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THE ECONOMIC POTENTIAL OF CROP ROTATIONS IN LONG ISLAND POTATO PRODUCTION

S.S. Lazarus

G.B. White

Department of Agricultural Economics
Cornell University Agricultural Experiment Station
New York State College of Agriculture and Life Sciences
A Statutory College of the State University
Cornell University, Ithaca, New York, 14853

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THE ECONOMIC POTENTIAL OF CROP ROTATIONS IN LONG ISLAND POTATO PRODUCTION

S.S. Lazarus and G.B. White*

INTRODUCTION

Suffolk County, the easternmost county on Long Island, has the highest value of farm receipts of any county in New York State. One of the major agricultural commodities raised there is potatoes. In 1981, 18,500 acres of potatoes were produced. However, in recent years potato production has declined. (For example, in 1970 potato acreage was 31,000.) There are several reasons for this decrease. Urban encroachment is a major problem.

Potato pests (disease, insects, and weeds) also cause many problems for Long Island growers. Since potato production is very intense on the island, pest populations tend to build up. It is believed that more pesticides are used per acre on Long Island potato fields than on potatoes in any other region of the United States. (For one estimate of per acre costs in various potato producing regions, see Putnam, 1981.) The insects on Long Island have become resistant to some pesticides and new effective chemicals must constantly be sought.

Aldicarb (Temik), a systemic insecticide, was widely used to control the Colorado potato beetle. In the late 1970's it was discovered that the ground water had become contaminated with aldicarb. In 1980 the use of aldicarb was banned on Long Island. Heavy use of other pesticides may also cause ground water contamination.

The withdrawal of aldicarb has caused an awareness of some of the problems of intense pesticide use. Continuous potato production has, in the past, been an economical practice for the fertile Long Island land; it may not be economical in the future given the pest management options now available to growers.

Integrated Pest Management (IPM) is a potential solution to some of the potato production problems on Long Island. IPM is the use of chemical, cultural, genetic, and biological pest control methods. These techniques are used in such a way as to have a minimum effect on nontarget organisms and the environment (Apple et al., 1979).

One IPM strategy that reduces pesticide use and incorporates other pest management tactics is crop rotation. Crop rotation can help reduce the population of potato pests. Crop rotation on Long Island potato farms will not become a major IPM technique until several economic questions are answered: 1) How will crop rotation affect growers' net income? 2) Are sufficient labor and other needed inputs available for other rotations? and 3) Are there markets for all crops raised in the rotations?

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*Research Support Specialist and Assistant Professor, Department of Agricultural Economics, Cornell University, Ithaca, NY 14853-0398. This research was supported by Cooperative Agreement No. 58-32U4-2-389 between the Agricultural Research Service, USDA, and Cornell University.

This paper focuses on the first of these three questions. A model was developed to examine the profitability of various crop rotations that are agronomically feasible for Long Island. It is important to examine the broad question of the economic feasibility of rotation as an IPM strategy on Long Island. Insufficient labor to raise certain vegetables can then be examined within the perspective of the relative profitability of these crops. Likewise solutions to various marketing problems may be found if certain crops are found to have economic potential. These questions may be addressed in the future depending upon the results of this research to evaluate the effects of crop rotation on growers' incomes.

METHODOLOGY

A linear programming model was used to determine the best crop production plan. Linear programming is a mathematical programming technique in which an optimal mix of production methods and crops is derived by allocating limited resources (such as land, labor, and capital) among various production activities to achieve the highest net return over variable costs. Additional analyses of a linear program solution can indicate when an optimal plan will change due to a change in the use of an input (such as pesticides), a change in the market price of a crop, or a change in the quantity of resources used.

There are two major areas that produce potatoes on Long Island. Both are on the eastern portion of the Island. One area is commonly called the South Fork, the other the North Fork. Linear programming models were developed for representative 150 acre farms on each Fork. This was necessary because the Forks have different soil types, and growers use different cultural practices on the two Forks. The soil on the North Fork is very light and irrigation is required to raise potatoes. Many growers on the North Fork have traditionally raised continuous potatoes. Rye, which is planted as a cover crop to prevent wind erosion during the winter, is plowed down in the spring. Although the land on the North Fork is well suited for the production of various vegetable crops, many potato growers prefer not to raise vegetables due to the problems of hiring seasonal labor.

Compared to the North Fork, the soil on the South Fork is heavier. Irrigation is not widely used to grow potatoes, due to the greater water-holding capacity of the soil. Even though many South Fork growers do not irrigate, potato yields are estimated to be approximately 5-10 percent higher than on the North Fork. Thus, South Fork growers have lower costs because they do not need irrigation equipment. At the same time they receive higher gross returns due to the higher yields. Growers on the South Fork have traditionally raised two years of potatoes followed by a year of rye. Like the growers on the North Fork, they plant a rye cover crop, but allow it to mature every third year. Few South Fork potato growers raise vegetables. In addition to the labor problems, irrigation equipment may need to be purchased to grow vegetables economically.

There are major difficulties hiring seasonal labor to weed and harvest vegetable crops. Migrant labor is typically used to harvest vegetable crops, and many New York State and federal laws regulate the employment of migrants. Many growers who have traditionally specialized in potato production lack the managerial expertise or are not inclined to handle a seasonal labor crew. In the past, these farms have relied largely upon family labor or used full-time hired employees. Potato growers have a strong preference to continue operating in a similar manner. There are some farmers on Long Island who raise large quantities of vegetables in spite of the labor difficulties. This implies that it would be possible for potato farmers to surmount the labor difficulties and raise vegetable crops.

Another problem with some rotations is that potatoes are raised on soil with a low pH. The pH is kept low to reduce the incidence of potato scab. Rye, cauliflower and cabbage are three crops that, like potatoes, can be grown on a low pH soil. However, fields planted to cauliflower or cabbage are generally limed prior to planting. These three crops are relatively common on Long Island. But many other crops require a higher pH to produce a high yield. It is possible to raise the soil pH slightly to allow the production of these crops, yet not so much that potato scab would be a major problem the following year.

The following rotations using various potato and field crop combinations were considered in the model:

1) Year 1 - Potatoes; Year 2 - Rye

2) Year 1 - Potatoes; Year 2 - Corn

3) Year 1 - Potatoes; Year 2 - Double Crop of Winter Wheat and Soybeans

4) Year 1 - Potatoes: Year 2 - Double Crop of Winter Wheat and Soybeans; Year 3 - Corn

5) Year 1 - Potatoes; Year 2 - Oats

6) Year 1 - Potatoes; Year 2 - Sunflowers

7) Year 1 - Potatoes; Year 2 - Dry Beans (Red Kidney Beans)

In addition to these rotations, continuous potatoes (the production practice currently used by many growers) was considered for the North Fork. Two years of potatoes followed by a year of rye was considered to be the traditional rotation in the South Fork model.

Some growers on Long Island raise large quantities of cabbage and cauliflower in spite of the labor difficulties. Thus, in some versions of the model two vegetable crop rotations were considered in addition to the field crop rotations:

1) Year 1 - Potatoes; Year 2 - Cauliflower

2) Year 1 - Potatoes; Year 2 - Cabbage

The models were also run to include two other rotations which contain crops not commonly grown on Long Island, but which are possibilities in the future:

1) Year 1 - Potatoes; Year 2 - Onions

2) Year 1 - Potatoes; Year 2 - Double Crop of Spinach and Soybeans

These two rotations may have some agronomic problems due to the higher pH soils required by the onions and spinach. The utilization of scab resistant varieties will help make these rotations possible. However, presently available scab resistant varieties can develop scab under severe conditions. Spinach is currently raised by some growers on Long Island. It takes somewhat less labor than many other vegetable crops. A rotation of spinach followed by soybeans, a less labor intensive field crop, might provide a compromise between the high labor needs of vegetable crops and the relatively low per acre return of some field crops.

Budgets were constructed for each of the crops considered in the models (Appendix Tables A1 through A12). Information for these budgets was gathered from a variety of sources. Three Long Island potato growers were interviewed to discover their current crop raising practices, as well as their costs and returns for potato production. Average yields and prices over the past five years for various Long Island crops were obtained from New York Agricultural Statistics. If the information was not available for Long Island, average New York State data were used. Cost data for field crops was obtained from Knoblauch (1981). Revenue and cost data for sunflowers was obtained from W. Lazarus (1982). Pesticide usage for crops other than potatoes were estimated from Cornell Recommends for Field Crops and Cornell Recommendations for Commercial Vegetable Production. The potato pesticide usage was obtained from 1981 surveys of Long Island potato growers participating in a Cornell-sponsored IPM program. Additional information about production practices for vegetable crops was obtained from Dhillon (1979), Phelps and How (1981), and Snyder (1981). Prices were obtained from several Long Island input suppliers.

Labor and machinery costs were estimated for each crop. An economic engineering approach was used. Using this approach, machinery costs and labor inputs were calculated based on such factors as machine width, operating speed, and machine efficiency (Benson 1974; Knoblauch, et al., 1980).

The representative farm was assumed to have the machinery complement presented in Appendix Table A13. The farm was assumed to have sufficient machinery to plant the entire farm in potatoes since this crop was currently grown. The farm was also assumed to have sufficient machinery to raise the various vegetable crops considered in some of the model variations. Since vegetable crops are important on Long Island, some potato growers have raised some vegetables in the past and thus would have the necessary machinery.

Custom corn planting, custom combining, and custom grain drying were assumed for the rotations requiring these operations. The use of custom machinery is a way to avoid the problem of having too few acres of a particular crop to justify (economically) the purchase of a specialized machine. A grower trying a new rotation with just a few acres of a field crop is not likely to purchase an expensive machine to produce that crop. The South Fork model farm, however, was assumed to purchase an irrigation system to irrigate any vegetable crops produced. It is handled as a continuous input rather than using an assumed equipment capacity.

The labor requirements for various crops are presented in Appendix Table A14. It was assumed that the grower and his family could provide 217 hours of labor during each semi-monthly period. This is the equivalent of two people each working a 50 hour week. Additional labor could be hired for $5.50 per hour (wages, taxes, and benefits).

The farm could borrow operating capital at a 12 percent annual rate for nine months. The various crops were assumed to be sold at harvest. The modeled farms could either raise the rye that is used as seed for the cover crop or buy the seed. It would cost $5.00 per bushel to buy rye seed. Excess rye could be sold for $2.80 per bushel.

In the models which included vegetable crop rotations, the acreage of any one crop was limited to 25 acres. This was done because of the price risk of having a large acreage in any one vegetable crop. The yield of potatoes was assumed to be five percent higher on the South Fork than on the North due to the better soil. The vegetable crops were assumed to have the same yield on both Forks. Field crops which were assumed to be irrigated on both Forks had the same yields, but yields of nonirrigated field crops were assumed to be 10 percent higher on the South Fork than on the North Fork.

The models were also run to examine what affect various acreage limitations on potato production would have on returns over variable costs. The model first allowed all acreage (150 acres) on the North Fork and 100 acres on the South Fork to be planted to potatoes. Maximum potato acreage was then reduced by increments of 25 acres in successive runs. This procedure examined possible reductions in farm returns over variable costs of using crop rotation as an IPM tactic.

Potato yields in the future might stay at current levels at the cost of relatively higher pesticide costs for potato crops. So a model variation was run that examined higher potato pesticide usage while the quantities of chemicals used for other crops was held constant. Another model variation examined the effect of potato yield reductions if chemicals no longer effectively controlled the Colorado potato beetle. It is also possible that potato yields in the past have been somewhat suppressed due to the high intensity of potato production. Another variation of the model examined the effect of yield increases for potatoes grown in a rotation.

RESULTS

If only field crop rotations were considered, continuous potato production was the most profitable cropping practice on the North Fork (Table 1). If all 150 acres of the farm were planted to potatoes, the highest return over variable costs would be attained. This result is not surprising since growers can be expected to have found a profitable cropping pattern by trial and error, and since existing machinery is geared to potato production. Relatively little seasonal labor must be hired. Large amounts of pesticides must be used to produce continuous potatoes.

Growers might be willing to raise other field crops if they could be subsidized for the income loss of not raising continuous potatoes. Pesticide use could be reduced if only two-thirds or half of each farm's acreage

Table 1. Optimal rotations with various limitations on maximum potato acreage (field crop rotations) - North Fork Model.

	Maximum Potato Acreage				
	150	125	100	75	50
Rotation:					
Continuous Potatoes	150	100	50	---	---
(1)Potatoes (2)Rye	---	12	12	12	8
(1)Potatoes (2)Corn	---	---	---	---	---
(1)Potatoes (2)Winter Wheat/Soybeans	---	38	88	138	---
(1)Potatoes (2)Winter Wheat/Soybeans (3)Corn	---	---	---	---	139
(1) Potatoes (2) Oats	---	---	---	---	---
(1) Potatoes (2) Sunflowers	---	---	---	---	---
(1) Potatoes (2) Dry Beans	---	---	---	---	---
Actual Number of Acres in Potatoes	150	125	100	75	50
Return over Variable Costs	$101,088	$88,618	$75,471	$61,972	$44,924
Family Labor Activity Level, Hours					
March (second half)	147	123	98	74	50
April (first half)	147	123	98	74	50
April (second half)	165	138	110	83	66
May (first half)	15	13	10	8	24
May (second half)	15	13	10	8	14
June (first half)	63	48	32	17	12
June (second half)	199	173	148	124	83
July (first half)	167	160	159	158	149
July (second half)	167	140	112	85	98
August (first half)	217	217	202	157	147
August (second half)	217	217	202	157	147
September (first half)	144	120	95	71	47
September (second half)	144	124	104	85	47
October (first half)	144	130	118	107	94
October (second half)	144	126	109	93	84
Hired Labor Activity Level, Hours					
August (first half)	76	30	---	---	---
August (second half)	76	30	---	---	---
Other Major Activities					
Borrow operating capital	$127,692	$107,966	$90,390	$73,140	$58,268
Buy rye seed (bu.)	225	---	---	---	---
Pesticide Active Ingredients					
Fungicide (lbs. A.I.)	1,907	1,589	1,271	953	639
Insecticide (lbs. A.I.)	4,047	3,314	2,580	1,847	1,416
Herbicide (lbs. A.I.)	900	769	647	522	371

was planted to potatoes resulting in less risk of ground water contamination. The Colorado potato beetle is less likely to develop resistance to various chemicals that are used less intensively.

If a grower on the North Fork did not raise potatoes on more than half of his acreage in any given year, the optimal cropping pattern would contain two rotations (Table 1). A potato/rye rotation would be raised on 12 acres (i.e. six acres of potatoes and six acres of rye). A rotation of potatoes followed the next year by a double crop of winter wheat and soybeans would be planted on the remaining 138 acres of the farm.[1] The return over variable costs was reduced by $39,116 if potato acreage was restricted by 50 percent. Pesticide use would be cut in half.

The potato/rye rotation was raised on just enough acreage to provide seed for the cover crop in all cases where potato acreage was restricted (Table 1). This was due to the dual pricing system used for rye in the model. Rye seed could be purchased for $5.00 per bushel, but the grower could sell excess rye which he raised for only $2.80 per bushel.

If both field and cole crop rotations were considered in the North Fork model, continuous potatoes would be planted on 100 acres in the optimal solution (Table 2). A two year rotation of potatoes and cauliflower would be planted on the remaining 25 acres. The return over variable costs would be $107,515. The 25 acres of cauliflower would provide the farm with a higher return than if continuous potatoes were raised on the entire farm. The cauliflower acreage required considerable hired labor. This modeled farm was representative of the current situation on some North Fork potato farms where some high income vegetable crops are grown.

If the maximum potato acreage was limited to half of the farm in any given year, three rotations would be raised (Table 2). Twelve acres of the two year potatoes and rye rotation would be raised. Eighty-eight acres of the two year rotation of the potatoes and double crop (winter wheat, soybeans) would be raised. The remainder of the farm (50 acres) would be planted in the potatoes and cauliflower rotation. The return over variable costs was $24,600 less than if no restrictions were placed on potato acreage. Pesticide use was reduced by 23 percent from the optimal plan. A constraint limited the acreage of any one vegetable crop to 25 acres, due to the price risk of raising vegetables. If the cauliflower acreage had not been limited, even more acres of the potato/cauliflower rotation would have been raised in all situations.

The model results on the South Fork were similar to those on the North Fork if only field crop rotations were considered (Table 3). The traditional cropping pattern of two years of potato production followed by a year of rye would be used for the entire 150 acres. The return over variable costs would be $91,640.

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[1]A grower would probably set up the rotations so that of the 138 acres, there would be 69 acres of potatoes and 69 acres in double-cropping in any one year. In an average year, potato acreage on the farm would be six acres (from the potato/rye rotation) plus 69 acres from the potato/double crop rotation, or a total of 75 acres of potatoes.

Table 2. Optimal rotations with various limitations on maximum potato acreage (field crop and cole crop rotations) - North Fork Model.

	Maximum Potato Acreage				
	150	125	100	75	50
Rotation:					
Continuous Potatoes	100	100	50	---	---
(1)Potatoes (2)Rye	---	---	12	12	8
(1)Potatoes (2)Corn	---	---	---	---	---
(1)Potatoes (2)Winter Wheat/Soybeans	---	---	38	88	---
(1)Potatoes (2)Winter Wheat/Soybeans (3)Corn	---	---	---	---	63
(1)Potatoes (2)Oats	---	---	---	---	---
(1)Potatoes (2)Sunflowers	---	---	---	---	---
(1)Potatoes (2)Dry Beans	---	---	---	---	---
(1)Potatoes (2)Cauliflower	50	50	50	50	50
(1)Potatoes (2)Cabbage	---	---	---	---	---
Actual Number of Acres in Potatoes	125	125	100	75	50
Return over Variable Costs	$107,515	$107,515	$95,505	$82,915	$64,700
Family Labor Activity Level, Hours					
March (second half)	123	123	98	74	49
April (first half)	123	123	98	74	49
April (second half)	138	138	110	83	60
May (first half)	13	13	10	8	14
May (second half)	13	13	10	8	9
June (first half)	47	47	32	16	11
June (second half)	172	172	145	121	80
July (first half)	179	179	172	172	139
July (second half)	209	209	182	154	145
August (first half)	217	217	217	208	175
August (second half)	217	217	217	217	217
September (first half)	171	217	217	217	217
September (second half)	217	217	217	217	217
October (first half)	217	217	217	217	217
October (second half)	217	217	217	217	217
November (first half)	209	209	209	209	209
November (second half)	53	53	53	53	53
Hired Labor Activity Level, Hours					
August (first half)	82	82	36	---	---
August (second half)	224	224	178	133	100
September (first half)	176	176	151	127	103
September (second half)	709	709	689	669	637
October (first half)	693	693	678	667	641
October (second half)	608	608	589	573	551
Other Major Activities					
Borrow operating capital	$151,872	$151,872	$131,722	$113,630	$92,846
Buy rye seed (bu.)	225	225	---	---	---
Pesticide Active Ingredients					
Fungicide (lbs. A.I.)	1,639	1,639	1,321	1,003	687
Insecticide (lbs. A.I.)	3,414	3,414	2,681	1,947	1,416
Herbicide (lbs. A.I.)	775	775	648	522	359

Table 3. Optimal rotations with various limitations on maximum potato acreage (field crop rotations) - South Fork Model.

	Maximum Potato Acreage				
	150	125	100	75	50
Rotation:					
(1)Potatoes (2)Potatoes (3)Rye	150	150	150	---	---
(1)Potatoes (2)Rye	---	---	---	11	3
(1)Potatoes (2)Corn	---	---	---	---	---
(1)Potatoes (2)Winter Wheat/Soybeans	---	---	---	139	---
(1)Potatoes (2)Winter Wheat/Soybeans (3)Corn	---	---	---	---	147
(1) Potatoes (2) Oats	---	---	---	---	---
(1) Potatoes (2) Sunflowers	---	---	---	---	---
(1) Potatoes (2) Dry Beans	---	---	---	---	---
Actual Number of Acres in Potatoes	100	100	100	75	50
Return over Variable Costs	$91,640	$91,640	$91,640	$77,378	$55,944
Family Labor Activity Level, Hours					
March (second half)	98	98	98	74	50
April (first half)	98	98	98	74	50
April (second half)	110	110	110	83	66
May (first half)	11	11	11	8	25
May (second half)	11	11	11	8	15
June (first half)	32	32	32	17	12
June (second half)	42	42	42	55	37
July (first half)	29	29	29	91	62
July (second half)	29	29	29	16	11
August (first half)	104	104	104	88	59
August (second half)	104	104	104	88	59
September (first half)	98	98	98	71	47
September (second half)	98	98	98	85	57
October (first half)	98	98	98	105	97
October (second half)	98	98	98	92	87
Other Major Activities					
Borrow operating capital	$76,001	$76,001	$76,001	$67,115	$52,902
Sell rye seed (bu.)	1,900	1,900	1,900	---	---
Buy rye seed (bu.)	---	---	---	---	91
Pesticide Active Ingredients					
Fungicide (lbs. A.I.)	1,584	1,584	1,584	1,188	796
Insecticide (lbs. A.I.)	2,903	2,903	2,903	2,147	1,628
Herbicide (lbs. A.I.)	625	625	625	522	374

Potatoes have traditionally been raised less intensively on the South Fork. The use of two years of potatoes followed by a year of rye as the traditional cropping pattern automatically limited potato production in any given year to two-thirds of the farm's acreage. If potato acreage was limited to half of the farm, 11 acres would be planted in the potato/rye rotation, providing enough seed for the cover crop. The remaining 139 acres would be planted in the potato/double crop (winter wheat, soybean) rotation. As noted before, growers would probably set up rotations so that approximately half the farm would be planted to potatoes each year. The return over variable costs would be $77,378, which was $14,262 less than if no restrictions were placed on potato acreage.

If both field and cole crop rotations were considered in the South Fork model, 100 acres would be planted in two years of potatoes, followed by a year of rye (Table 4). The remaining 50 acres would be planted in a potato and cauliflower rotation. The return over variable costs was $106,833. The use of pesticides was relatively high.

Pesticide use was reduced by 17 percent if the maximum potato acreage was restricted to half of the farm (Table 4). In this situation, 11 acres would be planted in the potato/rye rotation. The rotation of potatoes followed the next year by a double crop of winter wheat and soybeans would be planted on 89 acres. Potatoes followed by a year of cauliflower would be planted on 50 acres (an annual average of 25 acres of cauliflower, or the maximum acreage permitted by the model's constraints). The return over variable costs was $97,479, which was $9,354 less than it would be if no restrictions were placed on potato acreage.

The results shown in Tables 1 through 4 were summarized in Figure 1. The returns were higher on both Forks if field and cole crop rotations were considered rather than just field crop rotations. The flat portions of the two curves for the South Fork in Figure 1 reflect the current practice of growing two years of potatoes followed by a year of rye, resulting in no more than 100 acres of potatoes in a given year. The curves show the tradeoff in returns above variable costs as potato acreage is reduced.

Another way to study the economic feasibility of various potential crop rotations is to examine the amount that the optimal return over variable costs would be reduced if the modeled farm was forced to plant an acre of a nonoptimal rotation. For example, Table 5 shows that in the North Fork field crop rotation model, income would be reduced by $268.28 if an acre of the potato/dry beans rotation was forced into the solution. The greatest reduction in income would occur if an acre of the potato/oats rotation ($310.56) or the potato/double crop (winter wheat, soybean)/corn rotation ($372.15) was forced into the North Fork field crop model (Table 5).

With a corn price of $2.75 (see Appendix Table A3) and assuming that variable costs were not increased as yields increased, it is possible to calculate the corn yield required for an acre of the corn rotations to come into the model. For an acre of the two year rotation of potatoes and corn to come into the optimal solution, a minimum corn yield of 210 bushels of dry, shelled corn for the North Fork field crop model and 149 bushels for the South Fork field crop model would be required. In both these scenarios, the corn yield required to make corn a profitable alternative is probably

Table 4. Optimal rotations with various limitations on maximum potato acreage (field crop and cole crop rotations) - South Fork Model.

	Maximum Potato Acreage				
	150	125	100	75	50
Rotation:					
(1)Potatoes (2)Potatoes (3)Rye	100	100	100	---	---
(1)Potatoes (2)Rye	---	---	---	11	---
(1)Potatoes (2)Corn	---	---	---	---	---
(1)Potatoes (2)Winter Wheat/Soybeans	---	---	---	89	---
(1)Potatoes (2)Winter Wheat/Soybeans (3)Corn	---	---	---	---	75
(1)Potatoes (2)Oats	---	---	---	---	---
(1)Potatoes (2)Sunflowers	---	---	---	---	---
(1)Potatoes (2)Dry Beans	---	---	---	---	---
(1)Potatoes (2)Cauliflower	50	50	50	50	50
(1)Potatoes (2)Cabbage	---	---	---	---	---
Actual Number of Acres in Potatoes	92	92	92	75	50
Return over Variable Costs	$106,833	$106,833	$106,833	$97,479	$74,448
Family Labor Activity Level, Hours					
March (second half)	90	90	90	74	50
April (first half)	90	90	90	74	50
April (second half)	101	101	101	83	61
May (first half)	10	10	10	8	15
May (second half)	10	10	10	8	10
June (first half)	27	27	27	17	12
June (second half)	44	44	44	52	35
July (first half)	64	64	64	104	77
July (second half)	84	84	84	76	70
August (first half)	155	155	155	145	116
August (second half)	217	217	217	217	217
September (first half)	217	217	217	217	217
September (second half)	217	217	217	217	217
October (first half)	217	217	217	217	217
October (second half)	217	217	217	217	217
November (first half)	125	125	125	209	209
November (second half)	32	32	32	53	53
Hired Labor Activity Level, Hours					
August (second half)	78	78	78	67	39
September (first half)	148	148	148	130	106
September (second half)	685	685	685	676	649
October (first half)	660	660	660	664	644
October (second half)	575	575	575	570	553
Other Major Activities					
Borrow operating capital	$114,318	$114,318	$114,318	$107,329	$90,464
Sell rye seed (bu.)	1,192	1,192	1,192	---	---
Buy rye seed (bu.)	---	---	---	---	151
Pesticide Active Ingredients					
Fungicide (lbs. A.I.)	1,492	1,492	1,492	1,238	844
Insecticide (lbs. A.I.)	2,732	2,732	2,732	2,247	1,632
Herbicide (lbs. A.I.)	588	588	588	523	363

FIGURE I. RETURNS ABOVE VARIABLE COSTS FOR VARIOUS POTATO ACREAGE CONSTRAINTS

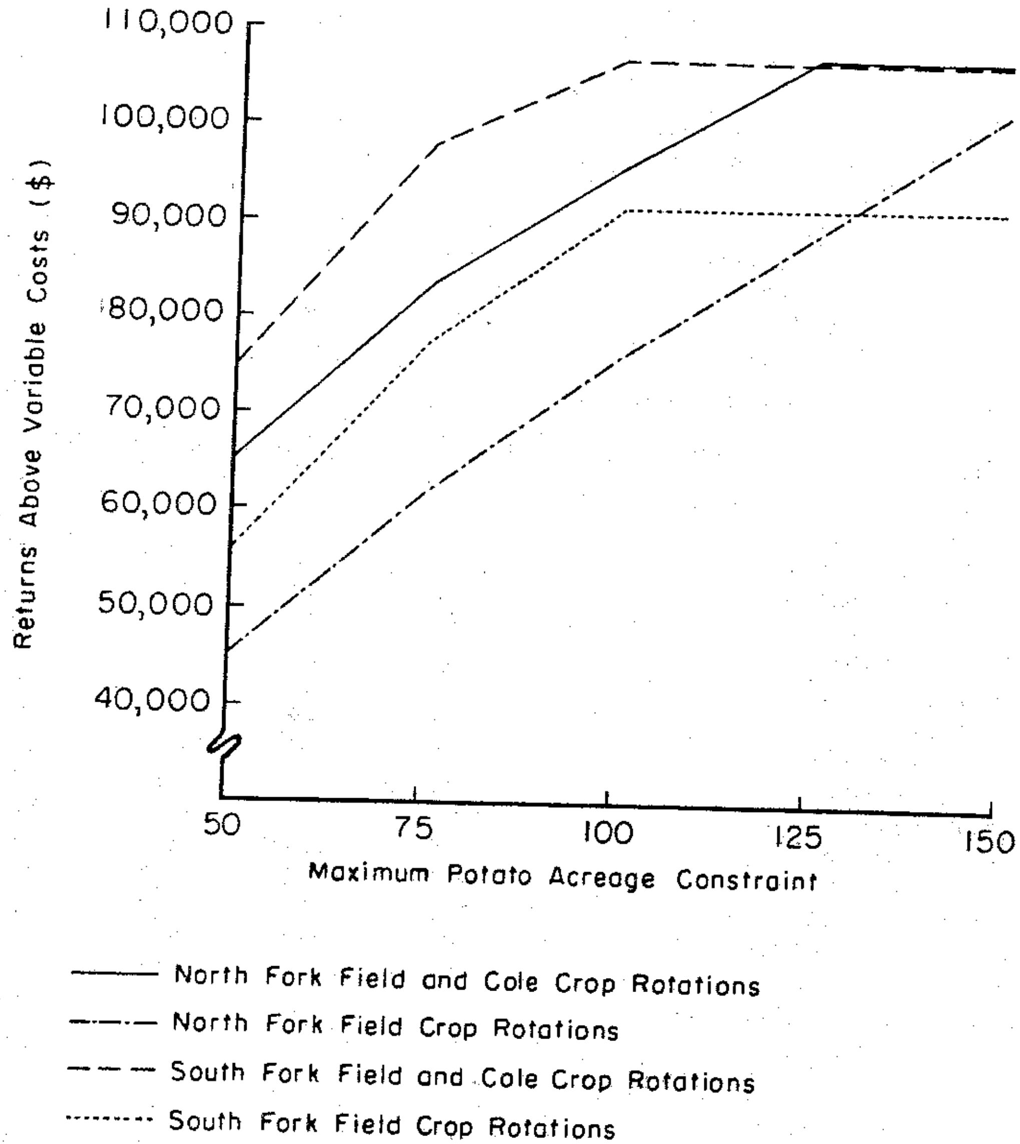

Table 5. Reduced income if an acre of various crop rotations was raised, potato acreage not constrained.

Rotation	North Fork		South Fork	
	Field Crop Rotations	Field & Cole Crop Rotations	Field Crop Rotations	Field & Cole Crop Rotations
Continous Potatoes	----	----	NA	NA
(1)Potatoes (2)Potatoes (3)Rye	NA	NA	----	----
(1)Potatoes (2)Rye	$218.59	$207.42	$112.16	$107.35
(1)Potatoes (2)Corn	295.74	287.31	128.63	126.55
(1)Potatoes (2)Winter Wheat/Soybeans	259.30	250.74	94.73	91.83
(1)Potatoes (2)Winter Wheat/Soybeans (3)Corn	372.15	360.33	238.88	233.06
(1)Potatoes (2)Oats	310.56	299.16	155.39	150.35
(1)Potatoes (2)Sunflower	294.15	285.24	135.65	133.10
(1)Potatoes (2)Dry Beans	268.28	259.37	108.73	106.18
(1)Potatoes (2)Cauliflower	NA	----	NA	----
(1)Potatoes (2)Cabbage	NA	330.74	NA	94.78

unrealistically high.

It is possible that the chemical costs required to produce potatoes will increase. If the Colorado potato beetle becomes more resistant to currently used pesticides, more applications of possibly more expensive chemicals will be needed to maintain potato yields. Table 6 shows the result of increased chemical costs. There are two columns for each group of possible rotations for the North Fork. The left column in each grouping gives the percentage change of chemical costs required for the optimal solution to change. For example, if only field crop rotations were considered as possibilities on the North Fork, the optimal rotation of 150 acres of potatoes (as shown in Table 1) would continue to be optimal until chemical costs increased by 98.8 percent (but returns over variable costs would decrease). If chemical costs increased by 98.8 percent, 138 acres of continuous potatoes should be raised and 12 acres of the potato/rye rotation. Pesticide cost increases of 100 percent would not cause any additional changes in the optimal solution.

The model was more sensitive to pesticide cost changes if both field and cole crop rotations were considered. The optimal solution would change in this situation if chemical costs increased by 93.8 percent on the North Fork. Pesticide cost increases of 100 percent would not change the optimal rotations on the South Fork.

In the past, potato producers have been able to maintain potato yields by using new chemicals or by increasing rates. In the future, however, the Colorado potato beetle may develop high levels of resistance to all registered chemicals. In this situation potato yields might decrease. Table 7 shows the changes in the optimal solution if potato yields decreased when all other factors were held constant. Potato yields must decrease by 27.5 percent on the North Fork and by 33.6 percent on the South Fork before the optimal solution changes if only field crop rotations were considered. A 26.1 percent yield decrease on the North Fork (32.9 percent on the South) was required for the optimal solution to change if both field and cole crop rotations were considered as cropping alternatives.

Table 7 also shows the percentage yield decrease required for the second change in the optimal solution. For example, on the North Fork, if only field crop rotations are considered, the optimal solution changed after a yield decrease of 27.5 percent. At this point 138 acres of continuous potatoes should be raised and 12 acres of the potato/rye rotation. If potato yields decreased by 32.6 percent, the optimal solution would again change. At this point, 67 acres of continuous potatoes, 12 acres of potatoes/rye, and 71 acres of potatoes/double crop (winter wheat, soybeans) would be raised.

Potato yields may, instead of decreasing in the future, increase in rotations. In this scenario, potato yields were held at current levels for continuous potatoes on the North Fork. They also remained constant for the second year of potatoes in the three year rotation of potatoes/potatoes/rye on the South Fork. The yields may increase in the rotations due to less pest problems if potatoes do not follow potatoes. Table 8 shows the percentages that potato yields in rotations would have to increase for the optimal solution to change. If only field crop rotations were considered

Table 6. Optimal rotations if chemical costs for potatoes increase by various percentages.

	North Fork				South Fork	
	Field Crops		Field & Cole Crops		Field Crops	Field & Cole Crops
	98.8%	100%	93.8%	100%	100%	100%
	--acres--					
Continuous potatoes	138	138	88	88	NA	NA
(1)Potatoes (2)Potatoes (3)Rye	NA	NA	NA	NA	150	100
(1)Potatoes (2)Rye	12	12	12	12	---	---
(1)Potatoes (2)Corn	---	---	---	---	---	---
(1)Potatoes (2)Winter Wheat/Soybeans	---	---	---	---	---	---
(1)Potatoes (2)Winter Wheat/Soybeans (3)Corn	---	---	---	---	---	---
(1)Potatoes (2)Oats	---	---	---	---	---	---
(1)Potatoes (2)Sunflowers	---	---	---	---	---	---
(1)Potatoes (2)Dry Beans	---	---	---	---	---	---
(1)Potatoes (2)Cauliflower	NA	NA	50	50	NA	50
(1)Potatoes (2)Cabbage	NA	NA	---	---	NA	---
Return over Variable Costs	$38,998	$38,342	$58,968	$55,956	$55,865	$74,658

Table 7. Optimal rotations if potato yields decrease by various percentages.

	North Fork				South Fork			
	Field Crops		Field & Cole Crops		Field Crops		Field & Cole Crops	
	27.5%	32.6%	26.1%	31.5%	33.6%	38.1%	32.9%	36.8%
	--acres--							
Continuous potatoes	138	67	88	10	NA	NA	NA	NA
(1)Potatoes (2)Potatoes (3)Rye	NA	NA	NA	NA	16	---	16	---
(1)Potatoes (2)Rye	12	12	12	12	---	11	---	11
(1)Potatoes (2)Corn	---	---	---	---	---	---	---	---
(1)Potatoes (2)Winter Wheat/Soybeans	---	71	---	78	134	139	84	89
(1)Potatoes (2)Winter Wheat/Soybeans (3)Corn	---	---	---	---	---	---	---	---
(1)Potatoes (2)Oats	---	---	---	---	---	---	---	---
(1)Potatoes (2)Sunflowers	---	---	---	---	---	---	---	---
(1)Potatoes (2)Dry Beans	---	---	---	---	---	---	---	---
(1)Potatoes (2)Cauliflower	NA	NA	50	50	NA	NA	50	50
(1)Potatoes (2)Cabbage	NA	NA	---	---	NA	NA	---	---
Return over Variable Costs	$35,511	$23,794	$55,659	$45,356	$35,325	$29,381	$56,252	$51,247

the yield would have to increase by 27.5 percent and 33.5 percent on the North and South Forks respectively. (The next optimal solution changes would be at 32.6 percent for the North Fork and 38.0 percent for the South Fork.) It is probably unrealistic to expect potato yields to increase this much due to the benefits of rotation.

The optimal solution was less sensitive to potato yield increases if both field and cole crop rotations were considered in the model (Table 8). In this situation, if potato yields increased by 26.1 percent on the North Fork and 32.8 percent on the South Fork, the optimal solution would change. Potato yield increases of about 32 percent would be associated with large increases in potatoes grown in rotations.

So far the results of the model have been discussed for field crop rotations and for field and cole crop rotations. A third model variation considered field and cole crops as well as two additional rotations. These rotations were as follows: (1) potatoes followed by a year of onions, and (2) potatoes followed by a double crop of spinach and soybeans in the second year. Both of these rotations have agronomic problems due to the higher pH soils required for the onion and spinach production. If potato varieties could be developed that were resistant to scab in higher pH soil, these rotations may have potential.

Table 9 shows that the maximum acreage of 50 acres of both the potato/onion and the potato/double crop (spinach, soybean) rotations would be raised on each Fork. (No more than 25 acres of any one vegetable crop was permitted in the model due to large possible price fluctuations.) The return over variable costs was higher than the returns have been with the traditional rotations on both Forks. The yield on vegetable crops was assumed to be the same on both Forks, but irrigation equipment had to be purchased for production of vegetables on the South Fork. Although returns above variable costs were approximately the same for vegetable crops on both Forks, total returns above variable costs were higher on the South Fork due to higher relative returns for potatoes on the 75 acres grown in the optimal solution on both Forks.

Two major problems must be solved before these two rotations will have potential on Long Island potato farms. First, an acceptable scab-resistant potato variety for relatively high pH soils must be developed. Second, growers must be able to handle large amounts of seasonal labor to successfully raise rotations with onions or spinach.

SUMMARY AND CONCLUSIONS

The current potato production practices on Long Island are the most profitable of the field crop rotations considered. On the North Fork, continuous potato production gave the highest return over variable costs. On the South Fork, two years of potatoes followed by a year of rye (a common current practice) gave the highest returns. There are many problems with intensive potato production. Researchers are constantly investigating new pesticides to stay ahead of insect resistance build-up. Heavy use of some alternative chemicals may result in ground water contamination similar to the problems caused by aldicarb.

Table 8. Optimal rotations if potato yields in rotations increase by various percentages.

	North Fork				South Fork			
	Field Crops		Field & Cole Crops		Field Crops		Field & Cole Crops	
	27.5%	32.6%	26.1%	31.6%	33.5%	38.0%	32.8%	36.6%
	--acres--							
Continuous potatoes	138	67	88	10	NA	NA	NA	NA
(1)Potatoes (2)Potatoes (3)Rye	NA	NA	NA	NA	16	---	16	---
(1)Potatoes (2)Rye	12	12	12	12	---	11	---	11
(1)Potatoes (2)Corn	---	---	---	---	---	---	---	---
(1)Potatoes (2)Winter Wheat/Soybeans	---	71	---	78	134	139	84	89
(1)Potatoes (2)Winter Wheat/Soybeans (3)Corn	---	---	---	---	---	---	---	---
(1)Potatoes (2)Oats	---	---	---	---	---	---	---	---
(1)Potatoes (2)Sunflowers	---	---	---	---	---	---	---	---
(1)Potatoes (2)Dry Beans	---	---	---	---	---	---	---	---
(1)Potatoes (2)Cauliflower	NA	NA	50	50	NA	NA	50	50
(1)Potatoes (2)Cabbage	NA	NA	---	---	NA	NA	---	---
Return over Variable Costs	$101,089	$101,583	$117,887	$120,580	$119,759	$125,288	$138,974	$143,629

Table 9. Optimal rotations for the North and South Fork models (all rotations).

	North Fork	South Fork
Rotations, acres		
Continous potatoes	---	NA
(1)Potatoes (2)Rye	NA	---
(1)Potatoes (2)Corn	---	---
(1)Potatoes (2)Winter Wheat/Soybeans	---	---
(1)Potatoes (2)Winter Wheat/Soybeans (3)Corn	---	---
(1)Potatoes (2)Oats	---	---
(1)Potatoes (2)Sunflowers	---	---
(1)Potatoes (2)Dry Beans	---	---
(1)Potatoes (2)Cauliflower	50	50
(1)Potatoes (2)Cabbage	---	---
(1)Potatoes (2)Onions	50	50
(1)Potatoes (2)Spinach/Soybeans	50	50
Actual Number of Acres in Potatoes	75	75
Return over Variable Costs	$120,287	$132,683
Family Labor Activity Leven, Hours		
March (second half)	85	150
April (first half)	217	84
April (second half)	217	217
May (first half)	217	217
May (second half)	217	217
June (first half)	217	217
June (second half)	217	154
July (first half)	217	200
July (second half)	217	217
August (first half)	217	217
August (second half)	217	217
September (first half)	142	217
September (second half)	217	217
October (first half)	217	217
October (second half)	217	217
November (first half)	209	209
November (second half)	53	53
Hired Labor Activity Level, hours		
April (first half)	81	71
April (second half)	69	71
May (first half)	494	502
May (second half)	562	565
June (first half)	568	573
June (second half)	4	---
July (first half)	46	---
July (second half)	674	681
August (first half)	704	723
August (second half)	846	862
September (first half)	134	134
September (second half)	667	671
October (first half)	655	656
October (second half)	570	571
Other Major Activities		
Borrow Operating Capital	$151,455	$132,683
Buy Rye Seed, bushels	225	225
Pesticide Active Ingredients		
Fungicide, lbs. A.I.	1,223	1,458
Insecticide, lbs. A.I.	2,001	2,301
Herbicide, lbs. A.I.	625	625

A variety of field crop rotations could be raised on Long Island, but all would result in lower returns over variable costs than traditional cropping practices. If potato acreage was limited, the two most economically feasible field crop rotations on both Forks are: (1) A year of potatoes followed by a year of rye, and (2) a year of potatoes followed the next year by a double crop of winter wheat and soybeans. The potato/rye rotation would be raised on only a few acres of land to provide seed for the rye cover crop. The potato/double crop (winter wheat, soybean) rotation is the most feasible replacement for large amounts of potato acreage. But, potato growers are unlikely to raise these rotations unless there is legislation forcing them to raise less potatoes or they are subsidized for the resulting income loss.

When cole crop rotations were also considered in the linear programming model, returns were increased. Returns over variable costs were higher (six percent for the North Fork, 16 percent for the South Fork) for the optimal plan with nonrestricted potato acreage if 25 acres of the farm was planted in a potato/cauliflower rotation. Cauliflower tolerates low soil pH. Relatively large quantities of seasonal labor must be hired if more than a few acres of cauliflower are raised. If a substantial number of growers grew 25 acres of cauliflower, however, the price of cauliflower may be significantly reduced, an event that cannot be handled by the farm-level models constructed for this research.

The development of insect resistance to pesticides on Long Island potato fields has caused many problems. In the past, growers have been able to cope by using new and/or heavier applications of insecticides. In the future potato production costs or potato yields (and thus returns) might change due to insect resistance to available chemicals. It might become more expensive to control the Colorado potato beetle. A second scenario is that potato yields might decrease due to the insect problems, or conversely, potato yields in rotations might increase since there would be less pressure from potato pests if potatoes were raised less intensively. The optimal solution to the linear programming model is not very sensitive to these changes. The traditional rotations of continuous potatoes on the North Fork and two years of potatoes followed by a year of rye on the South remain the most economically feasible unless extreme changes would occur in potato returns or production costs.

The highest returns in the linear programming model resulted when some vegetable crop rotations with agronomic problems were considered. Potatoes/onions and potatoes/double crop (spinach, soybeans) had significantly higher returns over variable costs than the traditional potato cropping pattern. Spinach and onions require higher pH soils than potatoes. If potato varieties could be developed which are resistant to scab, these rotations become possible alternatives.

Markets for some of the crop alternatives discussed in this report would need to be developed. (Cauliflower has the advantage of having an already well developed market.) However, the marketing problems could perhaps be solved if substantial acreage of these crops were raised on Long Island.

Labor is a problem in the vegetable crop rotations. Many of the potato growers have little experience managing seasonal labor and do not want to have to deal with the extra management required to utilize migrant labor. But, some vegetable growers on Long Island do use migrant labor, so perhaps potato farmers should consider vegetable crop rotations as a possible alternative.

The results of this research suggest other rotations or markets which will be analyzed in the future. Some of these are as follows:

1) A potato-potato-corn rotation with a rye cover crop as an alternative to the traditional rotation of potato-potato-rye on the South Fork.

2) Markets for oats and straw to horse owners. Some relatively high prices for oats on Long Island have been reported, but the market is perhaps limited.

These analyses may show a greater potential for field crops in mitigating losses from rotations.

Crop rotation has the potential of being used on Long Island, along with other IPM practices, to help solve some of the potato pest problems. The rotations must be carefully chosen to avoid significant losses in farm income.

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APPENDIX A

Table A-1: Potato Budget

	Unit	Price	Quantity	North Fork[a] Continuous Potatoes	North Fork[a] Potato Rotation	South Fork Second Year of Potatoes	South Fork Potato Rotation
				Total			
Receipts:							
North Fork -							
90% size A, U.S. No. 1	cwt.	$5.30	286	$1,515.80	$1,515.80		
10% culls and size B	cwt.	2.50	31	77.50	77.50		
South Fork -							
90% size A, U.S. No. 1	cwt.	5.30	301			$1,595.30	$1,595.30
10% culls and size B	cwt.	2.50	33			82.50	82.50
Total Receipts				$1,593.30	$1,593.30	$1,677.80	$1,677.80
Expenses:							
Seed	lb.	.073	2,130	$ 155.49	$ 155.49	$ 155.49	$ 155.49
Fertilizer - Nitrogen	lb.	.32	N.F.-175;S.F.-175	56.00	56.00	56.00	56.00
Phospherous	lb.	.28	N.F.-300;S.F.-350	84.00	84.00	98.00	98.00
Potassium	lb.	.14	N.F.-175;S.F.-175	24.50	24.50	24.50	24.50
Chemicals - Fungicide				38.59	38.59	46.19	46.19
Insecticide				356.00	332.50	312.75	262.88
Herbicide				23.98	23.98	23.98	23.98
Machinery Variable Cost				96.95	94.49	61.00	58.54
Selected Variable Cost				$ 835.51	$ 809.55	$ 777.91	$ 725.58
Return over Selected Variable Costs				$ 757.79	$ 783.75	$ 899.89	$ 952.22

[a] irrigated

Table A-2: Rye Budget

	Unit	Price	Quantity	North Fork	South Fork	Cover Crop Only
				Total		
Receipts:						
North Fork	bu.	$2.80	34	$95.20		
South Fork	bu.	2.80	38		$106.40	
Cover Crop	bu.	2.80	0			$0.00
Expenses:						
Seed	bu.	(a)	1.5	(a)	(a)	(a)
Fertilizer - Nitrogen	lb.	.32	20	$ 6.40	$ 6.40	$ 0.00
Chemicals - Herbicide				.70	.70	0.00
Custom Combine				25.00	25.00	0.00
Machinery Variable Cost				5.69	5.69	2.73
Selected Variable Costs				$37.79	$37.79	$ 2.73
Return over Selected Variable Costs				$57.41	$68.61	$-2.73

(a)Seed expense was calculated in the linear programming model instead of the budget, since the farmer had the option of buying seed for $5.00 per bushel or raising his own (valued at $2.80 per bushel).

Table A-3: Corn Budget

	Unit	Price	Quantity	North Fork[a] Total	South Fork Total
Receipts:					
North Fork	bu.	$2.75	102[b]	$280.50	
South Fork	bu.	2.75	102[b]		$280.50
Expenses:					
Seed	25,000 seeds	17.20	1	$ 17.20	$ 17.20
Fertilizer - Nitrogen	lb.	.32	100	32.00	32.00
Phospherous	lb.	.28	50	14.00	14.00
Potassium	lb.	.14	50	7.00	7.00
Lime	ton	28.00	.5	14.00	14.00
Chemicals - Insecticide				.46	.46
Herbicide				12.65	12.65
Custom Machinery - Planting				5.00	5.00
Combining				40.00	40.00
Drying				30.00	30.00
Machinery Variable Cost				35.46	11.70
Selected Variable Costs				$207.77	$184.01
Return over Selected Variable Costs				$ 72.73	$ 96.49

[a] irrigated

[b] dry, shelled corn

Table A-4: Winter Wheat Budget

	Unit	Price	Quantity	North Fork Total	South Fork Total
Receipts:					
North Fork	bu.	$3.25	46	$148.50	
South Fork	bu.	3.25	51		$165.75
Expenses:					
Seed	bu.	8.70	3	$ 26.10	$ 26.10
Fertilizer - Nitrogen	lb.	.32	30	9.60	9.60
Phospherous	lb.	.28	30	8.40	8.40
Potassium	lb.	.16	30	4.80	4.80
Lime	ton	28.00	.25	7.00	7.00
Chemicals - Herbicide				.70	.70
Custom Combine				25.00	25.00
Machinery Variable Cost				5.69	5.69
Selected Variable Costs				$ 87.29	$ 87.29
Return over Selected Variable Costs				$ 62.21	$ 78.46

Table A-5: Soybean Budget

	Unit	Price	Quantity	North Fork	South Fork
				Total	
Receipts:					
North Fork	bu.	$ 6.10	26	$158.60	
South Fork	bu.	6.10	29		$176.90
Expenses:					
Seed	bu.	14.40	1.2	$ 17.30	$ 17.30
Fertilizer - Nitrogen	lb.	.32	10	3.20	3.20
Phospherous	lb.	.28	40	11.20	11.20
Potassium	lb.	.16	40	6.40	6.40
Lime	ton	28.00	.25	7.00	7.00
Chemicals - Herbicide				7.95	7.95
Custom Combine				25.00	25.00
Machinery Variable Cost				11.59	11.59
Selected Variable Costs				$ 89.64	$ 89.64
Return over Selected Variable Costs				$ 68.96	$ 87.26

Table A-6: Oats Budget

	Unit	Price	Quantity	North Fork Total	South Fork Total
Receipts:					
North Fork	bu.	$1.70	65	$110.50	
South Fork	bu.	1.70	72		$122.40
Expenses:					
Seed	bu.	5.50	3	$ 16.50	$ 16.50
Fertilizer - Nitrogen	lb.	.32	40	12.80	12.80
Phospherous	lb.	.28	35	9.80	9.80
Potassium	lb.	.16	35	5.60	5.60
Lime	ton	28.00	.25	7.00	7.00
Chemicals - Herbicide				.70	.70
Custom Combine				25.00	25.00
Machinery Variable Cost				9.77	9.77
Selected Variable Costs				$ 87.17	$ 87.17
Return over Selected Variable Costs				$ 23.33	$ 35.23

Table A-7: Sunflower Budget

	Unit	Price	Quantity	North Fork	South Fork
				Total	
Receipts:					
North Fork	cwt.	$10.40	16	$166.40	
South Fork	cwt.	10.40	18		$187.20
Expenses:					
Seed	lb.	1.32	6	$ 7.92	$ 7.92
Fertilizer - Nitrogen	lb.	.32	60	19.20	19.20
Phospherous	lb.	.28	20	5.60	5.60
Potassium	lb.	.16	20	3.20	3.20
Lime	ton	28.00	.25	7.00	7.00
Chemicals - Herbicide				14.65	14.65
Custom Machinery - Combine				25.00	25.00
Drying				12.48	14.00
Helicopter spraying				5.00	5.00
Machinery Variable Cost				9.04	9.04
Selected Variable Costs				$109.09	$110.61
Return over Selected Variable Costs				$ 57.31	$ 76.59

Table A-8: Dry Bean (Red Kidney) Budget

	Unit	Price	Quantity	North Fork Total	South Fork Total
Receipts:					
North Fork	cwt.	$21.60	13	$280.80	
South Fork	cwt.	21.60	14		$302.40
Expenses:					
Seed	lb.	.50	90	$ 45.00	$ 45.00
Fertilizer - Nitrogen	lb.	.32	25	8.00	8.00
Phospherous	lb.	.28	75	21.00	21.00
Potassium	lb.	.14	50	7.00	7.00
Lime	ton	28.00	.5	14.00	14.00
Chemicals - Fungicide				.46	.46
Insecticide				.23	.23
Herbicide				28.85	28.85
Custom Combine				30.00	30.00
Machinery Variable Cost				12.90	12.90
Selected Variable Costs				$167.44	$167.44
Return over Selected Variable Costs				$113.36	$134.96

Table A-9: Cauliflower Budget

	Unit	Price	Quantity	North Fork[a]	South Fork[a]
				Total	
Receipts:	cwt.	$19.30	150	$2,895.00	$2,895.00
Expenses:					
Plants	1,000	26.40	10	$ 264.00	$ 264.00
Fertilizer - Nitrogen	lb.	.32	160	51.20	51.20
Phospherous	lb.	.28	320	89.60	89.60
Potassium	lb.	.14	160	22.40	22.40
Lime (hydrated)	ton	122	.5	61.00	61.00
Chemicals - Insecticide				102.96	102.96
Herbicide				10.60	10.60
Fungicide				19.25	19.25
Containers		1.45	429	622.05	622.05
Machinery Variable Cost				73.71	78.89
Selected Variable Costs				$1,316.77	$1,321.95
Return over Selected Variable Costs				$1,578.23	$1,573.05

[a] irrigated

Table A-10: Cabbage Budget

	Unit	Price	Quantity	North Fork[a] Total	South Fork[a] Total
Receipts:	cwt.	$8.20	257	$2,107.40	$2,107.40
Expenses:					
Plants	100	1.40	150	$ 210.00	$ 210.00
Fertilizer - Nitrogen	lb.	.32	150	48.00	48.00
Phospherous	lb.	.28	100	28.00	28.00
Potassium	lb.	.14	100	14.00	14.00
Lime (hydrated)	ton	122	.50	61.00	61.00
Chemicals - Fungicide				40.92	40.92
Insecticide				75.51	75.51
Herbicide				30.15	30.15
Crates		1.20	514	616.80	616.80
Machinery Variable Cost				83.88	89.06
Selected Variable Costs				$1,208.26	$1,213.44
Return over Selected Variable Costs				$ 899.14	$ 893.96

[a] irrigated

Table A-11: Onion Budget

	Unit	Price	Quantity	North Fork[a]	South Fork[a]
				Total	
Receipts:	cwt.	$ 9.65	175	$1,688.75	$1,688.75
Expenses:					
Seed	lb.	15.00	2.5	$ 37.50	$ 37.50
Fertilizer - Nitrogen	lb.	.32	100	32.00	32.00
Phospherous	lb.	.28	100	28.00	28.00
Potassium	lb.	.14	100	14.00	14.00
Lime	ton	28.00	1	28.00	28.00
Chemicals - Fungicide				13.86	13.86
Insecticide				2.39	2.39
Herbicide				23.20	23.20
Bags		.35	350	122.50	122.50
Machinery Variable Cost				53.61	57.06
Selected Variable Costs				$ 355.06	$ 358.51
Return over Selected Variable Costs				$1,333.69	$1,330.24

[a] irrigated

Table A-12: Spinach Budget

	Unit	Price	Quantity	North Fork[a] Total	South Fork[a] Total
Receipts:	cwt.	$22.90	80	$1,832.00	$1,832.00
Expenses:					
Seed	lb.	25.00	5	$ 125.00	$ 125.00
Fertilizer – Nitrogen	lb.	.32	150	48.00	48.00
Phospherous	lb.	.28	100	28.00	28.00
Potassium	lb.	.14	100	14.00	14.00
Lime	ton	28.00	.5	14.00	14.00
Chemicals – Fungicide				3.06	3.06
Insecticide				12.59	12.59
Packing Boxes		.85	160	136.00	136.00
Cooling		.30	160	48.00	48.00
Machinery Variable Cost				50.61	54.06
Selected Variable Costs				$ 479.26	$ 482.71
Return over Selected Variable Costs				$1,352.74	$1,349.29

[a] irrigated

Table A-13: Machinery Complement for Potato Production

Machine	New Cost	Speed (mph)	Field Efficiency
Tractor 60 hp	$17,900	--	--
Tractor 100 hp	36,300	--	--
Rollover plow with Clodbuster, 4-16" bottoms	9,500	4.0	.8
Sprayer, 48' boom	13,500	4.5	.5
Potato cultivator, 4 row	2,400	4.0	.8
Potato planter, 4 row	15,000	4.0	.65
2 big gun irrigation sets (80A)	44,000	--	--
Disk harrow, 13'	4,950	5.0	.8
Potato harvester, 2 row	31,000	2.0	.6
3 bulk bodies, 18'	13,500	--	--
Seed cutter	4,000	--	--
Grain drill, 18 x 7	5,100	4.0	.7
Precision seeder, 4 row	2,900	2.0	.8
Transplanter, 4 row	2,400	1.0	.7
2 wagons	5,000	--	--

Table A-14: Distribution of Annual Labor Needs by Semi-Monthly Time Periods

	March		April		May		June		July		August		September		October		November	
	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
	--hours--																	
Potatoes:																		
North Fork - Continuous		.98	.98	1.1	.10	.10	.42	1.33	1.11	1.11	1.95	1.95	.84	.84	.84	.84		
Rotation		.98	.98	1.1	.10	.10	.22	1.33	1.11	1.11	1.95	1.95	.84	.84	.84	.84		
South Fork - 2nd year		.98	.98	1.1	.10	.10	.42	.42	.20	.20	1.03	1.03	.84	.84	.84	.84		
Rotation		.98	.98	1.1	.10	.10	.22	.42	.20	.20	1.03	1.03	.84	.84	.84	.84		
Rye									.17	.17			.14	.14	.14	.14		
Rye Cover Crop													.12	.12	.12	.12		
Soybeans									1.07		.14	.14			.17	.17		
Winter Wheat								.34						.09	.29	.20		
Corn - North Fork				.22	.42	.20	.03		.91	.91	.91	.91			.26	.26		
South Fork				.22	.42	.20	.03								.26	.26		
Oats		.22	.42	.20					.11	.11	.11							
Dry Beans (Red Kidney)					.14	.46	.46	.18	.18	.03			.17	.17				
Sunflowers				.14	.24	.24	.1							.17	.17			
Cauliflower - North Fork								.22	1.6	2.29	2.2	7.89	10.9	32.24	31.33	27.94	8.34	2.12
South Fork								.22	1.6	2.4	2.42	8.0	11.01	32.35	31.33	27.94	8.34	2.12
Cabbage - North Fork							1.5	2.5	1.29	7.98	7.98	1.38	38.78	33.53	33.44			
- South Fork							1.5	2.62	1.4	8.08	8.08	1.49	39.89	33.53	33.44			
Onions - North Fork			.22	.22	.37	3.67	4.59	4.59	4.5	32.81	31.9	31.9						
- South Fork			.22	.22	.37	3.67	4.7	4.7	4.61	32.92	31.9	31.9						
Spinach - North Fork		.44	8.23	7.89	27.75	27.18	26.18											
South Fork		.44	8.35	8.0	28.08	27.29	26.18											