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A COMPARISON OF COSTS IN HARVESTING POTATOES BY HAND PICKING AND MACHINE PICKING

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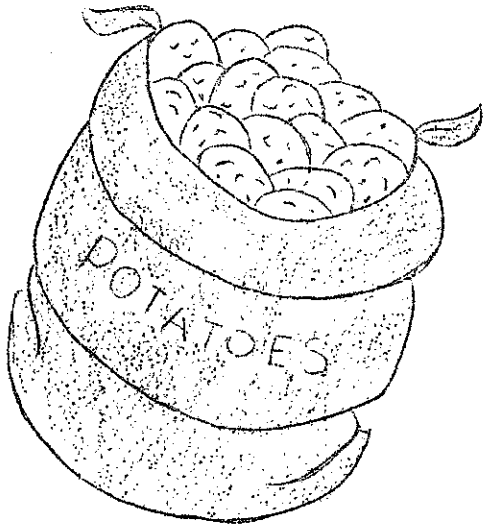

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SUMMARY

1. To help potato growers evaluate potential savings from machine harvesting information was obtained on the 1954 harvesting operations on 23 New York potato farms. This included eight Long Island farms using machine harvesting, eight Long Island farms using hand harvesting, and seven upstate farms using machine harvesting.

2. The Long Island growers harvesting by machine all used direct harvesting and bulk handling. A variety of combinations of machines and equipment was used on the upstate farms. On most upstate operations studied bulk handling was not used.

3. Producers hand picking had an average investment of $628 in harvesting equipment while Long Island growers machine harvesting had an average investment of $5,033 in harvesting equipment.

4. Harvesting equipment costs averaged $1,600 per year in Long Island machine harvesting operations compared to $908 upstate and $251 on Long Island hand picking operations.

5. Long Island farmers machine harvesting had costs of harvesting and hauling 4.6 cents per bushel below costs on Long Island farms hand picking.

6. Savings in labor costs more than compensated for increased machinery costs on the Long Island farms studied.

7. The illustrations used indicate that farmers raising 13,000 bushels of potatoes or less may be able to efficiently use machine harvesting and bulk handling.

8. Producers using machine harvesting reported a reduction in the quantity of damaged potatoes.

9. A reduced dependence on a large labor force at harvest time is an important advantage of machine harvesting.

10. Vines in early digging are a major difficulty in machine harvesting.

11. With direct harvesting potatoes may be somewhat less bright in appearance unless washed or brushed.

INTRODUCTION

Since the beginning of World War II producers of agricultural products have experienced increasing costs of production. Labor costs have increased more rapidly than costs of other factors of production. Also many growers have found adequate farm help difficult to obtain. In this situation farmers have turned to mechanization as a substitute for labor and to obtain greater production per farm worker and lower production costs. This trend has been observed in most types of farming and in all parts of the United States. Potato growers, with a high seasonal need for farm labor at harvest time, have sought means of reducing their labor requirements and reducing labor costs. Machine harvesting of potatoes by the use of the "potato combine" is one means they have used to accomplish this.

Potato "combine" harvesting machines, developed mostly during the last decade, dig the potatoes, elevate them to belts or chains where refuse is removed as the potatoes go past, and then transport them by belt or chain to drop in a bulk truck body driving along side. The harvester is pulled by a tractor and includes its own power plant for operating the belts and chains. Some operators dig the potatoes first with a conventional digger, winrowing 2 or 4 rows together, to be picked up by the harvester. This is known as indirect harvesting. Others, dig the potatoes as they are harvested, the direct method. Some who harvest by machine bag the potatoes on the harvester and pass the bags to a truck along side or drop them on the ground.

Purpose of the Study

Some New York potato growers have adopted the new harvesting practices. Others have asked how adopting the new practices might effect their costs and the quality of their potatoes. This study was conducted to help farmers evaluate alternative harvesting and handling methods by summarizing the experiences of a group of farmers who have adopted machine harvesting and other farmers using hand picking methods. The study is concerned primarily with comparing costs of harvesting and handling potatoes when harvesting by machine and by hand.

The Methods Used

Data were obtained by the survey method from twenty-three farmers during the winter of 1954. The data presented in this summary are the farmers' estimates of harvesting and handling costs, sometimes taken in part from financial records, but more generally from the farmer's memory of his 1954 harvesting operation.

Data were obtained on eight farms on Long Island using machine harvesting methods. Data were obtained also on seven farms in Upstate New York Using machine harvesting methods. This is approximately half of the farms in New York using these harvesting methods. For comparison, information was obtained from eight Long Island farms using hand picking. This of course is a small percentage of the farms on Long Island using

this harvesting method. Since there is relatively little variability in costs among those farms using hand harvesting methods on Long Island the sample of eight farms is thought to give fairly representative data.

THE FARMS STUDIED

The eight Long Island farms harvesting potatoes by hand averaged 82 acres of potatoes per farm. The largest enterprise was 140 acres while the smallest enterprise in the sample was 40 acres of potatoes. Yields reported on these farms ranged from 425 bushels to 500 bushels with an average of 462 bushels. On these farms either migrant labor or local labor was employed to pick up the potatoes and were paid on a piece-work basis. In general the farmers paid $.08 a bushel to have the potatoes picked and sacked. This included compensation for supervision of the crew by the crew leader. On most farms the sacks were loaded on trucks and hauled either to storage or the buying station by the farmers and his regular farm help. In some cases the farmer contracted with the crew of migrant workers to perform these services also for an additional cost.

TABLE 1 POTATO ACREAGE AND YIELDS ON SAMPLE FARMS

	Acres harvested			Bushels per acre			Number of farms
	Average	High	Low	Average	High	Low	
Hand picking, (L. I.)	82	140	40	462	500 425	425	8
Harvester							
Long Island	116	190	75	435	476 375	375	8
Upstate	75	330	20	499	691 350	350	7

The Long Island farms using mechanical harvesters, harvested from 75 to 190 acres by machine in 1954 with an average of 116 acres per farm, some farms had an additional acreage which was harvested by hand. Yields on these farms ranged from 375 to 476 bushels with an average of 435. The upstate farms using machine harvesting had a much wider range in size and of type of potato enterprise, ranging from 20 to 330 acres harvested by machine and averaging 75. Their yields also covered a greater range, from 350 to 691 bushels per acre with an average of 499. These farms were of a variety of types. They included specialized potato farms, general farms with potatoes as one enterprise, farms on mineral soil and farms on muck.

Harvesting Equipment Used

The Long Island potato farmers harvesting by machine had similar combinations of equipment. All used direct harvesting methods. All farmers handled the potatoes in bulk bodies on trucks or wagons. Seven of the eight farmers had two-row machines. To haul potatoes to storage or to the buyer six of the eight used three trucks with bulk bodies. These bodies, removed after potato harvest, are equipped with unloading devices. The grower with a one-row machine used two trucks, and one grower used a combination of trucks and wagons with bulk bodies. In all cases the average distance the potatoes were hauled from the field was less than four miles. The harvesters used were of several makes, including homemade machines, and early commerical models modified by the owner.

TABLE 2 HARVESTER TYPE AND HAULING EQUIPMENT USED

Farm Number	Acres harvested by machine	Harvester type	Hauling Equipment
8 Long Island farms			
2	110	2 row, direct, bulk	3 trucks with bulk bodies
3	80	2 row, direct, bulk	3 trucks with bulk bodies
6	75	2 row, direct, bulk	3 trucks with bulk bodies
7	110	2 row, direct, bulk	1 truck with bulk body 3 wagons with bulk bodies
8	96	1 row, direct, bulk	2 trucks with bulk bodies
9	190	2 row, direct, bulk	3 trucks with bulk bodies
10	170	2 row, direct, bulk	3 trucks with bulk bodies
11	100	2 row, direct, bulk	3 trucks with bulk bodies
Upstate			
1	35	1 row, direct, bags	1 truck
4	50	1 row, direct, bulk	3 wagons with bulk bodies
5	30	1 row, direct, bags	2 wagons
12	330	2 row, indirect, bags	4 trucks with bulk bodies
13	20	1 row, direct, bags	4 wagons
14	23	1 row, direct, bags	4 wagons
15	35	1 row, direct, bags	2 trucks

All but one of the upstate farms studied used one-row direct[1/] machines. One used a two-row indirect[2/] machine. Only two of these seven farmers handled potatoes in bulk, the others using bags and baskets. A variety of wagons and trucks were used for hauling.

1/ Direct machine -- digs and loads potatoes in one operation.
2/ Indirect machine -- follows a digger and picks up the potatoes.

Farmers using hand picking used a number of makes of diggers and hauled bagged potatoes by truck.

All farmers killed the vines before digging, generally using a combination of chemical vine killers and beaters.

Size of Crew and Harvesting Rates

Potato producers interested in machine harvesting have asked how rapidly potatoes can be harvested by machine. Table 3 presents information from the eight Long Island farms machine harvesting. These farmers harvested and hauled an average of from 1,700 bushel to 3,250 bushels per day. The most common rate was about 2,500 bushels per day. The labor force varied from 6 to 12 workers, depending on digging conditions, whether potatoes were going into storage or to the buyer, and other factors.

TABLE 3 SIZE OF HARVESTING CREW AND HARVESTING RATES, EIGHT LONG ISLAND FARMS MACHINE HARVESTING

Farm Number	Average Number of workers in harvesting crew	Number of bushels harvested by machine	Average number of bushels harvested per 9 - 10 hour day
2	8 to 11	50,000	2500
3	7	30,000	1700
6	10	35,625	2500
7	7	44,000	2200
8	6 - 7	38,400	2250
9	9 -12	90,440	3250
10	8	72,240	2600
11	8 - 9	47,500	2375

HARVESTING COSTS

Cost Items Included

Cost data presented in this report are estimates of costs starting with digging and including transportation to the storage and labor costs in unloading. It includes all labor, machinery and equipment costs in performing the operations of digging and transporting the potatoes. It does not include costs of the vine killing or equipment used in the storage. On Long Island a proportion of the potatoes are delivered to the farmer's storage and unloaded there by his labor force, while part of the potatoes are trucked to the buying station and there unloaded by the buyer. In these cases, costs of the services performed by the grower are estimated. All of the Upstate New York farmers unloaded the

potatoes with their labor force. These estimates for both machine harvesting and hand harvesting, therefore, include some but not all of the labor in unloading. Farmers made detailed estimates of costs of using specialized potato harvesting equipment -- diggers, harvesters, special truck bodies, baskets, and bags. The producers estimated the number of hours of use for tractors and trucks. Charges determined by cost accounts on other farms were used in determining cost in using trucks and tractors. The hourly or per mile rates used dependent upon the size and type of equipment as well as the amount of annual use.

Equipment Investment

A shift from hand harvesting to mechanical harvesting requires considerable additional investment in harvesters and truck or wagon bodies for bulk handling. On the farms using hand picking the current value of harvesting machines averages $628. The high was $1,170 and on the farm with the lowest investment the equipment was considered to be completely depreciated. The investment in harvesting equipment on these farms averaged $11 per acre. The original costs of this equipment averaged $927 and ranged form $550 to $1,900.

TABLE 4 INVESTMENT IN POTATO HARVESTING EQUIPMENT 1/

	Total investment			Investment per acre			Your farm
	Average	High	Low	Average	High	Low	
Hand picking	$ 628	$1,170	2/	$11	$27	2/	_____
Machine picking							
Long Island	$5,033	$8,145	$1,280	$46	$81	$17	_____
Upstate	$1,968	$4,607	$ 274	$42	$91	$13	_____

1/ Includes diggers, harvesters, truck and wagon bodies and unloading devices, but does not include trucks, tractors, wagons, beaters, and equipment for handling potatoes in storage.

2/ Equipment fully depreciated.

On the Long Island farms using machine harvesting the current value of potato harvesting equipment averaged $5,033. One farmer had an investment in harvester and truck bodies of only $1,280 while another farmer considered the current value of his equipment to be $8,145. The original cost of this equipment ranged form $3,050 to $8,550 depending on the size and type of equipment purchased. The farmer with the lowest original cost had a homemade harvester. In this and other similar cases the investment reported may not include full value of the farm labor used in equipment construction.

The upstate harvesting operations included a greater variety of type and size of equipment, including older machines and elevator attachments for standard diggers. The equipment investment on all but two of these farms does not include an investment in special truck or wagon bodies. One of the farmers handling the potatoes in bulk used special wagon bodies in which his investment was small. On these farms the average investment in specialized harvesting equipment was $1,968 ranging from $274 to $4,607.

Machinery Operating Costs

Producers were asked to estimate the annual costs of operating each of their potato harvesting machines. One of the major costs of owning and operating this machinery is depreciation. Each grower's estimate of depreciation was used in computing these costs. The Long Island farmers estimated that potato diggers should be depreciated over an average of nine years. All farmers but one depreciated diggers at the rate of 10% per year.

There was some uncertainty among these growers concerning the appropriate rate of depreciation for mechanical harvesters. In many repsects these machines are similar to diggers and probably should be depreciated at a comparable rate. However, many felt that obsolescence is likely to be very important in determining the rate of depreciation because harvesters are a recent development and likely to be improved as later models are developed. Long Island and upstate growers using harvesters were equally divided between a five year and a ten year depreciation rate. Truck bodies were thought to have a somewhat longer life. The average of the farmers' estimates was that truck bodies should be depreciated over a thirteen year period. The farmers ranged in their estimates from ten to twenty years.

Interest was charged at 5% on the current depreciated value of the harvesting equipment.

TABLE 5 ANNUAL COST OF OWNING AND USING HARVESTING EQUIPMENT

	Depreciation[1/]	Interest[2/]	Repairs	Other	Total
Hand picking, L. I.	$ 89	$ 32	$115	$ 16	$ 251
Machine picking					
Long Island	$735	$247	$453	$168	$1603
Upstate	$586	$ 87	$116	$ 84	$ 908

1/ The farmer's estimates of depreciation were used.

2/ Interest was computed at 5% of current value of equipment

In both types of harvesting operations the major repairs were new digger chains. Repairs average $115 per farm on the farms where potatoes were picked by hand, $453 on the Long Island farms using machine harvesting and $116 on the upstate farms using machine harvesting.

Other operating costs included charges for gas and oil used by harvesters and charges for use of buildings for housing the equipment. Gas and oil costs were estimated on the basis of the number of hours the machine was used and the horsepower of the engine. Housing costs were based on charges used for other equipment on cost accout farms.

The Long Island farms machine harvesting had annual costs of owning and operating harvesting equipment of about $1,603 compared to $908 on the upstate farms and $251 on the Long Island farms hand harvesting.

Average Cost Per Acre and Per Bushel

When potatoes were hand picked on Long Island the use of harvesting machinery cost an average of $3.51 per acre or .8 of a cent per bushel. This compared with $14.59 per acre and 3.4 cent per bushel for machinery costs on Long Island farms using machine harvesting. When machinery was substituted for labor on these farms, machinery costs increased by about 2.6 cents per bushel.

While the bags used harvesting potatoes by hand are mostly used fertilizer sacks, their use does represent a cost. Fertilizer can be obtained somewhat cheaper when the sacks are returned. Farmers using hand picking also have a small cost for baskets. The upstate farmers using machine harvesting continued to have a cost for bags since most of them were not handling potatoes in bulk. The bag and basket cost averaged $1.76 an acre on Long Island or about .3 of a cent per bushel.

On Long Island the use of tractors and trucks, to pull harvesting equipment and to haul potatoes, costs about the same whether potatoes were harvested by machine or by hand. Use of trucks cost about .4 of a cent per bushel and tractors and wagons cost about .2 of a cent per bushel.

The greatest difference between the Long Island farms harvesting by hand and by machine was in labor costs. Labor in digging, picking, hauling and unloading averaged 10.2 cents a bushel on the farms where hand picking was used and 3.3 cents per bushel on the farms using machine harvesting methods. Upstate New York the labor cost by machine harvesting was somewhat higher than on the Island, averaging 6.4 per bushel.

On the Long Island farms using machine harvesting the reduction in cost of labor, bags and baskets more than compensated for the increase in machinery costs, resulting in a net saving of 4.6 cents per bushel.

The upstate farms in general haul their potatoes greater distances, use harvesting machines with smaller capacity and bag their potatoes. On a per bushel basis their harvesting machinery costs were equal to the Long Island machine harvesting operations but their truck, tractor and labor costs were somewhat higher, resulting in a total cost per bushel averaging 11.3 cents.

TABLE 6 COSTS IN HARVESTING AND HAULING POTATOES

	Hand picking Long Island	Machine picking Long Island	Machine picking Upstate	Your farm
	Average cost per acre harvested			
Harvesting machines	$ 3.51	$14.59	$17.55	
Bags and baskets	1.76	--	1.14	
Use of tractors	1.78	1.92	4.20	
Use of trucks and wagons	1.32	.98	2.61	
Labor, digging, picking and hauling	46.40	14.37	31.29	
Total	$54.77	$31.86	$56.79	
	Average cost per bushel harvested			
Harvesting machines	.8	3.4	3.4	
Bags and baskets	.3	--	.2	
Use of tractors	.4	.4	.8	
Use of trucks and wagons	.2	.2	.5	
Labor, digging, picking and hauling	10.2	3.3	6.4	
Total	11.9	7.3	11.3	

Variations in Cost per Bushel

The variation in cost among farms on Long Island harvesting potatoes by hand was relatively small. Similar methods were used by all the farms studied and there were only minor variations in labor costs. The per bushel cost of labor varied somewhat because of differences in the estimated quantity of labor used in hauling, loading and unloading the potatoes and only slightly because of wage rates. Per bushel costs for use of equipment varied somewhat because of differences in investment, depreciation rates, and repairs. There was little variation among these farms in the number of hours of tractor use in harvesting potatoes. Tractor cost varied mainly because of differences in the rates applied, depending upon tractor size and the amount of annual use. The per bushel cost for the use of trucks and wagons also varied because of differences in the type of equipment, it's annual use and differences in the distance potatoes were hauled.

In the machine picking operations equipment cost per bushel varied mainly because of the size of the investment, the depreciation rates used, amount of repairs and the number of bushels handled.

In estimating labor costs, estimates were made of the typical or average size of crew represenative of the season's operation. On each farm, particularly on Long Island, the size of the harvesting crew varied considerably within the season. In early season the vines were generally killed one or two days before harvesting. Under these conditions the

TABLE 7 RANGES IN COST PER BUSHEL FOR EQUIPMENT, LABOR TRUCK AND TRACTOR

	Average	High	Low
Harvesting equipment			
Hand picking, L. I.	.8	1.3	.5
Machine picking			
Long Island	3.4	5.8	1.7
Upstate	3.4	6.3	1.8
Labor, digging, picking, hauling			
Hand picking, L. I.	10.2	12.0	9.0
Machine picking			
Long Island	3.3	4.8	1.7
Upstate	6.4	8.3	4.0
Tractor Costs			
Hand picking, L. I.	.4	.6	.3
Machine picking			
Long Island	.4	.9	.2
Upstate	.8	1.6	.2
Truck and wagon costs			
Hand picking, L. I.	.2	.8	.2
Machine picking			
Long Island	.2	.5	.1
Upstate	.5	1.8	.05

tubers cling to the roots and vines and it is necessary to use a somewhat larger crew to remove by hand considerable trash and to separate potatoes from the vines. In late season on Long Island, after the potatoes have been dead and ridged for sometime, the potatoes separate easily from the stems and a somewhat smaller harvesting crew is required than earlier in the season. Typically three or four additional workers are required for early season digging as compared to later in the season. Also at some times during the season lumps of dirt may cause difficulty and require a larger picking crew. The time during the season and digging conditions, therefore, are major factors determining labor costs in machine harvesting. Those farmers harvesting a high proportion of their crop early can expect a somewhat higher average labor cost than those digging a higher proportion of their crop later in the season. The average labor cost presented also varied to some extent because of the variable amount of unloading labor included.

TABLE 8 VARIATION IN HARVESTING COSTS

Farm Number	Acres Harvested by Machine	Current Value of harvesting Equipment	Man Hours Per 1000 bushels	Cost Per Bushel			
				Harvesting Machines	Labor	Tractor, Truck, Other	Total Harvesting and Hauling Costs
Long Island Farms Machine Harvesting							
2	110	$6870	25	4.5	2.7	.8	8.0
3	80	6880	42	5.9	4.5	1.2	11.6
6	75	1280	41	2.2	4.9	.6	7.7
7	110	3950	29	3.4	3.1	1.0	7.5
8	96	3578	21	2.6	2.2	.5	5.3
9	190	5200	33	1.7	3.5	.4	5.6
10	170	4360	16	2.6	1.7	.4	4.7
11	100	8145	30	4.3	3.7	.5	8.6
Upstate Farms Machine Harvesting							
1	35	$1450	54	3.1	6.0	1.3	10.3
4	50	1705	74	2.2	8.0	1.6	11.8
5	30	560	73	5.2	6.5	.8	12.4
12	330	4607	41	2.0	4.4	1.5	7.9
13	20	274	70	1.8	7.7	1.7	11.2
14	23	2100	34	3.4	4.1	1.1	8.5
15	35	3080	81	6.3	8.3	3.1	17.7
Long Island, Hand Picking							
21	45	630	—	1.1	9.1	1.5	11.6
22	140	990	—	.5	12.0	.8	13.3
23	130	1170	—	.8	9.2	1.1	11.1
24	40	106	—	.8	9.3	.8	10.9
25	75	700	—	.8	9.3	.9	11.0
26	65	665	—	.7	12.0	.8	13.5
27	28	760	—	1.3	9.5	1.0	11.8
28	130	0	—	.3	11.2	1.2	12.7

When we look at costs on individual farms we observe some interesting cost relationships. Among the Long Island machine harvesting operations farm number 9 had the lowest per bushel cost for equipment. Investment in equipment was considerably above average but the acreage harvested was high, making possible a low per bushel cost. Production per man hour was about average. In total the per bushel cost on this farm was one of the lowest.

Farm number 10 had the lowest per bushel harvesting cost. This farm had the most efficient use of labor combined with about average investment in machinery and a large acreage of potatoes.

The Long Island farm with the lowest equipment investment had the second lowest equipment cost per bushel, a higher than average labor cost, and an average total cost per bushel.

Among the upstate machine harvesting operations the one with the lowest cost per bushel (farm number 12) had the largest acreage and a low equipment cost per bushel.

The data presented in table 8 indicate that in machine harvesting machinery costs per bushel depend to a considerable extent on the size of the enterprise and on machinery investment. Labor productivity and costs vary considerably among the farms machine harvesting but labor costs per bushel on all farms machine harvesting are below even the most efficient farm hand picking.

These data indicate also that the upstate farmers machine harvesting and bagging potatoes might gain in labor efficiency by bulk handling.

ESTIMATING COSTS ON OTHER FARMS

Whether an individual farmer can profit by adopting machine harvesting depends on a number of conditions. The suitability of this machinery for his farm depends in part on the soil type, the number and size of stones, and the topography of the land. The Upstate New York farmers using potato combines were mostly located on rather light soils with few stones and rather level topography, or on muck. The Long Island farmers using machine harvesting, all on level land, had the several soil types common in eastern Suffolk County. Generally there are few stones in these soils. Other conditions determining the suitability of this equipment are the size of the potato enterprise, the labor force available and the capital available for investment in harvesting equipment.

In evaluating the costs one should consider that by mechanizing the harvesting operation he is, to a considerable extent, substituting machinery costs --- depreciation, interest, repairs, and etc. --- for labor costs. In hand harvesting operations labor accounts for about 80% of total harvesting costs and harvesting costs per bushel tend to be affected relatively little by size of enterprise. On the eight Long Island farms using machine harvesting about 1/3 of the harvesting costs consisted of the relatively fixed costs of depreciation and interest. Total harvesting cost per bushel is likely to be affected more by the size of enterprise when machine harvesting is used.

Table 9 is presented to help a grower determine the cost of machine harvesting on his farm.

In table 9 three situations have been assumed -- a farm with 75 acres of potatoes, one with 50 acres and one with 30 acres of potatoes using direct harvesting and bulk handling. Cost data from the average of the eight Long Island farms using machine harvesting have been projected to these situations. This projection may be useful to a potato grower who wishes to estimate costs on his farm.

In computing costs in these situations we have assumed each farm had a yield per acre equal to the average on the eight Long Island farms. We have also assumed that each of these farms had the same investment in specialized potato harvesting equipment, an investment equal to the average on these eight farms. In reality this probably is not a realistic assumption. The eight Long Island farms using machine harvesting were large enterprises and in most cases two-row harvesters were used. With smaller enterprises farmers could reduce their investment in machinery by using one-row machines. They might also be able to operate efficiently with less than three bulk bodies for transporting potatoes. Also in the smaller enterprises it is not likely that the farmers would have three trucks available on which to mount bulk bodies. In such cases greater use might be made of wagons or trailers and neighboring farmers might "pool" some of their equipment for hauling potatoes. This too, would affect machinery investment. Among the farms studied there was considerable variation in machinery investment, some farms using home-made truck bodies, homemade harvesters and used equipment in order to reduce machinery investment. Probably the first step in estimating your costs should be to determine the machinery investment you will require.

Machinery Costs

In our illustration we have indicated charges for depreciation and interest as being the same in the different sizes of enterprise. As indicated above a farmer may be able to obtain the necessary equipment for machine harvesting with a lower investment than the average for these farms. This would affect both depreciation and interest charges.

We have applied the same rate of depreciation on all sizes of enterprises. The average rate for the eight Long Island farms with harvesters was $7\frac{1}{2}$ years for harvesters and 13 years for truck bodies. One may question whether depreciation is due more to obsolescence or to use. If obsolescence in harvesters, due to improvements in design, is the more important factor, probably the same rate of depreciation should be used on all farms. If use is the more important consideration in determining depreciation then depreciation should be smaller on the smaller enterprises. You may wish to compute depreciation at some rates other than the rates used in table 9.

Interest had been computed at the rate of 5% on the current value of the harvesting equipment. This is a rate commonly paid by farmers for borrowed capital and seems appropriate for this purpose. However, you may wish to use some other interest rate, depending on returns you can receive from other uses of your capital.

TABLE 9 ESTIMATED COSTS OF HARVESTING MACHINERY AND LABOR USED IN HARVESTING AND HAULING ON SAMPLE LONG ISLAND FARMS AND THREE HYPOTHETICAL FARMS.

	Average of eight Long Island farms hand picking	Average of eight Long Island farms machine picking	Estimated costs on Hypothetical farms machine picking			Your farm
			75 acres potatoes	50 acres potatoes	30 acres potatoes	
Number of acres, harvested	82	116	75	50	30	
Yield per acre, bushels	462	435	435	435	435	
Number of bushels harvested	37,046	50,460	32,625	21,750	13,050	
Investment in harvesting machinery	$ 628	$5,033	$5,033	$5,033	$5,033	
Harvesting machinery costs			Total cost per farm			
Depreciation	$ 89	$ 735	$ 735	$ 735	$ 735	
Interest	32	247	247	247	247	
Repairs	115	453	293	195	117	
Other	16	168	108	72	43	
Total	$ 251	$1,603	$1,383	$1,249	$1,142	
Labor costs	$3,782	$1,597	$1,032	$ 688	$ 413	
Bags and baskets	126	—	—	—	—	
Tractor costs	1/					
Truck costs	1/					
Total harvesting machines and labor	$4,159	$3,200	$2,415	$2,415	$1,555	
Harvesting machinery costs			Average cost per bushel, cents			
Depreciation	.2	1.6	2.3	3.4	5.6	
Interest	.1	.6	.8	1.1	1.9	
Repairs	.4	.9	.9	.9	.9	
Other	.1	.3	.3	.3	.3	
Total	.8	3.4	4.3	5.7	8.7	
Labor costs	10.2	3.3	3.2	3.2	3.2	
Bags and baskets	.3	—				
Tractor costs	1/					
Truck costs	1/					
Total harvesting machines and labor	11.3	6.7	7.5	8.9	11.9	

1/ Tractor and truck costs were not projected in these illustrations because they will not be affected greatly by a change from hand picking to direct harvesting.

Repairs to harvesting equipment consisted largely of new digger chains. Repair costs may vary with soil type, the care of the machine and other factors. In these illustrations repair costs have been assumed to be proportionate to the number of acres harvested. Experience with potato diggers may provide a guide to indicate frequency with which replacements must be made.

Other machinery costs in these illustrations have been assumed to vary proportionately with the acreage harvested. These costs consist of gas and oil, the cost of housing machinery and other minor costs.

Labor Costs

On the eight Long Island farms, hired labor was charged at the rate the farmer paid. Most of the farmers reported a wage rate of $1.00 per hour. The value of the farm operator's time was charged at the arbitrary rate of $1.50 per hour. The quantity of labor used averaged 30 man hours per thousand bushels on the eight Long Island farms machine harvesting and ranged from 16 hours to 42 hours per thousand bushels. In the three case illustration the cost per bushel for labor has been assumed to be the same on large and small enterprises. In estimates for your farm you may wish to estimate that you will use more or less labor than average depending on conditions at your usual harvest time, unloading facilities, etc.

Other Costs

When a farmer switches to direct machine harvesting his costs for tractor operation should change little, since under the new method it is necessary to pull the harvester and under the old method it is necessary to pull the digger, about the same area is covered at about the same speed. Also hauling costs are not greatly affected by this change in harvesting methods, since the change in harvesting methods does not effect the distance the potatoes are hauled and does not substantially effect the quantity hauled per load. Therefore, these costs have been left out in these illustrative cases where we are comparing harvesting and hauling costs on different sizes of enterprise. Likewise the farmer who is estimating the effect of a new practice on his business can expect that these costs will be effected little by adopting the new method.

Illustrations

In the cases presented in table 9, as the size of the potato enterprise decreased the per bushel cost of harvesting increased, due to the fixed cost items of depreciation and interest. The farm with 30 acres and 13,000 bushels of potatoes had a per bushel cost of harvesting about equal to that on the eight Long Island farms using hand picking methods. As was pointed out above such a farmer, in reality, could reduce his investment in harvesting machines below the average of these eight Long Island farms and could have lower cost for depreciation and interest. On a farm with a potato enterprise of 30 acres or smaller it

seems possible to use machine harvesting methods with costs no larger than those incurred when hand picking methods are used. However, when farmers with smaller enterprises consider the adoption of machine harvesting methods they must be particularly careful with investment in machinery, if harvesting costs are to be maintained at a low level.

EXPERIENCES OF FARMERS MACHINE HARVESTING

Operating costs as presented in this publication are only one factor affecting the farmer's decision on harvesting methods. Potato growers who have considered the adoption of the new practices have questioned the effect of these practices on potato quality -- on the quantity of cuts and bruises inflicted in the harvesting and handling operations. Any increase in the quantity of damaged potatoes would represent an increased cost of harvesting, while any improvement in potato quality would contribute to a lower cost of potato harvesting. Other important considerations are the availability of labor, difficulties in supervising labor crews, the timeliness of harvesting and the ability of the farmer and his help to use and maintain mechanical equipment. No data were obtained on these questions in this study. We did ask the farmers for information on their experiences and observations.

Cuts and Bruises

Of the fifteen farmers using machine harvesting there was only one who said he had experienced more cuts and bruises than when he previously used hand picking methods. Practically all the farmers said that the number of cuts and bruises had been reduced. One who had data comparing his experience during two seasons reported that by machine harvesting he obtained a 10% reduction in the number of potatoes out of grade because of cuts and bruises. Growers who delivered directly to the buyer generally reported that the buyers were pleased with the improved condition of their potatoes. Several cited a reduction in the quantity of cuts and bruises as one of the important values they had received from machine harvesting. It was also pointed out frequently, that care must be exercised in the operation of the machines if these results are to be obtained. Some reported that until they became experienced in the operation of the machine they damaged more potatoes. Other farmers said that they personally, or a responsible member of their regular labor force, always operated the machine to see that it was operated properly to avoid potato damage. A grower pleased with the condition of machine harvested potatoes pointed out that each time potatoes are picked up and set down more tubers are damaged. He said that four times when potatoes are picked up have been eliminated in his operation by using machine harvesting and bulk handling. The experience of these growers seems to indicate that fewer potatoes are damaged by machine harvesting and bulk handling compared to harvesting.

Clods and Dirt

Several growers mentioned that their potatoes were not as bright and clean as when picked by hand. They felt that this is one of the disadvantages of machine harvesting. They suggested that it might be necessary to brush or wash the potatoes to overcome this difficulty.

Also this problem might be overcome by using the indirect method, allowing the potatoes to dry in the field before being picked up by the harvester. This would increase harvesting costs somewhat, because of the additional field operation.

Clods of dirt were mentioned as a problem by a few farmers. One grower reported that a concave roller ahead of the harvesting machine helped considerably in breaking up the lumps. Clods were not mentioned as a major difficulty by these farmers.

One Long Island farmer mentioned that during the very wet period in the 1954 season it was difficult to harvest by machine because of trouble in getting the heavy equipment through wet spots in the field. During this period he harvested some potatoes by hand. This could be a major problem in some areas in wet years.

Vines

Most of the Long Island growers during their early season harvest kill the vines with sprays and by beating one or two days befor harvest. Under these conditions their greatest difficulty seemed to be the additional labor required on the picking table. One grower said that late in the season he harvested with only one man picking trash. Several reported that for the early season digging three or four additional workers were required.

Labor Problems

A reduction in difficulties with labor was frequently mentioned as one of the important advantages of machine harvesting. Several farmers pointed out that when they harvested by machine no potatoes were left dug in the field at the end of the day, while frequently several rows may be left on the ground when picking by hand. This can be an important cost in terms of potato quality. Several growers said that they now harvest potatoes with their regular labor force. They no longer have to be concerned with difficulties in obtaining and supervising a large crew of workers. On one farm where the harvesting is now done by the regular labor force, previously 40 migrants would have been required. Another grower said that to dig potatoes at the same rate as with his harvester would require a crew of 30 pickers. He was happy to have substituted machinery for the headaches associated with a labor force of this size. One farmer said that potato harvesting is now easy work compared to what it used to be. Potatoes go into storage untouched by human hands; gone is all the back-breaking lifting of former years. He also said he can hire women to do part of the work on the harvester, making it easier for him to obtain the necessary help. He said that it is difficult to hire help that will load bags of potatoes well. Therefore, in the past he and his regular workers have done this back-breaking work. One farmer digging potatoes by hand pointed out that one of the difficulties with machine harvesting is that the farmer must be mechanically inclined and must be on the job constantly supervising the operation if damaged potatoes are to be avoided.

Mechanical Difficulties

None of the farmers using harvesting machines reported any serious mechanical difficulties with their machines. However, several had a number of suggestions for possible improvement of the machinery. Some of their suggestions are as follows: 1) Independent depth adjustment on each side of the two-row machine. 2) A device to regulate the engine speed on the harvester from the tractor seat. 3) Would like the machine self-propelled. 4) A new machine or tool to dispose of vines, placing them where digging has been completed. The farmer says this would save three or four men in his harvesting operation. 5) Modifications of the digger to prevent the potatoes from rolling out and around the side. 6) Would like to have different sizes of cross chain to drop out more small potatoes in a low price year.

SOME SUGGESTIONS TO OPERATORS OF MECHANICAL POTATO HARVESTERS

1. Avoid packing of soil and the production of clods by preharvest field operations. Using heavy equipment when soils are wet can greatly increase clod problem.

2. Kill vines either chemically or mechanically for controlling tuber size and to reduce skinning and bruising. Also, elimination of vines and weeds reduces mechanical interference.

3. More maturity in the tubers at the end of the season should allow higher harvesting rates without excessive injury.

4. Accurate control of the digger blades aids in good separation with out excessive agitation or excessive cutting of tubers. Proper depth control is more easily attained where the blade is carried on caster wheels or spool shaped ridge wheels just ahead of the digging point. Poor blade control and irregular response to the action of the operator may alternately increase cuts, or over-load the apron and reduce machine capacity.

5. The amount of agitation on the elevating apron should be so limited that some soil will be carried to a point above the last pair of agitators.

6. Independent power units are more desirable than power-take-off driven harvesters. An independent and instantly variable speed helps attain maximum capacity with minimum tuber injury. It will be necessary for a new operator to do some experimenting with different combinations of apron speeds and ground speeds to adjust to different field conditions. Start with a ground speed of about 1 to 1½ miles per hour and an apron speed of 5%-10% greater and combined with mild agitation.

7. Hand sorting efficiency can often be improved to proper coaching and practice. When sorting materials on a conveyor, it is more efficient for workers to toss materials to the oposite side of the conveyor than behind them. Soft clods can often be eliminated by pressing them through the apron.

8. Work out a system of simple and easily understood signals for communication between the harvester operator, the tractor driver and the driver of the truck. The harvester operator should be in command of maneuvers. Drivers should be on the alert for signals form the harvester operator. The tractor driver should be alert to stalling when the truck is nearly loaded. It may be desirable to select one truck driver to drive all trucks while being loaded.

9. The harvester operator should give constant, careful attention to the control of the bulk loader so that the tubers drop only a few inches. To begin filling the truck it is a good practice to start about two-thirds of the way forward and to the right center. Then work fore and aft evenly and complete filling from the far side to the near side.

10. Preventative maintenance is important in reducing labor costs due to breakdowns. Good maintenance includes regular use of clean lubricants, prompt attention to loose bolts, necessary adjustments, and rules for good farm machinery maintenance.