially marketed berries, including imports, are produced in California, Oregon, and Washington (Figure 1).

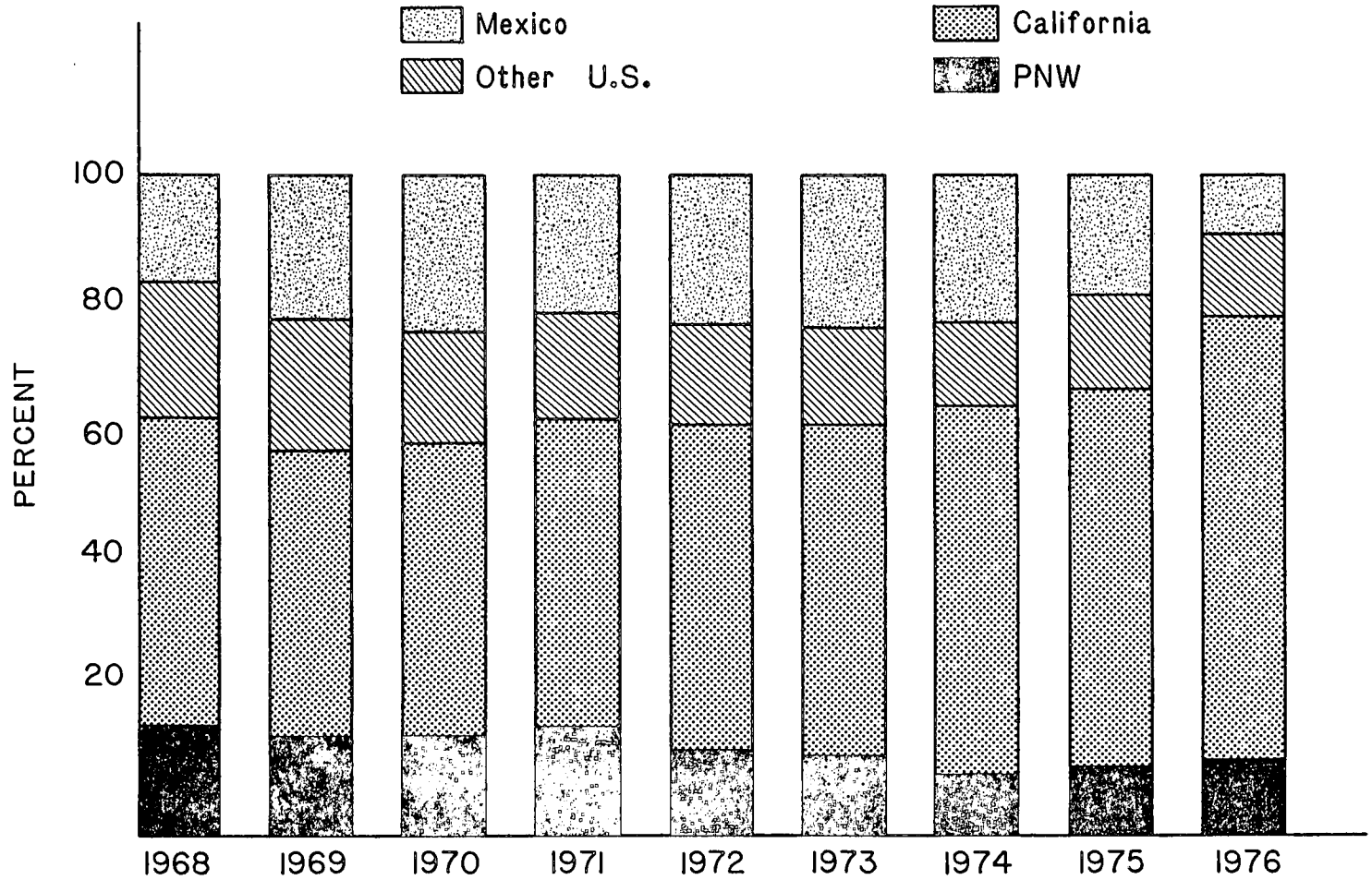
There are two commercial markets for strawberries: fresh and processed. The fresh market consists of U-pick operations and retail sales from fruit stands and supermarkets. Roughly half of the strawberries grown in the United States enter the fresh market. Only about 10 percent of the PNW berries are grown for fresh markets.

The processed strawberry market includes berries for juice stock, puree, individual quick freeze, and frozen sliced berries. Popular uses of processed strawberries include ice cream, jams and jellies, juices, flavorings, dessert toppings, and yogurt. Ninety percent of PNW strawberries are for processing. Traditionally this total has accounted for about half of the total processing market in the United States. In recent years the PNW share has been a declining proportion, down now to about a quarter of the U.S. share (Table 1). The PNW strawberry continues to be a high quality berry highly valued by processors for its excellent color and delicate flavor.

The purposes of this report are to assess the relative position of PNW (Oregon and Washington) strawberries in today's markets and to evaluate the long-term outlook for PNW strawberry production.

Figure 1.

STRAWBERRIES: REGIONAL PRODUCTION AS PERCENT OF TOTAL U.S. CONSUMPTION



Source: Oregon State University Extension Service, Commodity Data Sheet "Strawberries"

Table 1. Strawberry Production in the U.S. by State and Year, 1971-1978.

Area or State	Market	1971 Qty[1]	1971 % of U.S. market	1972 Qty[1]	1972 % of U.S. market	1973 Qty[1]	1973 % of U.S. market	1974 Qty[1]	1974 % of U.S. market	1975 Qty[1]	1975 % of U.S. market	1976 Qty[1]	1976 % of U.S. market	1977 Qty[1]	1977 % of U.S. market	1978 Qty[1]	1978 % of U.S. market
Oregon	Fresh	3.7	1	2.8	1	3.0	1	3.9	1	3.8	1	6.2	2	3.8	1	3.6	1
	Proc	79.5	44	51.4	37	45.8	28	37.6	22	38.0	22	41.6	20	31.2	13	30.4	17
	Total	83.2	16	54.2	12	48.8	10	41.5	8	41.8	8	47.8	8	35.0	5	34.0	5
Washington	Fresh	3.3	1	3.3	1	2.9	1	2.5	1	2.5	1	3.0	1	3.2	1	3.5	1
	Proc	23.4	13	21.0	15	18.7	11	20.2	12	20.6	12	22.1	10	16.9	7	14.0	8
	Total	26.7	5	24.3	5	21.6	5	22.7	4	23.1	4	25.1	4	20.1	3	17.5	3
PNW	Fresh	7.0	2	6.1	2	5.9	2	6.4	2	6.3	2	9.2	3	7.0	2	7.1	2
	Proc	102.9	57	72.4	52	64.5	40	57.8	34	58.6	34	63.7	30	48.1	21	44.4	24
	Total	109.9	21	78.5	17	70.4	15	64.2	12	64.9	12	72.9	13	55.1	8	51.5	8
California	Fresh	235.0	69	226.4	71	226.7	72	277.6	75	270.9	73	281.1	78	343.6	82	382.2	82
	Proc	68.0	38	58.3	42	93.3	57	105.1	62	109.1	63	140.1	66	178.4	77	131.6	72
	Total	303.0	58	284.7	62	320.0	67	382.7	71	380.0	70	421.2	74	522.0	80	513.8	79
Michigan	Fresh	15.4	5	13.3	4	9.6	3	12.4	3	11.0	3	10.0	3	9.5	2	8.4	2
	Proc	9.6	5	7.9	6	5.4	3	5.3	3	5.5	3	7.4	4	5.6	2	7.0	4
	Total	25.0	5	21.2	5	15.0	3	17.7	3	16.5	3	17.4	3	15.1	2	15.4	2
Other U.S.	Fresh	76.0	22	73.9	23	74.2	23	71.6	19	81.8	22	59.8	17	58.7	14	66.9	14
	Proc	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
	Total	76.0	15	73.9	16	74.2	15	71.6	13	81.8	15	59.8	10	58.7	9	66.9	10
U.S.	Fresh	340.4	100	319.7	100	316.4	100	368.0	100	370.0	100	360.1	100	418.8	100	464.6	100
	Proc	180.5	100	138.6	100	163.2	100	168.2	100	173.2	100	211.2	100	232.1	100	183.0	100
	Total	520.9	100	458.3	100	479.6	100	536.2	100	543.2	100	571.3	100	650.9	100	647.6	100

[1]In millions of pounds.

SOURCE: Commodity Data Sheets, OSU Extension Service, 1972-1979. (4)

PRESENT SITUATION AND TRENDS

Strawberry Production

In Oregon and Washington, commercial strawberry production is predominantly west of the Cascade Mountain Range. In Oregon, the major production areas are in the Willamette Valley.[1/] Washington strawberry production is in the inland area bordered by the Cascades on the east.

The typical grower has about 10 or 15 acres of strawberries. Relatively few growers are strictly strawberry producers, at least at the commercial level. Most have a fairly diversified operation. Raspberries, for instance, bear fruit later in the season, making them a good complement in production. Blackberries and tree fruits also are produced by some strawberry growers. Many growers are into vegetable production which requires much of the same equipment as strawberry production.

Establishment of Stand

Establishing a new stand of strawberries, or re-establishing an old one is an involved expensive operation (Table 2). Both capital investments and direct operating costs are high. More than 40 percent of the direct operating costs is attributable to the cost of strawberry plants.

The establishment of a strawberry stand begins nearly two years before berries are produced. Soil tests for nutrients, acidity, pests, and diseases are best done at least a year before planting, to allow time to incorporate fertilizers, fumigants, and pesticides into the soil (6). Strawberries are salt sensitive so

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1/ About 10 percent of Oregon's production is in Columbia County, sometimes considered part of the Oregon Coast production area. Production, in fact, occurs in the same broad valley as the rest of Oregon and Washington's production.

it is particularly important that sufficient time elapses between chemical applications and planting to allow leaching of soluble salts. Excess salt, not usually a problem in the PNW may cause stunting, leaf scorch, and loss of feeder roots.

Because the plants are intolerant of salinity and other problems with standing water, it is essential that good drainage be provided (6). The best soils, normally are a sandy loam type.

No one cultivar (from cultivated variety) dominates PNW production. The Marshall and Northwest varieties were in wide use, but they are being replaced by newer varieties. A considerable amount of breeding research is in progress, much of it aimed at developing cultivars suitable for machine harvesting. The "Linn" variety, for example, is firm and tends to have one bloom and flush of berries. Some of the newer varieties, yet to be named, are identified only by numbers. Growers select cultivars on the basis of soil and climate conditions as well as for their characteristics for particular markets: fresh or processed. If mechanical harvesting becomes more widespread, selection of cultivars will become more important.

It is best to work the soil several months before planting. Usually, this is done in the fall. In the spring, plants are taken from the nursery in Puyallup, Washington for planting in April and May. The number of plants per acre varies but a typical quantity is about 11,000. The cost of plants in 1979 was about $35 per thousand or $385 per acre ($385/Acre).

About two or three weeks after planting, herbicides are applied. The applications are repeated in the fall. Since the cultivars in use in the PNW take one year to bear fruit, there is little to be done with the stand after spring planting other than to apply fertilizers and herbicides. During the summer, the stand is irrigated, usually with three two-acre-inch applications for a total of six acre inches of water. Also, before the fall herbicide application, the stand is cultivated up to three times. Some hand weeding and insecticide application takes place following the post-planting herbicide application. The plants are then wintered over to the following year, the producing year.

The commercial production of strawberries, as with most crops, commonly entails considerable quantities of chemicals, especially during the establishment year. It is estimated that the typical strawberry producer spends $367 per acre on fertilizers, lime, and other chemicals, which represents 40 percent of direct operating costs (Table 2).

Nitrogen usually is applied twice during the establishment year, about half at planting and the rest in the middle of the summer. About 60 to 80 pounds per acre is recommended. This application rate is considerably less than the recommended quantity in some areas of California where the soils, climate, and cultivars result in dosages as high as 200 pounds per acre. However, California yields are also higher. In some cases, the relatively small requirement of nitrogen for establishing strawberries could be supplied adequately by nitrogen-fixing crops from the previous year. On soils previously cropped to strawberries or vegetables, pre-plant applications of fertilizer, including nitrogen, may not be needed and may even cause damage (17). Because of its adverse effects on fruit quality, nitrogen is not applied just before or during harvest. Too much nitrogen at any time can result in soft fruit and lower yields.

Other elements also are essential for successful establishment and growth of strawberries. A marked response of strawberries to phosphorus (P) for example, has been noted on some soils. Applications of phosphorus run from 20 to 50 pounds per acre (40 pounds P_2O_5 to 100 pounds P_2O_5 per acre). Phosphorus is applied by banding P_2O_5 on both sides of the row soon after planting. Nitrogen and phosphorus usually are banded with potassium at planting, although some growers prefer to broadcast all of the potassium before planting. The amount applied varies from 33 to 100 pounds per acre (40 to 120 pounds K_2O per acre).

Other elements often applied include sulfur and magnesium. Sulfur is often contained in fertilizers and fungicides such as sulfur spray. Additional magnesium is not always necessary, but

Table 2. Costs of Production Per Acre for Strawberries During Establishment Year, with Irrigation, Production areas 207, 208, 307, and 309, OSU Extension Service (5).

Cost Category	Price	Quantity	1978 Total
DIRECT OPERATING COSTS			
N Fertilizer (lbs. N)	.2175/lb.	70 lbs.	15.25
Non-N Fertilizer [1]			89.75
Chemicals			262.00
plants	$35/M	11.0M	385.00
Other [2]			36.50
Machine fuel--			
Gas (Gallons)	.59/Gal	12.0	7.00
Diesel (Gallons)	.44/Gal	19.25	8.50
Machine repairs			15.75
Irrigation power			6.00
Irrigation repairs			6.00
Water charge		8 a.i.	
Custom machine hire			45.00
Custom harvesting			
Op. Capital Int.			37.00
(TOTAL DIRECT OP. COSTS)			(913.75)
LABOR [3]			
Operator (not mgt.)	8.00/hr	8.4	67.25
Family			
Hired: Machine op.	5.00/hr	9.8	49.00
Harvest			
Irrigation	5.00/hr	3.0	15.00
Other	5.00/hr	8.0	40.00
(TOTAL LABOR)		(29.2)	171.25)
CAPITAL INVESTMENT			
Average investment in machinery			267.00
Depreciation			26.50
Interest (9%)			24.00
Taxes (2%)			5.50

Table 2, cont.

Cost Category	Price	Quantity	1979 Total
Insurance (3/4%)			2.00
Average investment in			
Irrigation equipment			154.50
Depreciation			19.00
Interest (9%)			14.00
Taxes (2%)			3.00
Insurance (3/4%)			1.25
Land taxes			12.00
(TOTAL CAPITAL EXPENDITURE)			(107.25)
TOTAL COSTS (Excluding land investment)			1192.25

1/ Includes lime

2/ Overhead

3/ Wages include all benefits

4/ Hand weeding

Based on a 300 acre farm, 20 acres in strawberries.

when it is it can be supplied in dolomite, a liming material. Boron is broadcast and worked into the soil before planting at a rate of one or two pounds per acre.

Because of fair tolerance of soil acidity, strawberries have a relatively low lime requirement. Lime is an anit-acidifying agent best applied before planting, a year if possible, at the rate of one to two tons per acre. About $45 of the non-nitrogen fertilizer costs (Table 2) is for lime although not all soils require lime. About $15 is attributable to nitrogen fertilizer.

The materials costs for herbicides and insecticides for a typical operation are $262 per acre, nearly 30 percent of direct operating costs. According to the latest estimates (Table 2), $140 of that is for soil fumigation which is generally done but is not always required. Fumigation, as practiced in the PNW, primarily is to control nematodes and symphylans. Diseases include red stele, gray mold fruit rot, and leaf spot. Plants are particularly susceptible to red stele when growing in low, poorly drained areas with free standing water, but symptoms may disappear as the season progresses. Careful growers buy certified plants from nurseries to ensure disease and insect free strawberry stock.

Closely linked to the diseases cited is the problem of insect pests. Not only do they cause direct damage to the plant, but they also may transmit diseases. Aphids for example, can cause considerable plant damage by transmitting viruses that debilitate, stunt, and even kill strawberry plants. Unfortunately, it has not been demonstrated that controlling aphids in the field reduces the spread of the virus (17).

Perhaps the most serious insect pest is the root weevil (7). Several types of weevils cause damage to strawberries but all have nearly the same effect. Some damage occurs from adults feeding on leaves and fruit but most damage results from larvae feeding on the roots, eventually destroying them. In the PNW, some of the

common weevils are the ashgray weevil, the black vine weevil, the small crusted weevil, and the obscure root weevil. Most are controlled by pre-planting soil treatments or post harvest foliage treatments. A number of chemicals are in common usage. The most common is malathion, normally applied at a rate of between two and four pounds per acre. Other insecticides commonly used include Kelthane, Guthion, Thiodan, and Sevin. Of the $262 per acre chemical expenditure, $57 is attributable to insecticides.

Herbicides account for the remaining $65 spent on agricultural chemicals. Because weeds compete with the plant for water, nutrients, and light, and because they may provide refuge for a number of diseases and pests, their control is considered essential. Cultivation can control weeds between rows, but cultivating too near the strawberry plants may cause root damage. Because of the high costs of labor ($5 per hour), weeding and [illegible] are considered prohibitively expensive. Even so, an average [illegible] per acre is spent on hand weeding at the end of the establishment year. A number of chemicals are used to control weeds in the establishment year, including simazine, napronamide, and diphenamid (8).

Producing Year

In the producing year cultural practices and resource requirements differ from those of the establishment year. Excluding depreciation and interest on the established stand and direct harvest costs, the non-land cost of producing an acre of strawberries is about $500, less than half the establishment costs (Table 3). Nearly all the difference is attributable to the expense of strawberry plants ($385) and the reduction in use of agricultural chemicals ($111 versus $367 in the establishment year).

Some cultivars may yield a crop of berries the first year but those grown in the PNW produce in their second year and have an average productive life of that year plus two more.

Diseases may require the destruction of younger stands but other healthier stands may have more than three bearing years.

There are fewer pre-harvest cultural operations in producing years since no planting is required. Operating expenses of a large tractor are thus eliminated. Yet, aside from planting and harvest, operations of the producing year are similar. Most growers cultivate one to three times in the spring and employ a hoeing crew. The stand is irrigated at least twice with two-acre-inch applications, an operation typically done by hired labor.

Insecticides and fungicides are applied in the spring; herbicides, fertilizers, and insecticides for weevil control are applied after harvest. Usually less herbicide is needed in producing years than in establishment years.

Plants bloom in April and six weeks later the berries are ready for harvest. The harvest period lasts three weeks during June and part of July.

After harvest the stand is irrigated twice with about four acre-inches of water. Wet winters and early spring rains of the PNW strawberry producing region eliminate the need for much irrigation before harvest but the area's dry summers necessitate some irrigation even after harvest.

During the post-harvest period tops of the plants are clipped, runners are cut back, and rows are cultivated. As with all fruits, eliminating unnecessary growth maintains good health and helps ensure a productive future for the plants. Diseased plants are removed when detected to avoid spreading disease to other plants.

Non-harvest activities in producing years tend to be for maintenance. With the stand established, it is only necessary to manage it by controlling pests and providing adequate moisture and nutrients.

Table 3. Costs of Production Per Acre for Strawberries During Producing Year, with Irrigation, Production area 207, 307, and 309, OSU Extension Service. (5)

Cost Category	Price	Quantity	1978 Total
DIRECT OPERATING COSTS			
N Fertilizer (lbs. N)	.2175/lb.	50	11.00
Non-N Fertilizer			36.00
Chemicals			64.00
Other [1]			24.00
Machine fuel--			
Gas (Gallons)	.55/Gal.	14.0	8.25
Diesel (Gallons)	.44/Gal.	3.9	1.75
Machine repairs			10.50
Irrigation power			7.00
Irrigation repairs			7.00
Water charge		8 a.i.	
Custom machine hire			
Custom harvesting [2]	.005/lb.	6900 lbs	34.50
OP. Capital Int.			15.00
(TOTAL DIRECT OP. COSTS)			(219.00)
LABOR [3]			
Operator (not mgt.)	8.00/hr	7.25	58.00
Family			
Hired: Machine op. [4]	5.00/hr	8.0	40.00
Harvest [5]	.145 lb.	6900 lbs	1000.50
Irrigation	5.00/hr	4.0	20.00
Other [6]			80.00
(TOTAL LABOR)		(19.25)	(1198.50)
CAPITAL INVESTMENT			
Average investment in machinery			220.00
Depreciation			21.50
Interest (9%)			20.00
Taxes (2%)			4.50

Table 3, cont.

Cost Category	Price	Quantity	1978 Total
Insurance (3/4%)			1.75
Average investment in			
Irrigation equipment			154.50
Depreciation			19.00
Interest (9%)			14.00
Taxes (2%)			3.00
Insurance			1.25
Average investment in			
Established stand			596.00
Depreciation			397.50
Interest (9%)			53.75
Land taxes			12.00
(TOTAL CAPITAL EXPENDITURE)			(548.25)
Subtotal			1965.75
Less 7/			(47.00)
TOTAL COSTS (Excluding land investment)			1918.75

Based on 6900 lb. yield, 300 acre farm, 20 acres in strawberries.

1/ Overhead

2/ Hauling (Exc. Labor)

3/ Wage includes all benefits

4/ Hoeing

5/ Hauling labor @ .005/lb.
Picking labor @ .140/lb.

6/ Bookkeeping, recruiting etc.

7/ Credit for cultural practices not incurred in last year.

Harvesting

Harvest is by far the most expensive, anxious time for the strawberry grower. The recent decline in PNW strawberry production has been attributed to the uncertain availability of labor. Recently developed mechanical strawberry harvesters may help the PNW regain a significant share of the U.S. strawberry market. Some growers believe mechanization will be the key to PNW strawberry production and that the harvestor is economically feasible already.

In his 1978 Ph.D. dissertation (10), Hussen argued that the principal reasons for the decline in PNW strawberry production were the high cost and the lack of harvest labor. The average labor cost per pound of strawberries in 1978 was 15.0 cents per pound, which at the base yield[2/] of 6,900 pounds per acre, means a labor cost of $1,035 per acre of strawberries harvested. Yields of up to 9,000 pounds per acre, not uncommon, cost more than $1,300 for harvest labor.

Exacerbating the problem of high costs is the shortage of pickers. Several factors account for this. The strawberry harvest is relatively short and early in the season. Unlike California with its long harvest, the PNW offers only about a month of picking to the migrant worker. Pickers who might be available later in the year are elsewhere because harvest is so early.

Another reason for the shortage is the nature of the work. Picking strawberries is a disagreeable job. Most other small fruits have been harvested mechanically for sometime. Until recently the strawberry has so far eluded mechanization.

2/ The base yield is defined as a "typical" per acre recovered yield for a "typical" PNW grower with current technology and hand picking.

In recent years, a third important impediment to finding harvest labor has been added. Children below certain minimum ages have been prohibited from picking by federal legislation. The controversy stems from child labor laws enacted in 1973. Despite various legal maneuverings, children under 12 have been baned from picking in fields where certain chemicals such as Captan, Benlate, or Kelthane have been used, and may be employed only when a waiver of the child labor law has been obtained.

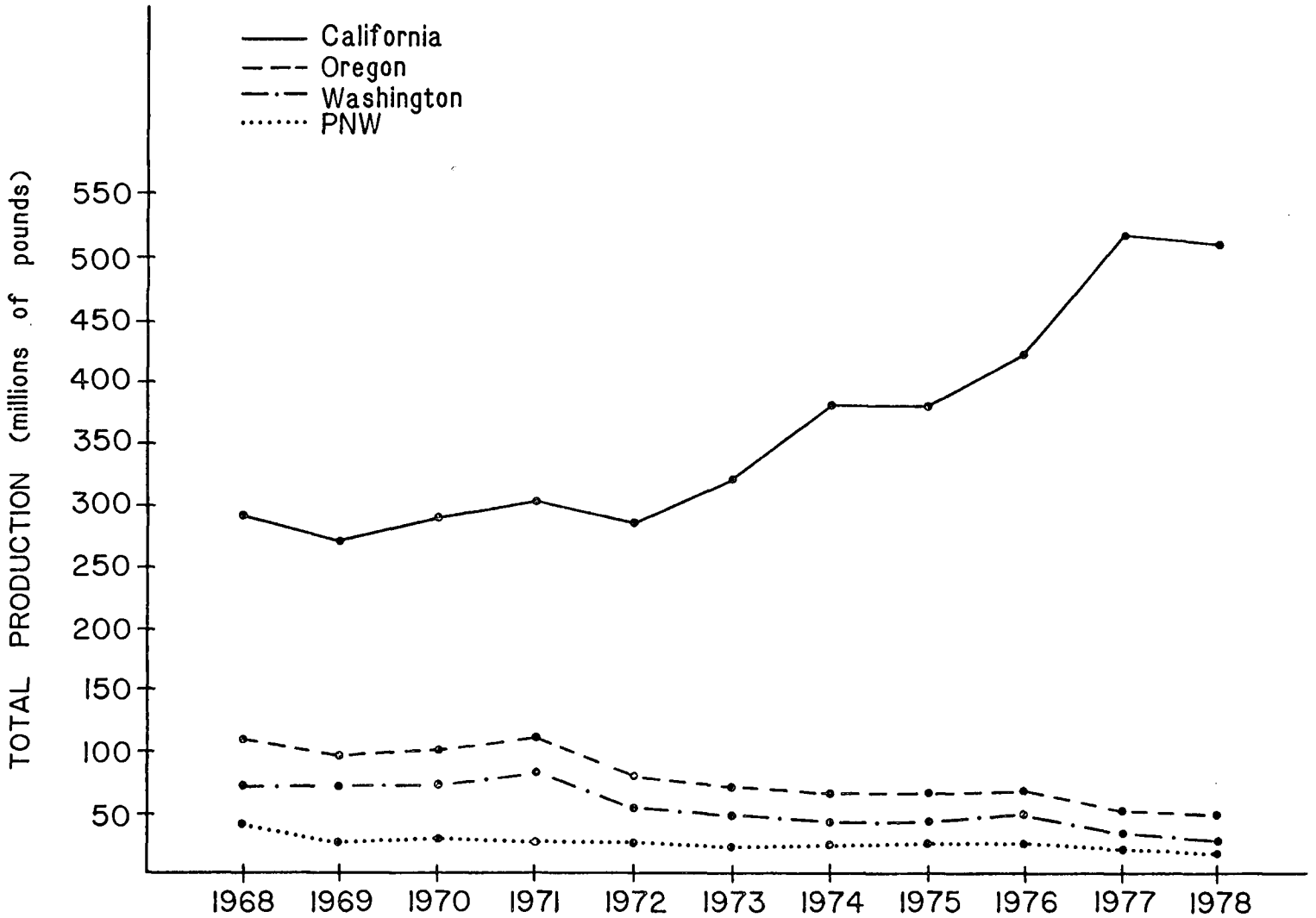
INTER-REGIONAL COMPETITION

Historically California has been the only major competitor of the Pacific Northwest in strawberry production but in recent years Mexico has become strong in U.S. markets. Since the mid-1960s, Mexico has been the second leading supplier in U.S. markets, easily surpassing the entire Pacific Northwest output (Figure 1). Hussen (1978) attributes the success of Mexican strawberry production to climatic advantages and especially to low cost labor. Nevertheless, the main competitor of the PNW continued to be California.

California's biggest advantage in strawberry production is its climate, although a large labor supply is also helpful. Production occurs over much of the state but mainly in the coastal regions near Monterey and further south in Orange County. Production soared in the late 1960s and has continued to grow (Figure 2). From 1965 to 1975, for example, acres harvested increased by 25 percent and total production more than doubled (17). During that period growers adopted new varieties and improved cultural practices. Now production takes place 10 months of the year with most occurring in the spring and summer. More than half a billion pounds of strawberries are produced each year in California.

Yields in California are well above those elsewhere in the United States, partly because of production practices but primarily because of climatic advantages. Instead of June bearing

Figure 2.
STRAWBERRY PRODUCTION TRENDS IN CALIFORNIA AND PACIFIC NORTHWEST, 1968-1977



Source: Oregon State University Extension Service, Commodity Data Sheet "Strawberries"

cultivars, such as those predominating in the PNW, the long growing season permits ever-bearing cultivars to be used in California. Even the mild California winters contribute to the long season. Like many deciduous fruits strawberries have a chilling requirement which if satisfied, allows a normal growth cycle to occur. In the spring, leaves and flowers develop, followed by runners in the summer. The mild winters in California, however, do not completely satisfy the chilling requirement. When cool summer temperatures follow, as they do in the coastal regions of the state, a prolonged fruiting season occurs. As a result, plants in a single stand may bear for many months. Yields of 40,000 pounds per acre are the rule.

This fortuitious circumstance has several benefits. Obviously, higher yields mean more gross revenue per acre. Nearly as important are the effects of the longer growing season. One is that pickers may be employed for several consecutive months. Growers have no serious problems obtaining labor and workers have the assurance of being employed several months each year.

The longer growing season also allows a longer processing season. The same equipment can be utilized for a longer time and the equipment costs can be spread out. PNW strawberry processors faced with a shorter season, must find some advantages in using the same equipment for other products.

Establishment and production costs per acre of California strawberries are high, but they are offset by high yields. Establishment costs are higher because of cultural practices and production costs are higher primarily because of yield related costs such as harvest labor, crates, and other supplies.

Strawberry stands in California tend to be managed more intensively than those in the PNW. Estimated non-land establishment costs per acre are $2,600 in some areas and about $2,100 for most areas. The PNW estimate is $1,200 also excluding land rent.

Trickle irrigation, becoming popular in California, is one reason for the higher costs. A bigger reason is the extensive use of polyethylene bed mulching. Cost of the plastic is about

$200 per acre, and the cost of labor and machinery to apply it is several hundred dollars more. Yet it appears to be worth the cost. The clear plastic warms the soil allowing early plant growth and higher yields. Decay may be reduced, the fruit is cleaner and ripens more evenly, and soil moisture is conserved. The high yields testify to the mulch's effectiveness.

The high yields make the more intensive management cost effective. A recent estimate of non-land unit costs in Oregon is a total cost of 27.8 cents per pound with the base or typical yield of 6,900 pounds per acre. A yield of 10,000 pounds, not uncommon, would lower unit costs to about 24.1 cents per pound. Recently, estimated costs in California were 19.2 cents per pound. An increase of 20 percent in yield would lower unit costs to nearly 17 cents per pound (Table 4).

MARKETS, CONSUMPTION AND PRICES

As with many agricultural commodities, there are two markets for strawberries. The fresh market accounts for about 10 to 13 percent (by weight) of total sales in the PNW.

The fresh market has two components. One is U-pick; the other is retail sales. With a U-pick system, the grower need not worry about hiring pickers; buyers supply their own labor. U-pick operations are popular with consumers because they get their fruit at lower cost and have a greater selection. Growers may combine operations, using a U-pick system when harvest labor is scarce. Because of the delicate nature of PNW berries, most of those that go to retail outlets are sold locally at fruit stands and supermarkets.

Uncertainty with respect to the market and the handling required act to constrain the proportion of berries sold in the fresh market. Also, the local market for fresh berries is limited. The strength of the processed market, in part could be attributed to risk minimizing behavior of growers. Despite the higher prices for fresh strawberries, many opt for the more secure processed

Table 4. Costs of Production Per Acre for Strawberries During Producing Year, with Irrigation in Santa Cruz, California, California Extension Service.

Cost Category	Price	Quantity	1978 Total
Direct Operating Costs			
N Fertilizer (lbs. N)			175.00
Non-N fertilizers (lbs)			
Chemicals			165.00
Plastic Mulch			150.00
Other[1]			205.00
Machine fuel			27.50
Irrigation power			56.00
Op. capital interest(9%)			216.00
(TOTAL DIRECT OP. COSTS)			(995.00)
Labor			
Operator (not mgt.)			
Family			
Hired: Machine operation			
Harvest[2]			4,000.00
Irrigation			1,040.00
Other			
(TOTAL LABOR)			(5,040.00)
Capital Investment			
Average investment in machinery and irrigation			540.00
Depreciation			134.00
Interest			54.00
Taxes			15.00
Insurance			7.50
Amortized investment in established stand			1,440.00
(TOTAL CAPITAL OWNERSHIP			(1,650.50)
Marketing			
Transportation to market			
Storage			
Supplies, crates, bags, etc.			
Other			
TOTAL COSTS (Excluding land investment)			(7,685.50)

Table 4., cont.

Cost Category	Price	Quantity	1978 Total

Non-land Unit Costs

Yield	Cost/pound
40,000	19.2
50,000	17.1

1/ Overhead

2/ Harvest @ $.10/lb.

3/ All cultural operations including installation of plastic mulch @ $5.00/hr. (includes benefits).

market. Fresh berries sometimes sell for a third to half more than fruit sold for processing.

A grower often operates under contract with a processor because he is assured of a buyer at an agreeable price. The price depends on the overall quality of the harvested berries. A simple categorization of quality is to divide the berries into standard quality and a poorer grade, puree, and juice stock. Processors freeze and can the berries or use them for flavoring food items, including dessert toppings, ice cream, jams and jellies, and the biggest item in recent years, yogurt.

The PNW share of U.S. strawberry production has steadily declined during the 1970s (Table 1). The fresh market has been a minor exception to that trend, with both Oregon and Washington hovering at the one percent share of the U.S. fresh market. In terms of the quantity of fresh strawberries produced, the PNW has consistently been near the seven million pound level for most of the decade, with Oregon and Washington making approximately equal contributions.

Because the quantity of fresh marketed PNW strawberries has remained constant, the increase in the proportion of berries on the fresh fruit market is attributable to the decline in production of processed berries. More than 100 million pounds of strawberries were sold on the processed market in 1971, accounting for nearly 60 percent of the total U.S. processed production. In 1978 less than half that amount was produced, and the PNW share was less than one-fourth of U.S. production.

Total (fresh plus processed) production of PNW strawberries has declined by 47 percent since 1971. U.S. production has increased by 24 percent during the same period, virtually all of it occurring in California, especially the fresh market. The total U.S. processed production varies from year to year, but has shown almost no net change since 1971. Decreases in PNW and Michigan's production have been balanced just about evenly by increases in California processed production. But the real gains have been

from fresh market increases. From 235 million pounds in 1971, California fresh market production increased by 147.2 million pounds, or 63 percent. California production now accounts for 82 percent of the U.S. produced fresh market strawberries and 72 percent of the processed market. Overall, 79 percent of the strawberries produced in the United States are grown in California (Table 1).

Demand for Strawberries

If historical trends are a guide, the future demand for strawberries will be stable. A 1963 USDA study showed total per capita consumption of strawberries in the United States had increased slightly over time (2). The total amount of processed berries has varied widely over the decade of the 1970s but per capita annual consumption in 1971 was .87 pounds; it was .84 pounds in 1978. However, total quantities of strawberries, and fresh berries in particular, have increased significantly. Per capita annual consumption of fresh berries went from 1.64 pounds in 1971 to 2.13 pounds in 1978. For all strawberries the increase was 2.52 pounds in 1971 to 2.97 pounds in 1978.

The study also found that strawberries appear to be a normal good; that is, as peoples' incomes rise they tend to buy more. Everything else equal, if real national income were to continue to rise, then so would the national demand for strawberries.

A 1979 demand study done by Desmond O'Rourke at Washington State University confirms these results. The two variables, income and price, account for 60 percent of the variation in quantity of strawberries demanded (15).

As a whole, strawberries are normal goods but fresh and processed berries do not appear to substitute for each other. Fresh berries are bought mostly during a four-week period in late spring, with most of the rest spread out over the year. California does have production most of the year, but the bulk is in the spring.

Processed berries do not have a strong season; their purchases seem to be spread uniformly over the year.

Finally, the quantity of berries demanded appears to be inversely related to the price; as the price changes, the quantity demanded responds in an inverse fashion: higher quantities at lower prices, lower quantities at higher prices. This phenomenon gives rise to a strong incentive to keep production costs, hence product prices low.

Price Trends

The average price received by strawberry producers has increased over time both in the PNW and in the Unites States (Appendix A). The most striking increase has been in the price received for Oregon and Washington strawberries for processing. From 1976 through 1978 the average price was about 26 cents per pound. The PNW processed price has increased much more rapidly than either the U.S. or California price; the trend has been for the price of PNW processed berries to increase 1.4 cents per pound per year compared to the overall U.S. trend of 0.8 cents per pound per year. The result has been a huge increase in the price differential between the PNW and U.S. processed berries now averaging more than five cents per pound compared to about a penny per pound from 1969 to 1972. California processed berries simply have failed to keep pace with PNW berries with respect to price.

For fresh berries, prices in the PNW and California historically have been fairly close although in recent years California and hence U.S. berries have brought slightly higher prices.

The steady increase in the price which processors are willing to pay for PNW berries over California berries is consistent with the contention of this paper that the quality of the PNW berry is superior to that of California. Explotation of the quality differential by advertising and other marketing strategies might enhance the position of the PNW in the U.S. strawberry market.

FACTORS AFFECTING FUTURE PRODUCTION

Conventional wisdom suggests that it makes no difference to the plant whether nutrients are supplied artificially or by organic methods such as compost. It also is a widely held view that, used properly, pesticides are safe and that any problems that may arise from their use are more than outweighed by derived benefits.

At least four major concerns have been identified with respect to modern farming methods, and these also apply to PNW strawberry production.

Nutrients

Strawberry plants depend on an association with various soil microorganisms for adequate uptake of minerals, organic compounds, and moisture. For the plant to take up nutrients through its roots, the nutrients must be water soluble so they may pass through permeable membranes of the roots from a suspended solution in the soil. For that process to succeed, it is essential that there be a good soil structure. However rich in nutrients, fertile soil must contain water and oxygen which can move freely (1). If the soil lacks structure, the nutrients will not reach the roots. Decaying organic matter and various soil organisms--worms, nematodes, insects, and bacteria--provide structure to the soil. The microorganisms, in a process requiring oxygen, release the nutrients into the water solution. This is one area where the addition of artificial fertilizers may create a problem. Those organisms to which the addition represents a food supply will increase in number and lock up the nutrients. Those to which it represents a waste product will decrease in number and release nutrients to the plants. In addition, there is evidence that superphosphate[3/] inhibits the uptake of numerous

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3/ Phosphorus treated with sulphuric acid to obtain gypsum and phosphorus pentoxide--P_2O_5--a common strawberry fertilizer.

trace metals including zinc, copper, and iron (1). It is possible in principle, to add trace metals to the soil, but that does not eliminate the inhibition nor is it always appropriate because excess trace minerals may be toxic to the plant. The need for any element should be determined by soil or tissue analysis in conjunction with known requirements of the plant.

Energy

A second major problem with modern production practices is that they are energy intensive. This problem is well recognized with respect to farm machinery, or course, but not so much with respect to other factors of production. It has been estimated that a large tractor represents an energy expenditure of more than 70,000 kilocalories (Kcal) for every working hour, including fuel to power the tractor and energy used in its production (13), implying that there are hidden energy costs in the costs of production tables (Tables 2 and 3). Direct expenditures on fuel and electrical costs for powering irrigation are shown but the energy to produce the machinery appears only implicitly as part of the average investment in machinery. This is not the only hidden cost, however. The fertilizers and chemicals themselves represent large quantities of energy. Some examples: phosphorus pentoxide (P_2O_5), the soluble constituent of commonly used strawberry plant fertilizer, requires 760 Kcal per pound of fertilizer produced, which at normal dosage levels, represents between 30,000 and 91,000 Kcal per acre; liquid ammonia, the basis of many nitrogen fertilizers, requires 5,250 Kcal per pound of fertilizer produced; insecticides and herbicides require even more energy for their production--as much as 11,500 Kcal per pound or 35,000 to 100,000 Kcal per acre. The reason these products are so high in energy content is because virtually all are produced or derived from naptha and other petroleum derivatives and from natural gas (13).

Costs

Not unrelated to the energy factor is that of costs. It may be safe to assume that the reason behind a chemically intensive production activity is that growers find it to be the least cost alternative.

Use of some chemicals has resulted in additional de facto costs to growers. Waivers allowing employment of pickers under 12 years old may be obtained only when certain pesticides, mostly those suspected of being carcinogens, are not used. In 1979, for example, no waivers were issued to growers who used Captan and Benlate effectively reducing the supply of pickers. Growers who cannot obtain enough pickers lose some of their crop. Whether they lose more than they gain by spraying or dusting is unknown.

There is a good possibility that the historically low cost of chemicals will not prevail in the future. As the available supply of petroleum and natural gas declines and as costs accordingly rise, the expected savings from the use of agricultural chemicals of all types will decline. To cite one example, the PNW cost per ton of nitrogen fertilizer which was $75 per ton in 1972 rose to $145 per ton in 1978, nearly twice as much. In addition, OPEC price increases now occur regularly. When the cost of certain chemicals will cease to be economically feasible is unknown, but it is almost certain that energy costs will continue to increase for the remainder of the century.

Environment and Health

Many chemicals are being reviewed by EPA because of suspected health hazards and their uses may be severely restricted or banned (18). An example in strawberry production is Dinoseb, a herbicide suspected of causing birth defects, slated for review soon.

People tend to be most familiar with the health problem. Most notable are the possibilities that certain pesticides (Sevin,

Benlate, Dinoseb, and Captan) may cause birth defects, tumors, mutations, cancer, or death (18). Also worrisome is the general environmental degradation that may occur with regular applications of various chemicals. Populations of various microorganisms certainly will be altered. Genetic change could easily occur as only those organisms able to tolerate the chemicals survive, passing their genes to the next generation (9, 19).

Once applied, chemicals either decay or are leached into and out of the soil by rain or irrigation. If the latter happens, the chemicals may collect in streams and lakes causing damage to algae and other plant and animal life and eventually may be passed along the food chain to man (1, 15, 16).

This review is not intended to imply that there is no place in strawberry production for artificial fertilizers and pesticides, only that there are some troubling aspects to their use--both technical and economical--that may evenutally cause growers to modify their cultural practices.

It is not difficult to identify problems associated with the use of artificial fertilizers and pesticides. It is less easy to identify technically and economically feasible procedures to take their place.

Alternatives

The practice of conservation is a virtue in nearly all aspects of agriculture, including a conservative use of agricultural chemicals. According to Dr. Lloyd Martin, superintendent of the North Willamette Experiment Station, growers are becoming more conscious of the risks of overuse of chemicals (14). It has become less a tendency to use chemicals to prevent insect and other problems and more a tendency to live with minor pest problems, treating only the significant ones. In light of the health concerns raised earlier, this approach is encouraging because it is likely that the environment can tolerate some (unknown) degree

of chemical treatments with minimal ecological degradation. Beyond that limit, whatever it is, each additional application may be more harmful than the last (16).

Aside from a more conservative approach to the use of agricultural chemicals, an approach that eventually will be dictated by higher costs, there may be other approaches for strawberry growers that allow the curtailment of unnecessary chemical use without a sacrifice in yield or profit. The economic feasibility may be questionable now, but over the next two decades that could change, especially if the increasing consumer demand for "organically grown" food continues.

It is possible to use less artificial fertilizer. It was noted already that strawberry production usually involves the application of about 70 pounds of nitrogen per acre, less than most other crops. Scientists have discovered that an average acre of farm soil contains huge quantities of mineral nutrients, all within plough depth (1). Many micoorganisms in a well-structured organic soil release nitrogen to be taken up by the plants' roots.

The time-honored but economically infeasible practice of applying manure and compost also may regain a place in strawberry production because of rising input and energy costs. Most strawberry growers have diverse operations and raise several crops. All produce waste material of some kind. Most have no animals, however, and because livestock is raised on a limited scale in the Willamette Valley and western Washington, there is limited manure available. Dairy and sheep operations could provide some.

Douglas Campbell, former Farm Director of the Soil Association, has developed a simple method of composting manure and vegetable matter using standard farm equipment and one day's work of three men for a farm operation of about 150 acres (1). One of the best advantages of composting over artificial fertilizers is that the addition (or rather the return) of the organic matter to the soil eventually will build up its humus content which is essential for flavorful, healthy berries. One of the essential

soil characteristics for crop production is a good "sponge" structure--that is, a structure which allows the suspension and retention of moisture and nutrients. Without the sponge, these nutrients would be leached down through the soil out of reach of strawberry roots.

Organic matter is itself essential. The strawberry plant certainly needs a variety of minerals and chemical elements. But it can no more survive without organic material than we could survive on a diet of vitamin pills. Both minerals and organic matter are required for plant growth. Farming only with artificial fertilizers without regard for improving the soil structure could denude the soil of important organic matter (1, 3).

Reducing the quantities of insecticides and herbicides is not as easy. Once the grower has come to rely on them he is trapped because chemical dependence reduces the capacity of the plants to maintain their own health. For example, the red spider mite became troublesome only after its more vigorous competitors had been eliminated by spraying (1, 19). It is now resistant to most insecticides. There is, however, another mite which preys on it and multiplies more rapidly. The red spider mite is introduced to the strawberry crop and allowed to proliferate and then the predator is introduced. The predator takes hold and controls the red spider mite populations indefinitely. Similar procedures--predator-prey relationships--may become feasible for other insect problems as well.

The diversity of most strawberry growers also may work in their favor because it means there is a substantial area of headland and field edge. These areas of relatively wild land permit stable populations of insects, including the predators of the real pests, to become established. This feature may be offset partially by the possibility of pests migrating from uncultivated lands to the crops.

It also is well to remember that the appearance of large numbers of any type of pest are symptomatic of an imbalance in

the natural cycle. Merely controlling the pest by spraying does not treat the problem. An integrated pest management program which balances but does not eliminate populations of various pests is a sound means of maintaining long run soil fertility, a healthy crop, and preventing future pest problems.

Herbicides are essentially a replacement for labor and, as such, limitations on their use necessarily will involve increased production costs, primarily labor costs, or reductions in yields. Another cultural method with added benefit of some weed control is mulching. In the Willamette Valley, there is a vast supply of cheap mulch--straw from grass seed production. Disposal of straw by means other than open field burning is a problem of considerable magnitude. An even more effective mulch is black plastic which could keep a crop virtually weed free. The major problem with it is that since the plastic itself is a petroleum derivative certain to increase in cost, it fails to overcome the problems of cost and energy raised earlier. But plastic mulch could increase yields significantly by raising the soil temperature and allowing better moisture retention (6, 10, 17).

Although moisture retention is the principal benefit of mulching and limited weed control is an extra bonus, there is still another benefit which does not accrue with plastic mulch. An organic mulch eventually is broken down by the decaying action of soil organisms, thus, a continuous supply of organic matter is being added to the soil. Some disadvantages with straw mulch include the high cost of application and the possible presence of weed seeds in the straw. Also, the insulating effect of the straw may delay harvest by keeping the soil cool. The severity of these problems depends on management skill.

The alternatives to agricultural chemicals are neither new nor exotic. They may be expensive. But, as the costs of chemicals increase, as they will, and if restrictions are placed on them, as they may be, their use will become more limited. Strawberry establishment and production are no more intensive in the perceived requirements of nutrients and pesticides than many other

crops so it may not be affected any more seriously than other crops by restrictions (legal or economic) on chemical use. On the other hand, long term soil fertility may depend on the judicious use of artificial chemicals and the imperative task of building and maintaining good soil structure.

An Uncertain Future for Mechanical Harvesting

Many in the industry believe the development of a mechanical harvester would sidestep labor problems and allow the PNW to gain a greater share of the national market. The Oregon Strawberry Commission certainly believes it. They have spent more than a quarter of a million dollars in the last decade on research related to mechanized strawberry harvest (11).

Many have participated in the effort to develop a mechanized strawberry harvester in both the private and public sectors, with the machines adapted to local conditions because of different cultivars and cultural practices among regions. The most active participants in developing mechanized harvesters are BEI (Blueberry Equipment, Inc.), CML (Cannery Machinery Ltd.), SKH&S (initials of four private investors in Oregon), Oregon State and Michigan State universities.

There are two basic requirements for the successful implementation of mechanical harvesting. The first, obviously, is efficient machinery. In turn, there are two aspects to the efficiency criterion. One is that the harvester itself be efficient. A commonly accepted level of efficiency would be a machine that can harvest an acre of strawberries in four hours with an 85 percent recovery rate (11). The other requirement is for processor cooperation in the installation of equipment to stem and cap the berries.

Both machine requirements appear to have been met. Field tests have demonstrated the success of the harvester and processors have developed and installed stemming and capping machinery (14).

Also crucial to the success of mechanized harvesting is the development of suitable varieties of strawberries (11). To be compatible with mechanical harvesting, cultivars should meet the following criteria:

1) The plant must have uniform ripening characteristics to permit a once-over harvest.
2) The berries must be firm enough to withstand machine handling.
3) The berries must be easily stemmed and capped.
4) The plant should have an upright fruiting habit.
5) The plant should be disease resistant.
6) The fruit must be high yielding and of commercially acceptable quality.

No single cultivar has meet all the requirements but breeding program results at Oregon State University are encouraging. For example, variety number 4681, evaluated in 1976, produced a yield of 18,000 pounds per acre (twice the current yield), almost 90 percent ripe fruit concentration, and had good quality taste and color. Its only major shortcomings were its poor stemming and capping characteristics. Prospects are considered good for the development of even better cultivars (11).

The enthusiam for the mechanical harvester shown by the Oregon Strawberry Commission is not shared by everyone in the industry. There is little concern about labor displacement since it would not be replacing what are now permanent workers in the industry. Also, even the most enthusiastic supporters of the harvester concede that there will always be a place for hand-picking. A common assumption among some is that stands will be hand-picked once or twice before a pass with the machine harvester. Others within the industry believe mechanical harvesting will be a factor only when the entire crop can be machine harvested.

Most of the concern is about the quality of the fruit under machine harvest conditions (14). The feeling is that either the berries will be damaged by handling, or will be too tough to be

acceptable to processors and consumers. Whether breeders can come up with a high quality berry which can be mechanically harvested without damage is unknown.

Still, there are those who feel the mechanical harvester is already economically feasible. In 1979 at least four harvesters were employed by commercial growers. About 200 acres were harvested by machine (14). Naturally, there success, to some extend, will determine the immediate future of machine harvest.

The assumptions and procedures used to analyze the economic feasibility of mechanical strawberry harvest are detailed in the footnote to Table 5. A critical assumption is that strawberry varieties will be developed that can be harvested by machine with minimum damage and difficulty, and to have a total potential yield equal to current yields. Further, it is assumed that the mechanical strawberry harvester will be capable of harvesting an acre of these strawberries in four hours with an 85 percent recovery rate. Then after removing 10 percent culls and other foreign material, 70 percent of the remaining product is assumed to be of standard quality for individual quick freeze, frozen sliced berries, etc.--the remaining 30 percent would be used for puree and juice stock. These assumptions were made by Hussen, et. al. after consulting with strawberry growers, engineers, plant breeders, and Extension workers. In addition, assumptions about the machine's cost and performance were based upon observations of the actual as well as the potential performance of harvesting machinery operating in Oregon on an experimental basis during 1977.

According to this analysis, the total revenue from strawberry sales would be less with mechanical compared to hand harvest. However, the harvest costs also would be lower. The net return above harvesting costs for mechanical harvest would amount to $631.50 per acre compared to an estimated $731.40 per acre for hand harvest. This indicated a net loss of nearly $100 per acre for mechanical harvesting.

Before concluding that mechanization is a losing prospect, however, one should be aware of the uncertainties of this analysis. The cost of extra processing labor, for example, may be over estimated. If the extra labor costs are closer to zero, as is possible, then net revenue from the mechanical harvester obviously would increase and would compare favorably with hand picking revenue. Also, different yield figures would give rise to different costs and revenues for both mechanical and hand harvest. Since yields are highly variable from field to field, this is an important consideration.

The assumptions and information used to compare mechanized and hand harvest are as accurate as possible. There are plausible assumptions that would show a net gain from using the mechanical harvester. Therefore, it should be stressed that although the analysis shows a net loss would be expected to occur with mechanized harvest, there is still a great deal of uncertainty with respect to the profitability of the mechanical harvester.

From this analysis, it is quite clear that the economic feasibility of mechanical harvesting is not a foregone conclusion, even with the yet to be developed cultivars capable of being harvested mechanically. There is also a question as to the quality of fruit obtained from these new varieties. Will it have the same taste and other preferred characteristics found in varieties now hand harvested?

The Oregon strawberry industry, of course, is concerned about the cost and availability of labor for hand-picking. These costs are likely to increase in the future, but then the costs associated with mechanical harvesting and the increased energy requirements associated with mechanization also will increase. Consideration should be given to developing and supporting research programs relating to the market for harvesting labor, to develop new institutional relationships for improving the availability of this labor, and adopting management techniques to recruit, train and utilize this labor. The problem of displaced labor is a national problem as well as a regional problem.

Because of the high capital cost of mechanical harvesters (more than $20,000), their economic feasibility will require some changes. Enterprises might become larger so the cost of the equipment can be spread over more acres, or some growers might purchase the machines and do custom work for others, or growers might form cooperatives to purchase the equipment and share in its use. In any case, some way of ensuring different harvest time is essential to maximize the availability of the machine. This could be done by growing different varieties or planting at different elevations. Another requisite is processor cooperation both in accepting the new varieties and in installing the necessary stemming and capping equipment.

A final requirement is beyond the control of growers, at least, and probably processors too. With significant production increases, prices could drop, meaning that gross revenues either would not increase commensurately with increased net yields or would decrease. While no one can say what will happen to prices in the future, it would seem doubtful that implementation of mechanization could occur quickly enough to upset the market. It would not be significant enough to alter the relative share of PNW production in the United States, except over a long period of time. Oregon processors now buy California strawberries to meet production goals, so have the capacity to process a larger volume of PNW strawberries. The depression of prices resulting from increased production is not considered by most people in the industry to be an immediate problem.

Most growers remain optimistic about future strawberry production in the PNW (14). They feel the decline in acreages has bottomed out finally and acreage may be on the rise. Many growers contract directly with processors, thereby guaranteeing themselves at least reasonable returns on their investments in the short-run. U-pick operations are becoming more popular and will provide a small but firm market.

Institutional changes may be the biggest concern to growers. Labor laws with respect to children and aliens will

Table 5. Economic Comparison of Mechanized and Hand Strawberry Harvest ($ per acre)

Revenue with Mechanization			
Strawberry sales (5279 lbs/acre[a] @ 23.4¢/lb[b])			$1235.29
Harvest Costs with Mechanization[c]			
Harvest labor [d]	$ 50.00		
Trucking and handling [e]	78.27		
Depreciation of machine [f]	97.78		
Interest on Ave. investment (9%) [g]	26.40		
Fuel and Repairs [h]	14.60		
Miscellaneous [i]	11.70		
Extra processing labor [j]	137.70		
Extra processing machinery costs	187.34		
Total of Harvest costs		603.79	
MECHANIZED: Revenue minus harvest costs			631.50
Revenue with hand harvest			
Strawberry sales (6900 lbs/A @ $.256/lb)[k]		1766.40	
Harvest costs with hand harvest			
Hand picking costs (15¢ per pound)[l]		1035.00	
HAND HARVEST: Revenue minus harvest costs			731.40
NET LOSS FROM USING MECHANICAL HARVESTER			(99.90)

Footnotes

a/ The yield of useable product per acre assumes that the total yield available for harvest is 6,900 pounds per acre (see text) and that the harvester would recover 85 percent of this yield or 5,865 pounds per acre. It is further assumed that culls and other foreign material will amount to 10 percent leaving 5,279 pounds per acre of useable product.
Source: Hussen et al.

b/ The price of 23.4 cents per pound assumes that 70 percent of the yield will be of standard quality and prices at 27 cents per pound and that the remaining 30 percent will be used for puree and juice at 15 cents per pound.
Source: Hussen et al.

c/ The initial investment required to purchase the harvester is estimated to be $22,000 and it would be capable of harvesting an acre of strawberries in 4 hours. Assuming 150 hours of annual utilization, one harvester would be capable of harvesting 37.5 acres per year.
Source: Hussen et al.

d/ The labor cost for mechanical harvesting was estimated using wage rates of $6.50 per hour for the machine operator and $3 per hour for two assistants.

e/ To estimate trucking and handling costs the strawberries recovered per acre were multiplied by factor of 4/3 to account for foliage and other foreign material. Then, the cost of hauling and handling was estimated to be $20 per ton.

f/ Annual depreciation was calculated based on a $22,000 initial investment, a six-year useful life, and a zero salvage value. The annual depreciation was divided by 37.5 acres to calculate the depreciation cost per acre.
Source of Assumptions: Hussen et al.

g/ The average investment over the life of the machine would be $11,000 at 10 percent interest. This would be $1,100 per year or $29.33 per acre.

h/ Fuel and repair costs are as estimated by Hussen et al.

i/ Miscellaneous costs include the additional costs for preparing the land, housing or storage for equipment, insurance, etc.

Source: Hussen et al.

j/ The estimate for extra processing costs for mechanical harvesting was obtained by Hussen et al. from a Michigan study (Holtman et al., 1977). Hussen et al. made an adjustment for usage differences between Oregon and Michigan, and the two cappers were assumed to have 100 tons annual utilization.

k/ The price per pound of 25.6 cents is the average of farm prices received for processed strawberries for the last five years. These data are reported by the Oregon Crop and Livestock Reporting Service, ESCS, USDA, and compiled by the Extension Economic Information Office, Oregon State University. See "Commodity Data Sheet", May 8, 1979.

l/ The estimated harvest costs for hand-picking of 15 cents per pound include labor cowts, transportation and supervision, and hauling and handling of the berries.

Source: Oregon State University Extension Enterprise Data Sheet, February 1979.

have a direct impact on the availability of the all-important harvest labor. As the supply of labor becomes more uncertain either the mechanical harvester will become a part of the harvest scene, or other methods of production, U-pick for example, will need to be employed.

Other Production Factors

Other institutional changes such as restrictions or outright bans on toxic pesticides also will concern the grower. As outlined, alternatives to these chemicals do exist, however. Also, restrictions on these chemicals likely will affect all agricultural production, not just the strawberry industry, so all farmers will be faced with the same problems. Possible restrictions are of

[illegible] pickers.

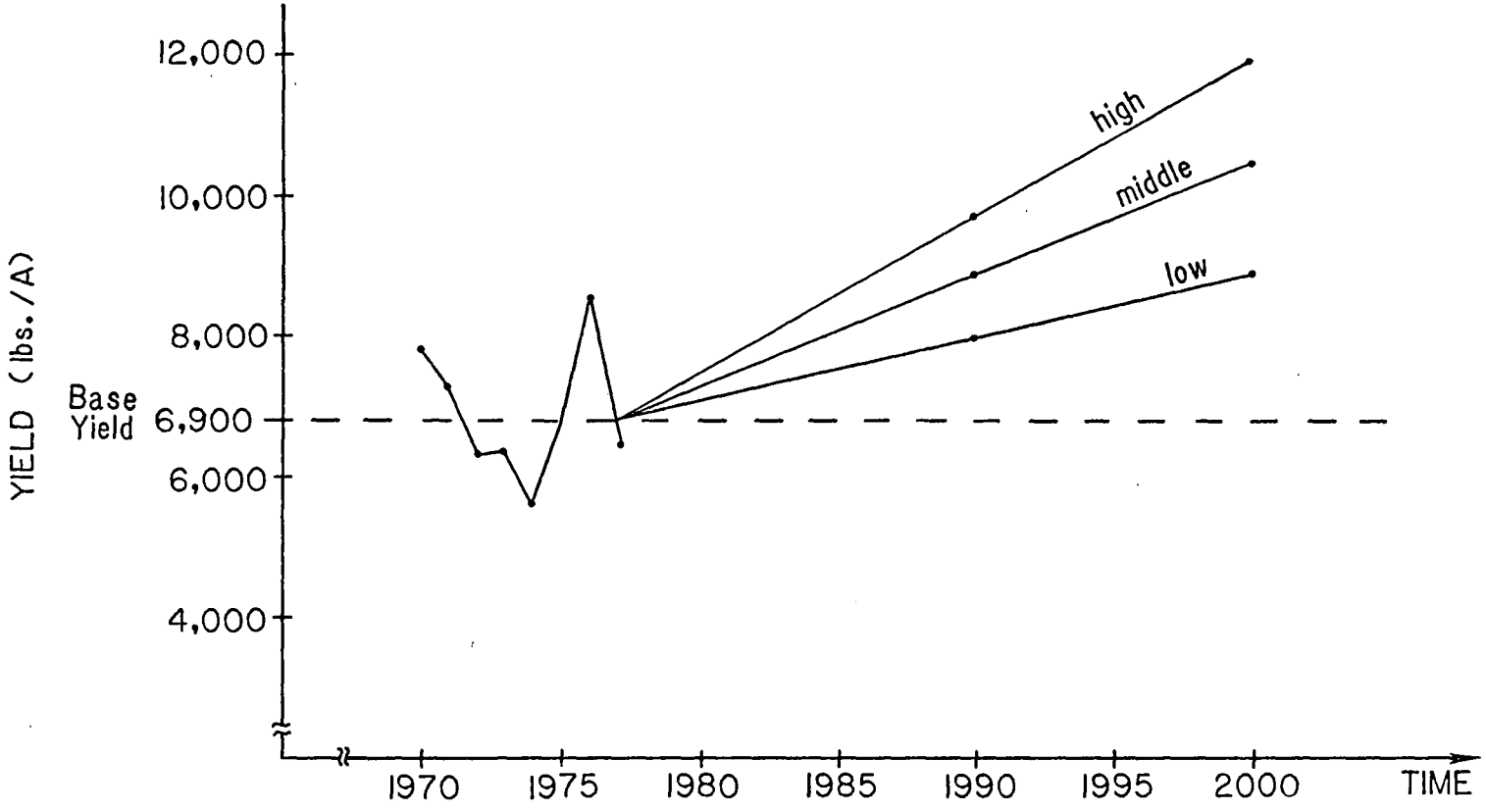
[illegible] mer

principally, could result in [illegible] sumers accept spotting, symphylan holes, [illegible], will growers decrease pesticide use voluntarily. Similarly, USDA standards permit only a very small proportion of insect parts and decayed fruit in processed berries. Fewer pesticides would be necessary if the standards were relaxed.

Despite the almost universal trend in American agriculture toward consolidation and specialization, the PNW strawberry farm remains a diverse enterprise. The strawberry crop is rotated with grains and cereal crops, and the farmer tends to produce several other crops. This diversity is beneficial to the all important soil structure. The soil structure may become denuded by crop specialization with repeated applications of the same substances over time. The long run health of the land is promoted by the diversity offered by the typical small PNW strawberry grower.

PNW strawberry yields vary considerably from year to year but a typical yield is 6,900 pounds per acre. Yields are as high as 10,000 pounds per acre are not unusual, however. In 1976, for example, the average yield for the PNW was 8,700 pounds (Figure 3).

Figure 3.
CURRENT AND PROJECTED STRAWBERRY YIELDS
IN THE PACIFIC NORTHWEST



The broken line represents the current or base average yield of 6,900 lbs./A.

The jagged line represents PNW average yields for 1970–1977.

The high, middle, and low projections are based on trend line analysis and the opinions of experts in the strawberry industry.

Projections are:	1990	2000
High	9,800	12,000
Middle	8,900	10,500
Low	8,000	9,000

Based on historical trends in yield increases and the opinions of experts in the industry, yield projections have been developed for the remainder of the century. Three projections were made: a high, or optimistic projection assumes the yield increases will continue unabated and that improved higher yielding cultivars will be developed; a medium projection assumes a more modest continuation of yield increases and a moderate advance in technology; the low projection assumes increases in technology but no breakthroughs in breeding or mechanical harvesting.

Figure 3 shows the variation in the average PNW yields for the 1970s[4/]. The base yield of 6,900 pounds per acre is shown as a broken line. From 1977, the three projections are drawn out to the year 2000. (One might consider the base yield to be a benchmark for comparing the projected yields.) For 1990, the high, middle, and low projections are, respectively, 9,800 pounds per acre, 8,900 pounds per acre, and 8,000 pounds per acre. The low forcast (8,000 pounds) is 16 percent higher than the base yield, but already many growers exceed that amount (14). For 2000, the projections in the same order are 12,000 pounds per acre, 10,500 pounds per acre, and 9,000 pounds per acre.

While the predicted yields are indeed impressive, they pale by comparison with California's yields Already 40,000 pound yields are typical. According to King et. al., by 1985 the predicted yield will be 45,000 pounds over a 12 percent increase from 1977 yields (12). They could go even higher later in the century. As a result, even the most optimistic forecast leaves PNW yields way behind California.

Increasing Competition From Other Regions

The future of strawberry production in the PNW is in doubt because of California's current position, and the emergence of

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4/ Yields do not differ significantly within the PNW producing region.

Mexico as a competitor. More advanced cultural practice may be necessary to boost yields, providing the additional cost is outweighed by the additional revenue from higher yields. On the other hand, because of climatic conditions alone, the PNW cannot compete with California or Mexico in volume of production. It may be that the PNW will need to concentrate on producing a tasty, high quality berry for which processors and consumers may be willing to pay just a little bit more.

Certainly it will not be easy for the PNW to maintain its share of the U.S. strawberry market. Projections made by King et. al. (12) indicate that from 1975 to 1985 total California strawberry acreage will increase by about four percent to 10,400 acres or about twice the current acreage in Oregon. This combined with the higher expected yields of 45,000 pounds per acre would boost total production about 23 percent above 1975 levels. A predicted level of 468 million pounds would be fully 80 percent of the predicted total U.S. production of 585 million pounds. The 1975 PNW share of U.S. production was about 12 percent. To keep that share the PNW would have to produce about 70 million pounds in 1985, 40 percent more than in 1978. That can only happen if acreages increase sharply which few expect (14) or if yields are higher than the optimistic or high projections discussed earlier.

A shrinking share of the national market is not all that critical as long as PNW growers continue to have profitable operations. The potential of local and fresh markets has hardly been explored. A marketing specialist might prove beneficial to the PNW strawberry industry. Processors could also exploit the quality differential between the PNW strawberry and the California strawberry.

These approaches also have problems. The Oregon Strawberry Commission which has spent a lot of money on research for the mechanical harvestor is unable to use grower assessments for promotional purposes. A referendum vote by the growers would be required to change the charter.

Also, many PNW processors blend California and PNW berries for some products making it more difficult to increase consumer demand for PNW berries. Promotion of PNW berries on the basis of superior quality would have to be carried out almost exclusively by processors.

CONCLUSIONS

The per acre costs of producing strawberries in the PNW ($1,960.75 are much less than California's costs ($7,685.50) but the unit cost (28.4 cents per pound) is higher than California (19.2 cents per pound) because of yield difference. The difference in yield is a result of climatic differences and the more intensive cultural practices in California. Climate precludes the PNW from approaching California's yields although improved cultural practices could boost production.

The only substantial advantage PNW growers have is their ability to produce a high quality, tasty berry. Instead of trying to make up for weaknesses, growers could exploit their strengths by following either of two alternate plans or both.

Research could center on selecting new varieties based on high quality fruit. Research has been ongoing in this area and is expected to continue.

Or money could be spent on promoting markets. The size of the fresh market accounted for only 16 percent of the total PNW production in 1978, its highest total ever. In Washington, the fresh market has been increasingly steadily as a portion of total sales but the reason is because of a decline in the processed market. In absolute quantities the PNW fresh market has not increased for years. A vigorous marketing campaign promoting the berries could result in taking some of the California share, at least in the Northwest, although this is an uncertain possibility.

The potential for local market outlets also could be explored. Food cooperatives and growers' markets are becoming

even more popular, providing ready outlets for growers. Also, U-pick operations are popular with consumers. This marketing technique is well-known and requires practically no investment.

At least one caveat is in order. Improved cultivars almost certainly will be required for the PNW to expand fresh market sales. Current varieties are simply too delicate and have too short a shelf life for significant market expansion. Also, the short harvest season makes competition with California difficult.

The mechanical harvester has yet to fulfill its potential. Despite huge sums of money spent researching it, its profitability is questionable as the earlier analysis shows. The possibility of developing a berry tough enough to be machine harvested yet tender, tasty, and of a quality superior to the California berry seems unlikely. Finally, the labor displacement resulting from mechanization would involve some cost to society.

Strawberry production has a future in the PNW, of course. It is unlikely however, that the share of the national market can be increased or even maintained. But, as mentioned, the PNW itself could provide a small but firm market outlet. Unless costs increase drastically relative to those in California, processors will still demand PNW strawberries. Therefore, while acreages are not expected to increase in the absence of new market promotion, neither should they decline. PNW strawberry industry may have reached a stable level of production.

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HISTORICAL TRENDS 1950-77
OREGON
STRAWBERRIES

YEAR	ACRES PLANTED	ACRES HARVESTED	YIELD LBS/A	TOTAL PRODUCTION 000 LBS	PRICE CTS/LB	TOTAL VALUE OF PRODUCTION (1000) $
1950	14000	14000	3070.0	42980		
1951	15700	14500	2220.0	32190		
1952	15300	15300	3610.0	55233		
1953	15500	15500	4020.0	62310		
1954	15200	15200	3890.0	59128		
1955	17500	17500	4770.0	83475		
1956	16800	16800	4210.0	70728		
1957	18500	18300	5000.0	91500		
1958	16000	15600	4400.0	68640		
1959	15600	15600	5700.0	88920		
1960	14500	14500	5000.0	72500		
1961	13000	13000	5200.0	67600		
1962	14000	14000	6100.0	85400		
1963	14000	14000	4950.0	69300		
1964	14000	14000	7700.0	107800		
1965	14500	12000	5000.0	60000		
1966	12500	12500	7704.0	96300		
1967	13200	13200	6901.5	91100		
1968	12200	12000	5900.0	70800	16.7	11,856
1969	12400	12000	5800.0	69600	17.2	11,994
1970	12000	11600	6103.4	70800	15.9	11,246
1971	10800	10800	7703.7	83200	15.1	12,541
1972	8700	8600	6302.3	54200	17.8	9,647
1973	8100	7800	6205.1	48400	23.9	11,578
1974	8100	7200	5694.4	41000	25.6	10,620
1975	6200	6100	6803.2	41500	23.0	9,610
1976	5300	5200	9192.3	47800	28.5	13,622
1977	5400	5300	6603.7	35000	28.5	9,979

1950-67 Data unavailable

HISTORICAL TRENDS 1950-77
WASHINGTON
STRAWBERRIES

YEAR	ACRES		YIELD	TOTAL PRODUCTION	PRICE	TOTAL VALUE OF PRODUCTION
	PLANTED	HARVESTED	LBS/A	000 LBS	CTS/LB	(1000) $
1950	7200	7200	3260.0	23472		
1951	8000	8000	2580.0	20640		
1952	8300	8300	4110.0	34113		
1953	8500	8500	5130.0	43605		
1954	8500	8500	5130.0	43605		
1955	8500	8500	4620.0	39270		
1956	3500	3500	2750.0	9625		
1957	8000	8000	5300.0	42400		
1958	7500	7500	5400.0	40500		
1959	7000	7000	6600.0	46200		
1960	6900	6900	6800.0	46920		
1961	6800	6800	7200.0	48960		
1962	7300	7300	6800.0	49640		
1963	7000	7000	6400.0	44800		
1964	6200	6200	7300.0	45260		
1965	6200	4800	6600.0	31680		
1966	5600	5600	6892.8	38600		
1967	5600	5600	6392.8	35800		
1968	5300	5300	7207.5	38200	17.6	6,722
1969	4500	4300	6093.0	28200	18.4	4,810
1970	4100	4100	7292.6	29900	16.9	5,057
1971	4100	4100	6512.1	26700	15.8	4,222
1972	3800	3800	6394.7	24300	18.7	4,556
1973	3600	3600	6000.0	21600	24.1	5,215
1974	3600	3600	6305.5	22700	25.7	5,823
1975	3400	3400	6794.1	23100	21.6	4,992
1976	3000	3000	7700.0	23100	27.7	6,945
1977	3300	3300	6090.0	20100	28.0	5,626

1950-67 Data unavailable

HISTORICAL TRENDS 1950-77
PACIFIC NORTHWEST
STRAWBERRIES

YEAR	ACRES		YIELD	TOTAL PRODUCTION	PRICE	TOTAL VALUE OF PRODUCTION
	PLANTED	HARVESTED	LBS/A	000 LBS	CTS/LB	(1000) $
1950	21200	21200	3134.5	66452		
1951	23700	22500	2348.0	52830		
1952	23600	23600	3785.8	89346		
1953	24000	24000	4413.1	105915		
1954	23700	23700	4334.7	102733		
1955	26000	26000	4720.9	122745		
1956	20300	20300	3958.2	80353		
1957	26500	26300	5091.2	133900		
1958	23500	23100	4724.6	109140		
1959	22600	22600	5978.7	135120		
1960	21400	21400	5580.3	119420		
1961	19800	19800	5886.8	116560		
1962	21300	21300	6339.9	135040		
1963	21000	21000	5433.3	111100		
1964	20200	20200	7577.2	153060		
1965	20700	16800	5457.1	91680		
1966	18100	18100	7453.0	134900		
1967	18800	18800	6750.0	126900		
1968	17500	17300	6300.5	109000	17.0	18,578
1969	16900	16300	5877.3	95800	17.5	16,804
1970	16100	15700	6414.0	100700	16.2	16,303
1971	14900	14900	7375.8	109900	15.3	16,763
1972	12500	12400	6330.6	78500	18.1	14,203
1973	11700	11400	6140.3	70000	24.0	16,793
1974	11700	10800	5898.1	63700	25.6	16,443
1975	9600	9500	6799.9	64600	22.5	14,602
1976	8300	8200	8646.3	70900	28.2	20,567
1977	8700	8600	6406.9	55100	28.3	15,605

1950-67 Data unavailable