AN ENGINEERING ANALYSIS OF ON-THE-FARM HANDLING AND PACKING OF CULTIVATED BLUEBERRIES AND THE DEVELOPMENT OF IMPROVED METHODS AND EQUIPMENT FOR HANDLING AND PACKING THIS FRUIT

Thesis for the Degree of M. S.

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This is to certify that the

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By

Jordan H. Levin

AN ABSTRACT

Submitted to the School of Graduate Studies of Michigan State College of Agriculture and Applied Science in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

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JORDAN H. LEVIN ABSTRACT

Michigan blueberry production has increased very rapidly during the period 1935-1955. Harvesting and packing methods did not keep up with production.

The study was made to determine whether or not improvements and economies in packing and handling could be obtained and, if so, how they could be brought about.

Conventional methods of harvesting, handling and packing blueberries were analyzed. A trailer pick-up system and an on-the-farm central packing operation were developed and tested under commercial conditions. The results of using the new method and equipment were analyzed and compared with those obtained when conventional methods and equipment were used.

It was found that the trailer pick-up system of assembling the fruit increased pickers' output and facilitated central farm packing. Central packing increased efficiency and output, lowered costs and enabled growers to put up a better and more uniform package.

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INTRODUCTION

The low-bush (wild) blueberry is native to North America. The supply of fruit was so abundant up to the turn of the century that there was not much incentive to bring this fruit into cultivation.

In 1908, because of the fact that the supply of wild blueberries was rapidly diminishing, Dr. F. V. Coville of the U.S.D.A. became interested in the cultivation of this fruit. He studied the soil requirements, selected breeding stock and developed several varieties of large size and high quality blueberries.

The first commercial planting was made at White's Bog, near New Lisbon, New Jersey, and the first commercial shipments of cultivated blueberries were made from there in 1916.

The Michigan Experiment Station started investigations of blueberries in 1923 at the South Haven Experimental Station. The first commercial plantings in Michigan were made near Grand Junction in 1928.

In the early years the growth of the industry was slow. Michigan's commercial crop was still small in 1940, being just over 10,000 crates. About this time growers began to realize the commercial possibilities of the cultivated blueberry and several hundred acres were planted. When these plantings began to bear fruit four years later, the production increased to over 100,000 crates.

This production was marketed at a good profit and growers again increased their acreage. In 1954 over 1,000,000 crates were produced in Michigan. W. A. Donald, Manager of the Michigan Blueberry Growers' Association, estimates that the crop will be over 1,500,000 twelve-pint

crates in 1955 and 2,000,000 by 1957.

Similar expansion took place in New Jersey and North Carolina, the other states that produce blueberries in commercial quantities. In 1954 production in New Jersey was about the same as in Michigan (1,000,000 crates) and production in North Carolina was about 400,000 crates.

The rapidly rising production of cultivated blueberries has already surpassed the amount of wild blueberries harvested in this country annually. The wild blueberry production is now about 1,000,000 crates, 3/4 of which is produced in Maine. This production is on the decrease.

Fig. 1 shows graphically the rapid increase of blueberry production and number of growers in Michigan.

The gross return from an acre often exceeds $1,000. In the area where this fruit is grown it is of considerable commercial significance. This year the Michigan crop returned over $2,500,000 to growers and, as already pointed out, the crop is rapidly increasing.

Ever since commercial plantings were made the demand for the fruit has exceeded the supply to the point where even inefficient growers could usually make a profit. Most growers have concentrated their efforts on increasing their acreage rather than increasing efficiency of handling and packing.

Research agencies that have worked in the blueberry field have, for the most part, concentrated their efforts on cultural studies because little or nothing was known about the growth habits of the plant.

Because of these facts very little effort has been made to improve packing and handling techniques. The methods employed today are, in most cases, similar to those used by the first commercial growers 25

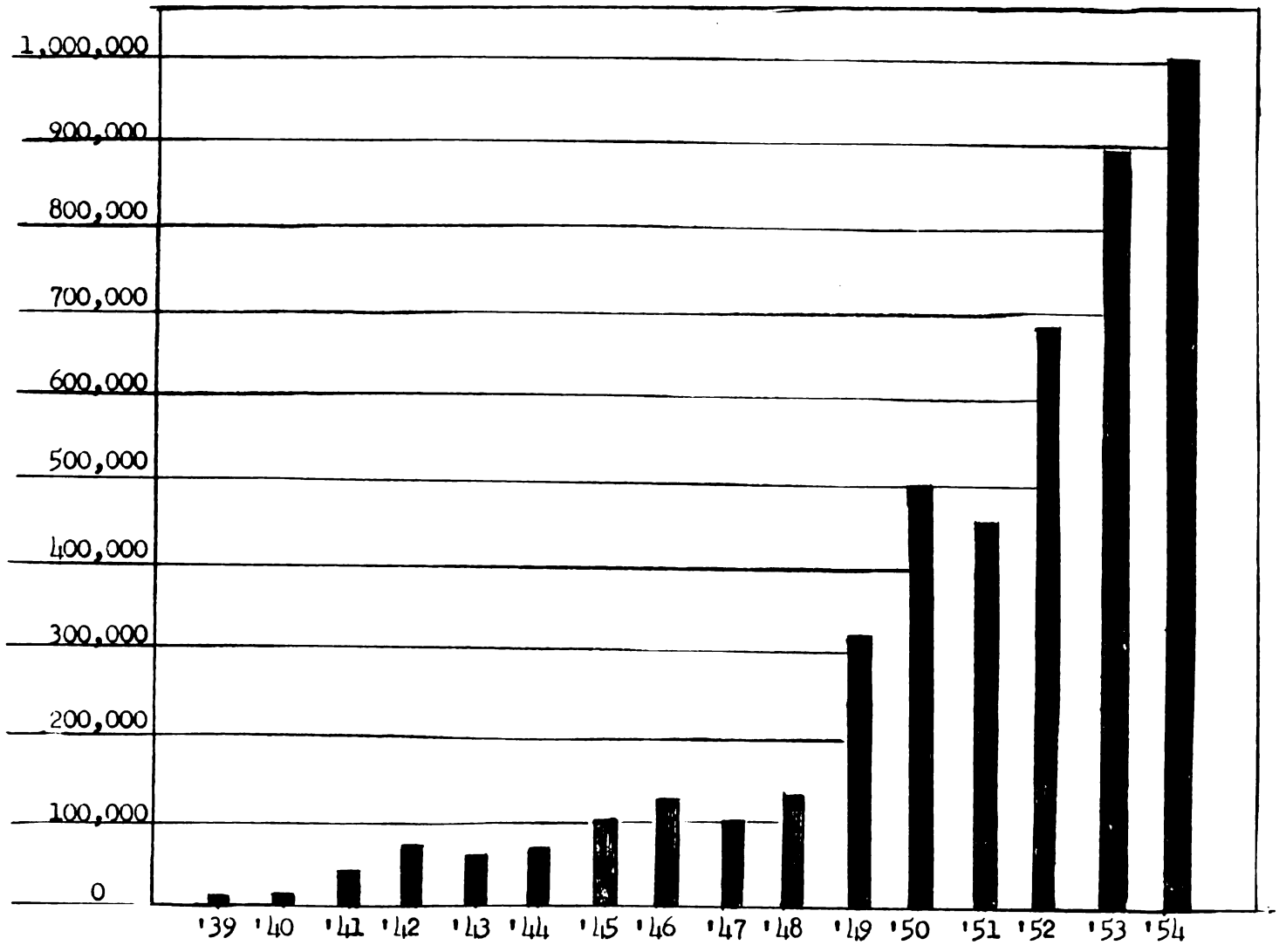


Fig. 1 Michigan production of cultivated blueberries
(based on records of Michigan Blueberry Growers' Association)

TABLE I. GROWTH OF MICHIGAN CULTIVATED BLUEBERRY INDUSTRY

Year	Number of Growers	Production in Crates[1]	Dollar Value of Sales[2]
1938	20		
1939	30	8,839	17,650
1940	36	10,952	19,000
1941	41	46,430	88,000
1942	44	74,190	182,000
1943	51	68,321	264,000
1944	82	74,508	249,000
1945	105	107,870	429,000
1946	136	123,539	416,000
1947	176	101,345	322,000
1948	190	135,594	445,000
1949	231	320,000	784,000
1950	286	500,000	1,180,000
1951	338	450,000	1,110,000
1952	372	685,000	1,633,000
1953	410	897,000	2,175,000
1954	418	1,000,500	2,575,000

1. Crates contain 12 pints each

2. Dollar values rounded off to nearest thousand

years ago. A study made by Wright and Johnson (14) in 1946 showed that the cost of picking, handling and packing blueberries was more than 1/3 of the total production cost. This figure exceeds that of other fruits.

Increased production will no doubt mean lower gross returns, and many growers will have to increase the efficiency of their operations or operate at a loss. The directors of the Blueberry Growers Association have indicated that the most logical place to cut costs is in handling, harvesting and packing.

The study here reported was undertaken to determine whether or not economies in handling and packing can be obtained and, if so, how they can best be brought about.

REVIEW OF LITERATURE

The literature on the wild blueberry as well as the cultivated blueberry was reviewed. All the available publications on the subject were obtained from states producing blueberries. A review of articles appearing in trade and popular magazines was made. A list of the 31 publications and the 16 magazine articles reviewed appears in the appendix.

Only six of the 31 government and state publications mention handling and packing, and then only briefly. A total of only six pages was devoted to discussion of these operations.

Chandler (8)[1] and Dow (25) mention the method of handling wild berries. They both state that the berries are gathered with hand-rakes having 42-48 teeth and are put into one-half bushel baskets. The blueberries are then put through field winnowing machines, driven by gas engines, which remove some of the leaves and stems. About 95 percent of the wild crop then goes to the processing plants to be canned or frozen.

Bailey (26) and Johnston (18 and 20) mention briefly the handling and packing of cultivated blueberries. Their discussion can be summarized by the following few sentences. Cultivated berries are hand picked into small pails that are hung on a strap tied around the picker's waist. The undergrade berries, leaves and stems are removed and the marketable berries put into pint boxes and covered with cellophane. The cellophane sheet is fitted tightly over the box and held in place by means of a rubber band. This operation is performed by hand. The boxes are usually

1/ Numbers in parentheses refer to appended references.

packed for market in 12-pint crates called flats.

The articles appearing in trade and popular magazines dealt mostly with the history, cultural practices and economics of growing blueberries. In the articles where harvesting and packing were mentioned, only one or two paragraphs were devoted to these operations. The discussions were essentially the same as those in the publications already mentioned.

The review of literature showed that up to this time very little thought has been given to handling and packing.

EXPERIMENTAL METHOD

Industrial engineering techniques are being applied more and more to agricultural operations. Examples of the kind of analytical data obtainable with the aid of industrial engineering methods are: Standard unit-time requirements for performance of essential on-the-farm tasks; estimates of the proportion of working time that is actually spent in productive work; and pattern of flow in handling. With such data better work methods, better layouts and more efficient equipment can be developed.

The methods usually used in obtaining this material are the "time study" and the "production study". In the "time study" the amount of time required to perform specific operations is measured. In the "production study" a continuous time log of each operation, delay or other event associated with a particular job is made.

The actual experimental work was carried out in the following four phases:

1. The Conventional Methods of Harvesting, Handling and Packing Were Analyzed. In this phase of the work time, production, motion and cost studies of the various steps involved were made.

Layout and equipment were studied. Standard unit times and rates were worked out for each operation as well as actual rates and times. Sixteen different blueberry plantations were visited and twenty-eight packing sheds studied.

2. A New Method For Handling and Packing Blueberries Was Developed. An analysis of the data obtained in the first step led the investigator to believe that the efficiency of handling and packing might be improved. In an attempt to improve the efficiency of these operations a new procedure for handling and packing was worked out.

3. New Equipment Which Would Facilitate the Method Was Designed and Constructed. In some instances the new procedure required new pieces of equipment or modifications of existing mechanical aids. A field trailer, movable storage table, filling table, sorting table, mechanical shaker, holding table, cellophaning and packing units, and nailing table were designed and constructed.

4. The New Method and Equipment Were Tested and Evaluated. Arrangements were made to test the new method under actual commercial conditions with a large blueberry grower. Over 50,000 pints of berries were handled and packed in a three-week period by the new method and equipment. An engineering analysis was made and the results compared to those obtained when the conventional methods were used.

DESCRIPTION OF METHODS AND RESULTS OF EXPERIMENTS

CONVENTIONAL SYSTEMS

Most of the commercial blueberry growers in Michigan provide a centrally located packing shed for each five to seven acres of

full-bearing plants. The picking crew in any field work together in the area surrounding one of the sheds and carry the harvested fruit to that shed for packing. When the fruit is harvested from that area, the picking crew is moved to another section of the field and a new shed is opened for receiving and packing the fruit. The layout of a typical 25-acre blueberry field showing four packing sheds appears in Fig. 2.

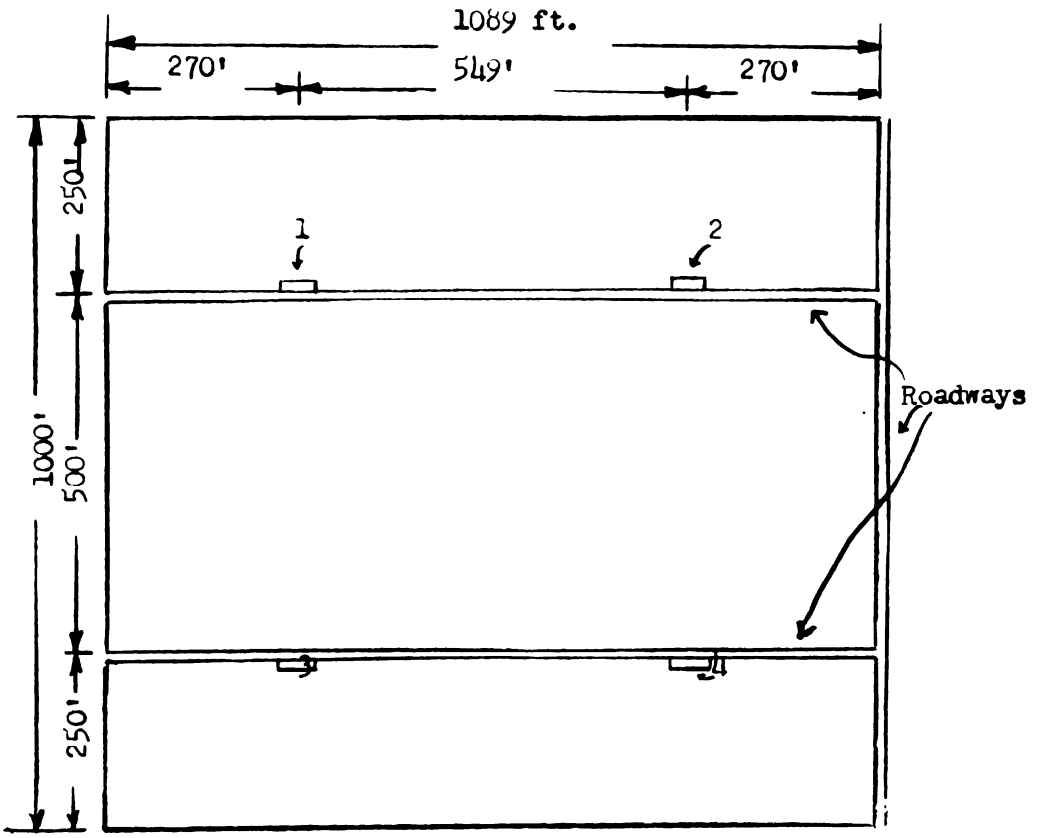


Fig. 2 Layout of a typical 25-acre blueberry field (1, 2, 3 and 4 are packing sheds)

From this layout and others it can be calculated that the average distance a picker walks in making the round trip to the shed is approximately 440 feet.

It was found that there were two methods in common use for carrying the fruit to the sheds. They are the "carrier" method and the "pail" method.

The "Carrier" Method

The various steps involved when the carrier method is used are as follows:

1. Fruit is picked in pails holding from four to ten pints, the size depending on the personal preference of the owner. (Fig.3)

Fig. 3 Fruit being harvested into 4½ pint pails. These pails are hung on a strap tied around the picker's waist. Plants in the picture are only 3 years old and not in full bearing.

2. After being picked the fruit is poured from pails into pint cups which have been previously placed in carriers. As the fruit is being poured the picker sorts out the defective fruit. (Fig. 4)

Fig. 4 Berries are poured into pint cups which have been set in a carrier. Note plants are in full bearing.

3. When all of the pint cups in a carrier have been filled, the carrier is moved to the shed by the picker.

4. At the packing shed the picker moves the filled cups from his carrier to a tray and makes sure that all the cups are heaped with berries. He is then credited with the number of pints he has checked in. (Fig. 5)

Fig. 5 At the shed cups are removed from the carrier and set on trays by the picker. He makes sure each cup is heaped with berries.

5. The picker then fills his carrier with empty cups and returns to his station in the field and proceeds as before.

Table 2 shows the standard time required to perform each step. It also shows how the average picker and the superior picker spends his time during the working day. The standard times shown in this table, as well as figures in Tables 3, 4, 5, 6, 7 and 8, are based on studies of many workers handling hundreds of pints of blueberries. See Appendix F for details (page 50).

TABLE II

CARRIER METHOD TIME RATES

	AVERAGE PICKER			SUPERIOR PICKER		
Operation	Std. Time Mins.[2]	Mins. for 65 pts.	% of 8 hr. day	Std. Time[2] Mins	Mins. for 80 pts.	% of 8 hr. Day
Picking	54.0	351.5	73.2	45.0	360.0	75.0
Sorting	2.5	16.0	3.3	2.5	20.0	4.2
Walking	1.3	8.5	1.8	1.2	10.0	2.1
Check In	3.0	19.5	4.0	3.0	24.0	4.9
Walking	1.3	8.5	1.8	1.2	10.0	2.1
Resting	-	40.0	8.4	-	20.0	4.2
Reassignment[1]	-	36.0	7.5	-	36.0	7.5
		480.0[3]			480.0	

1/ When a picker finishes picking a row he is assigned a new one by the field boss.
2/ Standard times are minutes per 10 pints of berries.
3/ Based on an 8-hour day or 480 minutes.

Pickers normally harvest between 50 and 85 pints per 8-hour day, the average being 65 pints per day when this method is used. The superior picker picks faster than the average (10 pints in 45 minutes as compared to 54 minutes) and he spends less time resting (20 minutes per day instead of 40 minutes).

Pickers take a bout two to three minutes to sort and pour 10 pints of fruit into the carriers, the average time being 2.5 minutes.

As pointed out in the discussion of the field layout, the picker walks on the average of 220 feet each way from the picking area to the

shed. The pickers walk at about 2½ miles per hour, therefore it takes them between 27 and 78 seconds each way. On the average, when picking in carriers the pickers check in just a little over a carrier (10 pints) per trip, which means they spend about 1¼ minutes walking to the shed and another 1¼ minutes returning for every 10 pints picked.

At the shed the pickers spend from 2.5 to 4 minutes per carrier for transferring the pints from the carrier to trays and for checking-in the fruit, the average being 3 minutes.

Under the carrier method the worker spends approximately 7.5 percent of his time being assigned rows for picking, about the same amount in resting, about 15 percent walking and sorting fruit, and from 73 to 75 percent of his time in actual picking.

The "Pail" Method

The various steps involved in this method are listed below:

1. Fruit is harvested in pails as in the carrier method.
2. After being picked the fruit is usually poured from one pail to another and defective berries removed (Fig. 6).

Fig. 6 When berries are handled in pails they are usually poured from one pail to another for sorting.

3. After several pails are filled with sorted berries they are carried to the packing shed.

4. At the packing shed the filled pails are checked in and a supply of empty pails is obtained. (Fig. 7)

Fig. 7 A picker checking-in several pails of berries at one of the sheds.

5. The picker then returns to his harvesting area and resumes work as before.

Table 3 lists the steps involved in the pail method and shows standard unit times and the amount of time spent in each step during an 8-hour day.

It was found that with this method the average picker harvested 70 pints per 8-hour day and a superior picker 85 pints. This is an increase over the carrier method.

TABLE III

PAIL METHOD TIME RATES

Operation	AVERAGE PICKER			SUPERIOR PICKER		
	Std. Time Mins.[1]	Mins. for 70 pts.	% of 8-hr. Day	Std. Time Mins.[1]	Mins. for 85 pts.	% of 8-hr. Day
Picking	52.0	360.0	75.0	44.0	372.1	77.7
Sorting	2.5	17.4	4.0	2.5	21.3	4.4
Walking	1.3	9.3	2.0	1.2	11.1	2.2
Check In	1.0	7.0	1.3	1.0	8.5	1.8
Walking	1.3	9.3	2.0	1.2	11.0	2.2
Resting	-	40.0	8.2	-	20.0	4.2
Reassignment	-	36.0	7.5	-	36.0	7.5
		480.0				480.0

1/ Standard times are minutes per 10 pints of berries

The picker harvested between 50 and 90 pints of berries per 8-hour day, the average being 70 pints for this method.

At the picking area it took the picker from 2 to 3 minutes to pour ten pints from one pail to another and sort out the defective berries.

The distances walked and the rate of walking were the same as for the carrier method, for the layout of the fields was the same. It was found that the pickers carried 2.84 pails per trip on the average, which is about 12 pints, making the time spent in walking 10 pints about the same as in the carrier method.

At the shed very little time was spent. The picker set down his full pails, was credited for the number of pints, obtained empties and returned to the field. Time spent was about one minute per 10 pints checked in.

When using the pail method the worker, as in the carrier method, spent approximately 7.5 percent of his time being assigned rows and about the same amount of time in resting. However, he spent about 10 percent in walking and sorting, which left between 75 and 77 percent for the actual picking operation.

Table 3 shows, as did Table 2, that the reason the superior picker harvested more fruit was the faster picking rate and less resting time.

Shed Packing

All the blueberries received at the packing sheds are either placed in lug boxes or thirty-pound tins and dispatched to processing plants, or they are packaged for the fresh fruit market.

For Processing The capacity of lug boxes and the tins is approximately the same, about 24 pounds of berries. A packer can fill either of them at the rate of one every two minutes when the berries are checked in at the sheds in pails (Figs. 8 & 9). However, when the fruit arrives in carriers it takes about five to eight minutes per tin or lug. At most sheds the fruit is checked at a rate of 500 to 700 pints per hour, which is about 20 to 30 lugs or cans per hour. This means that if the fruit comes in pails one checker and one packer can handle it. If the fruit comes in carriers one checker and two packers are needed because of the extra time needed to empty the large number of containers.

Fig. 8 Berries being put into lugs at the shed. These lugs are sent to canning plants.

Fig. 9 Berries being packed into 30-pound tins at the shed. These containers hold 24 pounds of berries and go to the freezing plants.

For Fresh Market Practically all the Michigan grown blueberries which are sold as fresh fruit are put up in pint boxes covered with cellophane that is held on by a rubber band. Twelve of these boxes are placed in a master container called a flat. The individual pint boxes are of attractive appearance and the flat can be handled and displayed easily.

Although practically all the fruit is marketed through the Blueberry Growers' Association, it is packed by the individual growers.

The most serious problem faced by most growers is that of packaging the berries rapidly and economically. This work is ordinarily done in the various packing sheds already mentioned.

The berries that are to be sold as fresh fruit are brought to the sheds by the carrier method which has already been described. The trays on which the filled pints have been placed are set down within easy reach of a packer. (Fig. 10).

Fig. 10 After the berries have been set on trays by the pickers, the shed-boy sets these trays within easy reach of the packer or stockpiles them on shelves.

The packer moves a filled pint to a position in front of her, covers it with a piece of cellophane, slips a packing frame over the pint in such a way that the cellophane is held down while a rubber band is slipped onto the package (Figs. 11 and 12). The pint is then removed from the frame and placed in a flat. The operation consists of five separate movements. Another worker called the "nailer" staples or nails a slatted cover and stamps the grade and the grower's name on each flat after it has been filled with 12 pints of berries, and also keeps the packers supplied with empties.

Fig. 11 View of the hand packing operation

Fig. 12 View of the hand packing operation

Table 4 shows the time required for packing

TABLE IV

RATE OF PACKING IN SHEDS

Operation	No. per min. per packer	No. per hour per packer
Packing lugs	.6	36
Packing 30 lb. tins	.6	36
Packing pint cups for fresh market	4.0	240 pint cups or 20 flats

A shed crew generally consists of one shed boss who supervises the shed operation and checks the fruit in, a shed boy, a nailer and two packers. Such a crew can pack for fresh market up to 330 flats

(4000 pints) and 50 lugs or cans in an 8-hour day. This is about 9.2 flats per hour per worker when the crew is packing for the fresh market.

The study of motions involved, layout and standard time requirements led the writer to believe that the efficiency of packing could be increased.

IMPROVED METHODS

Trailer Pickup System In order to reduce the amount of time pickers spend in walking and sorting fruit it was decided a trailer pickup system, using only pails, should be used instead of conventional systems of handling. It was hoped the result would be more time spent in actual picking and more efficient handling.

A low narrow trailer 3.5 feet wide and 10 feet long, having a capacity of 150 four-and-one-half-pint pails was designed and constructed. The trailer was procided with a canvas awning to keep rain and the sun off the holding area. The hitch was constructed in such a way that the trailer could be turned in a short radius.

The trailer was pulled up and down the rows by a tractor in such a way that the pickers could check-in their fruit with a minimum amount of walking. At the time the picker checked-in his full pails of fruit he was provided with a supply of empty pails so he could immediately return to his picking work (Fig. 13).

Fig. 13 View of trailer and picker checking-in two pails of berries.

Table 5 shows the steps a picker goes through when the fruit is picked up by a trailer. Standard unit-time requirements and amount of time spent during an eight-hour day for each operation of the picker are also shown.

TABLE V
TRAILER PICKUP TIME RATES

Operation	AVERAGE PICKER			SUPERIOR PICKER		
	Std. Time Mins.[1]	Mins. for 74 pts.	% of 8-hr. Day	Std. Time Mins.[1]	Mins. for 89 pts.	% of 8-hr. Day
Picking	52.0	382.0	79.1	44.0	390.0	81.3
Sorting	2.5	18.5	3.7	2.5	22.5	4.7
Walking	.5	3.0	.6	.4	3.75	.8
Check In	1.0	7.5	1.5	1.0	9.0	1.9
Walking	.5	3.0	.6	.4	3.75	.8
Resting	-	30.0	6.0	-	15.0	3.0
Reassignment	-	36.0	7.5	-	36.0	7.5

1/ Standard times are minutes per 10 pints of berries

When fruit was checked-in to a trailer, pickers harvested between 50 and 95 pints of berries in an eight-hour day. The average picker harvested 74 pints per day.

The picker spent 7.5 percent of his time being assigned rows for picking and 6 percent of his time resting. He did not have to walk far to check-in fruit and as a result did not rest as much as when he had to walk to the shed. Less walking meant that he spent approximately 7 percent of the time walking, checking-in and sorting. This left 80 percent of the time for actual picking. He therefore was able to harvest more fruit per day.

After the pails were checked in at the trailer the fruit, if it was destined for a processor, was poured into cans or lugs by the tractor driver and a helper. These two workers could handle as much as 5,000 pints a day because the fruit arrived at the trailer in pails.

If the fruit was to be packed for the fresh-fruit market, the filled pails were placed in the trailer and hauled to a central packing house equipped to receive and pack berries which came in pails.

Central Packing The study of the conventional methods of packing led the writer to believe that the efficiency of this operation could be improved by central packing. A layout for central packing was made and necessary equipment designed and constructed. Procedures for packing blueberries that arrived by trailer in pails were worked out. Fig. 14 shows the layout of the packing line.

Items 1, 2 and 3 are mobile receiving and storage tables. They are 36 inches high, of sturdy construction, mounted on castors so they can be moved easily, and have a capacity of 75 four-and-a-half-pint pails each. The purpose of these tables is to provide surfaces onto which the fruit could be unloaded quickly from the trailers and moved about the packing floor easily. These tables were also used to stock empty pails and move them to the trailer to be returned to the pickers.

Item 4 is a sorting table (Fig. 15). This piece of equipment was used when it was necessary to remove defective fruit. The table consisted of a white oilcloth-covered and hinged top on which it was easy to see the berries, and which would hold a full pail of berries. After the fruit was inspected the top was raised and the berries rolled off. The table was inexpensive yet very effective.

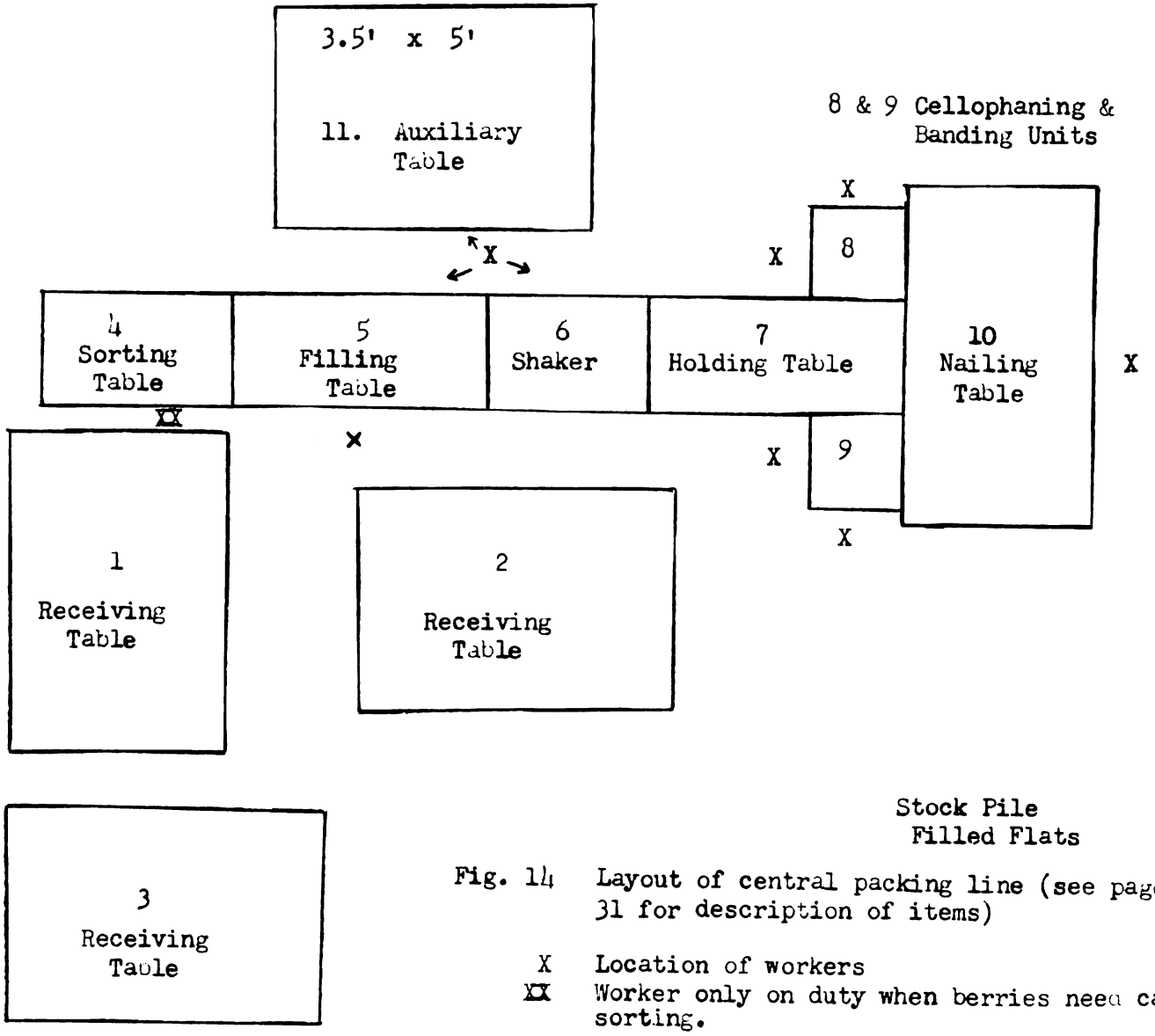


Fig. 14 Layout of central packing line (see pages 25-31 for description of items)

X Location of workers

XX Worker only on duty when berries need careful sorting.

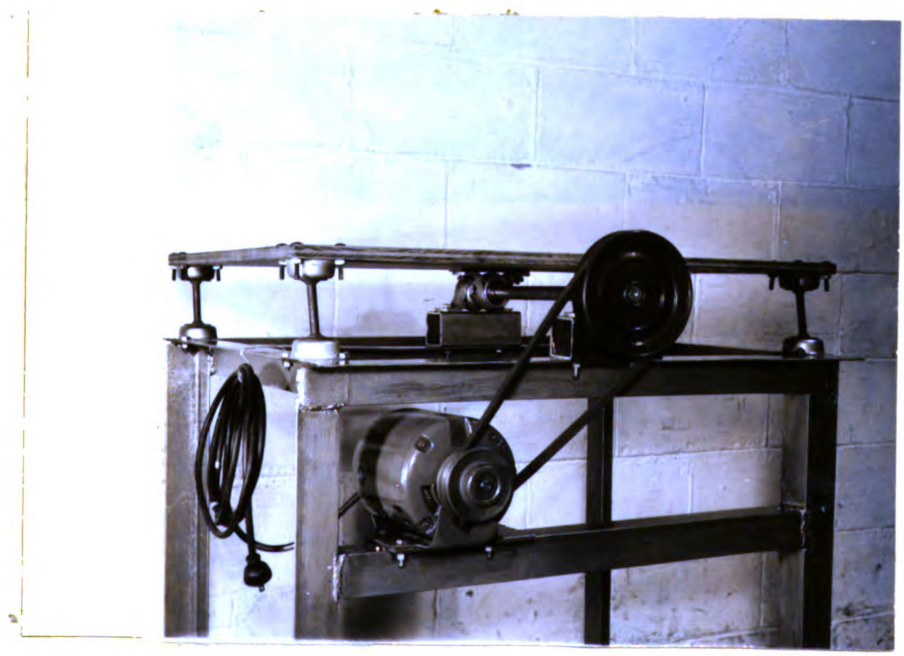
Item 5 is a table on which the pint boxes are filled with berries.

Item 6 is a mechanical vibrator over which the filled pints passed. The purpose of this piece of equipment was to cause the fruit to settle sufficiently to prevent the development of a slack pack during transit.

Fig. 15 View of the sorting table. Berries from one full pail just covered the surface. The defective fruit can easily be seen against the white surface.

The advantage of handling berries in pails has been recognized by growers and has been pointed out in a previous section. However, pails have not been used because the invariable result was a slack unattractive pack which the sales managers found hard to merchandise. Filling the pint cups in the field, and the jarring which occurred when they were carried to the sheds, caused the fruit to settle before the cellophane was applied. The fruit packed in this way carried better,

and no objectionable settling took place as a result of vibration in truck transit.



Figs. 16 and 17. Views of the mechanical shaker. The lower view shows the bearing which is attached to the frame and the one which is attached to the shaker platform with the eccentric shaft going through it.

The shaker (Figs. 16 and 17) had a platform 22 inches by 30 inches which could hold two frames of 12 pints each, at the same height as the rest of the line, so materials could be moved from one unit to another. This vibrating surface was set on airplane shock mountings. The motion was a 360 degree circular motion of 1/8 inch diameter at 600 rpm. This motion was achieved by driving a shaft at 600 rpm with a 1/8 inch offset through a bearing rigidly connected to the vibrating surface. The drive was from a 1/4 hp electric motor through a variable speed pulley so that the number of vibrations per minute chould be changed. It was found 600 rpm was most effective.

The rotary type motion was used because it is simple to obtain, and effective for settling the berries (see Figs. 18 & 19). Other types of motion such as vertical, horizontal or any combination could have been obtained by proper design if it had been deemed advisable.

Item 7 (Fig. 14) is a holding table on which the filled pints were held until picked up by the "cellophaner". This table had a slatted top through which excess blueberries dropped. These were collected in lugs and then sent to the processor.

Items 8 and 9 are cellophaning and banding units. These are important pieces of equipment because the speed of the whole line is determined by how fast the berries pass through these units. Each machine was provided with a hinged arm activated by a foot pedal in one direction and a spring in the other direction. It was by means of this device that the cellophane holding frame was lowered onto the filled pint. When in this position a rubber band was placed on the filled pint and the pint then removed and placed in a flat resting on item 10.

Item 10 is a sturdy table on which the flats were stamped and covers were applied and nailed on. It was constructed with a shelf so that a supply of lids, cellophane and rubber bands could be kept handy.

Fig. 18. Two pints identically filled with berries.

Fig. 19 The same two pints except that the pint on the right was placed on the mechanical shaker for eight seconds. Note how it has settled. It is now ready for cellophaning.

Item 11 is an auxiliary table on which a worker placed a tray and a 12 x 16 inch bottomless wood frame just large enough to hold 12 pints, (Fig.20). When the frame had been filled with empty pints the entire assembly consisting of tray, frame and pints was lifted onto the filling table (item 4).

Fig. 20 One worker places frames on trays and places 12 pint cups inside each frame. This work is done on the auxiliary table next to the line.

When the trailer load of filled pails arrived at the central packing house the pails were transferred to the storage tables (Fig.21). The tractor driver then loaded the trailer with empty pails and returned to the field.

Fig. 21 The pails of berries are transferred from the trailer to the holding tables on arrival at the packing center.

One of these holding tables containing filled pails was moved into working position at the end of the packing line. A worker then poured the fruit from the pails into the tray-frame-pint-cup assembly (Fig. 22).

Fig. 22 One worker dumps the berries into the tray-frame-pint-cup assembly.

The filled frame assembly was then moved onto the shaker. After 6 to 10 seconds, during which time the fruit settled in the pints, the assembly was pushed to the holding table and the frame removed, leaving the tray containing the properly filled pint cups within easy reach of the packers (Fig. 23).

Fig. 23 The berries were settled in the pint cups by vibrating them from 6 to 10 seconds.

At each station the "cellophaner" picked up a filled pint, moved it into position under the packing frame, placed a piece of cellophane over the fruit, and moved the packing frame into holding position by means of a foot pedal. Another worker, the "bander" applied the rubber band in such a way as to hold the cellophane in place, and then set the packed pint into the flat (Fig. 24). As previously pointed out, the cellophaning and banding operation is composed of five steps. When the

banding unit was used the step of applying the frame was changed from a hand action to a foot action. The remaining four steps were split up so that the cellophaner performed two of them and the bander the other two. This resulted in a faster rate of packing.

Fig. 24 One girl places the filled pint under the holding frame and covers it with cellophane. Another girl applies a rubber band and places the packed pint cups into a flat which holds twelve.

When a flat was filled another work, the "nailer", applied a cover, stamped the flat and stock-piled it for shipment (Fig. 25).

Fig. 25 The nailer at work.

Table 6 lists the steps involved in central packing, and the time required to perform each step.

The packers cellophaned and banded flats at rates between 45 and 60 per hour. The average was 50 flats per hour. This meant that with the two cellophaning-banding stations, the line could turn out 100 flats per hour or 1200 pints.

TABLE VI

STANDARD TIME RATES FOR CENTRAL PACKING

Operation	Pints per hour	Flats per hour
Making tray-frame-pint assemblies	1320	110
Dumping fruit and shaking	1320	110
Cellophaning	600	50
Banding	600	50
Nailing	1500	125

The crew of seven or eight workers packed at the rate of 100 flats or 1200 pint cups per hour. During the trials this crew packed over 50,000 pint cups. The crew consisted of:

2 cellophaners (girls)
2 banders (girls)
1 nailer (man)
1 dumper (girl)
1 tray-frame-pint assembler (man)
1 grader-handyman (girl) (was not always used)

When a crew of seven was used the rate per worker was 14.3 flats per hour.

When a crew of eight was used the rate of packing, per worker, was 12.5 flats per hour.

COMPARISONS

Carrier and Pail Methods vs Trailer Pickup. Table 7 shows how the picker spent his time while working under each of the above methods.

TABLE VII

HOW PICKER'S TIME WAS SPENT UNDER VARIOUS METHODS

Operation	Carrier	Pail	Trailer-Pickup
Picking	73.2%	75%	79.1%
Sorting	3.3	4.0	3.7
Walking	1.8	2.0	.6
Check In	4.0	1.3	1.5
Walking	1.8	2.0	.6
Resting	8.4	8.2	6.0
Reassignment	7.5	7.5	7.5
Average pints picked per day	65	70	74

The picker was able to spend more time in actual picking when working under the trailer pick-up method and therefore he could harvest more fruit per day. An increase of 4 to 9 pints per worker is of importance. A field boss can handle up to 100 pickers efficiently. Crews of this size are utilized and the 400-900 pints which they could pick under the trailer system are normally lost.

Not only does the trailer pick-up system result in more fruit picked per worker but it makes possible the assembly of fruit at one place for central packing and shipping.

Shed Packing vs Central Packing. Table 8 compares the rate of cellophaning and banding per person and the output per worker for each type of packing.

TABLE VIII

PER-DAY OUTPUT PER WORKER AND OF TOTAL CREW FOR CELLOPHANING AND BANDING

Operation	Shed packing	Central packing
Cellophaning and banding	20 flats	25 flats
Total crew	9.2 to 10 flats	12-5 to 15 flats

Central packing utilizing present equipment is more efficient than shed packing. The new method is not only faster but enables the grower to put up a more uniform pack and to exercise a more positive control of quality of the pack. Central packing also makes the physical handling of the packed fruit easier and facilitates accounting because all the fruit is assembled and shipped from one point.

Another significant advantage of central packing is that it makes a considerable number of packing sheds unnecessary. A 50-acre plantation that uses the conventional method must provide 10 packing sheds which together cost from $5,000 to $7000. In central farm packing, one house costing $1,500 to $2,000 would provide an adequate amount of space. This building could be used in the off season for shop or storage.

CONCLUSIONS

1. Conventional methods of handling and packing tend to be expensive, cumbersom and inefficient.
2. The trailer pick-up system of assembling the fruit increases pickers' output and facilitates central farm packing.
3. Central packing:

   Increases efficiency and output

   Lowers costs

   Enables growers to put up a better and more uniform package

RECOMMENDATIONS FOR FUTURE STUDY

1. Conduct research to find a mechanical means of picking the fruit in order to speed up picking and get more of the fruit harvested.
2. Investigate the possibility of further improvement by using larger picking containers and improving the trailer pick-up system.
3. Develop a completely automatic cellophane and banding unit.

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APPENDIX

SAMPLE OF FIELD TIME STUDY DATA SHEET

Blueberry Handling

Method Time Study
Shed System

Place Triangle Plo
Field 3

Date 8-16-54

Operation	Time	Amount	Distance	
picking	18.4 Min	1 pail	man	
	20.1	1 "	man	
	22.4	1 "	woman	
	21.6	1 "	boy (15yrs)	
Sorting	49 sec	1 pail	man	
	2 min	2 "	girl (18yrs)	
	58 sec	1 "	boy (17yrs)	
Walking	3.1 min		400'	
	2.9 "		400'	
	4.3 "		510'	
	1.6 "		210'	
picking	22.1	1 pail	girl (15yr)	
	24.0	1 "	"	
	23.1	1 "	"	
	Lunch			

Monday Morning

SAMPLE OF FIELD PRODUCTION STUDY DATA SHEET
Blueberry Handling

Method Production Study
Pail Method - Shed

Place Triangle Field 2

Date Aug. 10, '54

Operation	Time	Amount	Distance
picking	8.00 AM	1 pail	
sorting	823	1	
picking	824 10	1	
sorting	850	1	
walking	851 05		220'
checkin	853	2	
rest	854		
walk	857 20		220'
Reasg.	859		
Picking	903	1/2	
rest	913		
picking	914	1/2	
sorting	922	1	
picking	923	1	
sorting	943	1	
walking	944		240'
checkin	945 20	2	
walking	946 20		240'
picking	948	1	
sorting	1011	1	
picking	1012	1/4	
rest	1017		
picking	1018	3/4	
sort	1033	1	
picking	1034	1	
sort	1054	1	
pick	1055		

3 hours picked 7 pails
Worker - Man - 27-30 yrs old

SAMPLE OF TIME STUDY ON PACKING OPERATIONS

Blueberry Handling

Method Time Study — Central Packing

Place Triangle Pl. Field 5

Date 8-21-54

Operation	Time	Amount	Distance	
Placing pt. in position	46 sec	10 pts	Woman operator was sitting	4.5 sec/pt
	45 sec	10		
	91	20		
	91	20		
	45	10		
cellophane on pint.	60	20 pts	using exp. unit	3 sec/pt
	59	20		
	30	10		
	31	10		
	29	10		
banding	61	20	Operator standing	3 sec/pt
	62	20		
	61	20		
	31	10		
	32	10		
vibrating pints	6	1 flat	on mech. vibrator	6 sec/flat
	6	12 pts		
	6	12 "		
	6	12		

SAMPLE OF PRODUCTION STUDY ON PACKING OPERATIONS

Blueberry Handling

Method Production Study — Central Packing — Complete crew

Place Triangle Pl — Field 5

Date 8-21-54

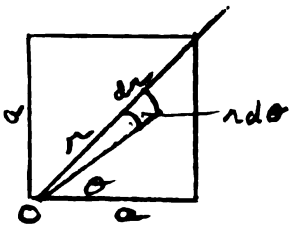
Operation	Time	Amount	Distance
Packing 12 pt. flats	12:30 PM	- start	
	151	107 out of box	
	210	resume	
	250	160 out of berries	
	301	resume	
	330	- Milk Break	
	340	resume	
	430	278	
		Truck load to asstys.	

Crew of 7
2 banders, 2 cellophaners
1 nailer, 1 filler, 1 assembler
First run of crew

CALCULATION OF APPROXIMATE AVERAGE DISTANCE WALKED TO SHEDS

o - location of packing shed

a - distance to edge of field



then sum of all the r's divided by number of r's equals averge distance which equals

$x = a = r\cos\theta$

$r = a\sec\theta$

$$\frac{\int_{\theta=0}^{\pi/4}\int_{r=0}^{r=a\sec\theta}(r\,r\,dr)\,d\theta}{\text{area}} = \frac{\text{volume}}{\text{area}} = \text{distance}$$

$\text{area} = a^2/2$

$$\left[\frac{r^3}{3}\right]_0^{a\sec\theta} = \int_0^{\pi/4}\frac{a^3\sec^3\theta}{3}\,d\theta =$$

$$= \frac{a^3}{3}\left[\tfrac{1}{2}\sec\theta\tan\theta + \tfrac{1}{2}\ln(\sec\theta+\tan\theta)\right]_0^{\pi/4}$$

$$= \frac{a^3}{3\times 2}\left[\sqrt{2} + \ln(1+\sqrt{2})\right] - \left[0+0\right]$$

$$= \frac{a^3}{3\times 2}(1.41 + .88) = \frac{a^2}{2}\times .76\,a$$

$$\therefore \text{average distance} = \frac{\frac{a^2}{2}\times .76\,a}{a^2/2} = \underline{.76\,a}$$

∴ if shed is in middle of 6 acres

average distance walked (approx) =

$.76 \times 270 = 205$ ft to shed

BASIS FOR TABLES II-VIII

Table II. The carrier method time rates are based on time and production studies of 22 pickers working in four different fields, harvesting 300 pints of blueberries.

Table III. The pail method time rates are based on time and production studies of 18 pickers working in three different fields, harvesting 350 pints of blueberries.

Table IV. The shed packing rates are based on the packing of 151 lugs and 139 tins by three different workers.

Table V. The trailer pick-up time rates are based on time and production studies of 21 pickers working in one field, harvesting 340 pints of blueberries.

Table VI. The central packing time rates are based on the packing of 7,000 pints of blueberries.

Table VII. The time rates shown in this table are based on Tables II, III and IV.

Table VIII. Worker output is based on the packing of 1,200 pints in three different packing sheds and 10,000 pints in the central packing line.