THE PERFORMANCE OF SUGAR BEET HARVESTERS IN SOUTHERN ALBERTA.

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THE PERFORMANCE OF SUGAR BEET HARVESTERS IN SOUTHERN ALBERTA

CHAPTER I.

Introduction

Location

The mechanization of any field crop requires that present practices and procedures be modified to some degree in order that optimum machine use may be obtained. Modifications must always be carried out with the governing principle in mind, that the ultimate goal is efficient crop production. The adoption of the use of harvesting machinery in beet sugar production is no exception to the general rule. The study reported in this thesis is an attempt to evaluate some of the factors involved in the adoption of complete machine use in the beet harvest.

Practically all of the major beet growing areas of Southern Alberta are found within a radius of 50 miles from the City of Lethbridge. The parent district is located in the vicinity of the town of Raymond about 22 miles south by the road. The factory in this town was opened in the middle twenties and beet growing on irrigated land has expanded from this area. The soils vary from light to medium texture, with a good proportion of clay and silty clay loams. Most of the land falls within the Dark Brown soil belt.

The second factory is located at Picture Butte within the Lethbridge Northern Irrigation District. The village is about 16 miles north by road from Lethbridge, just beyond the Oldman river. As in the Raymond district, the soils fall partly within the Dark Brown and Brown soil zones. Medium textures predominate throughout the area.

The third major district involved in this study is the Lethbridge - Coaldale area which now forms part of the St. Mary's and Milk River Development Project. Medium soils of the clay loam texture predominate near Coaldale, while loams and silt loams are found in the Lethbridge district. The area falls for the most part within the Dark Brown zone.

The fourth district is located from thirty to forty miles east of Lethbridge and constitutes the Taber Irrigation Project. The soil textures tend to become progressively lighter toward the eastern edge. Sandy loam and fine sandy loam soils are very common. This district is located within the Brown soil zone.

Meteorological Data.

The following summary of weather data obtained from the Dominion Experimental Station at Lethbridge is included here to give a broad picture of the climatic conditions under which the beet crop is harvested. This information represents closely the picture for the area as a whole. The major difference is found at Taber where the growing season is slightly longer and where average temperatures are slightly higher than at Lethbridge. The precipitation and temperature records are 46 year average values for the period 1902 to 1947 inclusive. Sunshine and free water surface evaporation records cover 39 years and 26 years respectively. Table I includes precipitation, temperature, sunshine and evaporation data. Frost information is tabulated below.

The average frost free period has been 116 days; while the average number of days between killing frosts in the spring and fall has been

141 days. The shortest frost free season, 80 days, occurred in 1910; the shortest crop season, 110 days, occurred in 1921. The longest frost free season and longest crop season was 171 days and 178 days in 1940. Dates of frost occurrence are as follows:

Earliest last spring frost	- 30°,	April 26, 1940
Latest last spring frost	- 32°,	June 9, 1926.
Earliest first fall frost	- 31°,	August 14, 1928.
Latest first fall frost	- 27.8°,	October 14, 1938.
	23°,	October 14, 1940.
Earliest last killing spring frost	- 28°,	April 11, 1915.
Latest last killing spring frost	- 28°,	May 30, 1917.
	26°,	May 30, 1920
Earliest first killing fall frost	- 28°,	September 6, 1929.
Latest first killing fall frost	-19.5°,	October 22, 1914.

In the above data, 32° has been considered as frost, and 28° or less as killing frost, unless the observers' notes indicated otherwise.

The study of the field performance of harvesting units included the 1946 and 1947 harvest seasons. Normally beet digging starts about the 20th of September and is not completed until the end of October or the middle of November. The daily weather records for September, October and November, 1946 and 1947, are given in Appendix A. These data include precipitation, maximum and minimum temperatures and total daily hours of sunshine. Consideration of the weather records indicates that the precipitation received during the 1946 harvest season was considerably above average. In 1947 heavy snow fell in September just before digging commenced. October, 1947 was more favourable, there being only one storm of sufficient size to hinder digging. Harvesting was nearly

Table 1.

Meteorological Data - "Dominion Experimental Station" Lethbridge, Alberta.

Month	Ave. Temperatures. Highest for Month 46 yr. Ave.	Low for Month 46 yr. Ave.	Mean 46 yr.Ave.	Sunshine Daily Ave. 39 years hours.	Evaporation 26 yr. Ave. inches	Precipitation 46 yr. Ave. inches
January	58.0	-24.2	17.5	3.20		0.63
February	54.6	-23.9	18.9	4.34		0.71
March	62.9	-11.0	28.7	5.23		0.88
April	75.8	11.6	42.2	7.07		1.13
May	82.3	25.4	50.9	8.27	4.68	2.28
June	86.6	34.9	58.3	9.30	4.71	2.79
July	92.8	40.4	64.7	11.01	6.21	1.70
August	91.3	36.9	62.3	9.64	5.05	1.56
September	84.0	25.9	53.3	6.86	3.36	1.76
October	77.7	13.9	44.6	5.39	2.37	0.97
November	63.7	-7.8	31.1	3.66		0.81
December	54.7	-19.6	22.1	3.02		0.69
Average			41.2		Total	15.92

completed before the November snowfall. Generally the 1947 season was close to average while the 1946 season was one of the most unfavourable experienced over a number of years. This information is relatively important when considering performance data. No direct comparison is valid, if made between the two years, because of the difference in the weather conditions that prevailed.

The Trend Toward Mechanization.

The sugar beet crop is one of the latest to receive the benefits of mechanization in all, or in part of its stages of production. There are several reasons for this.

Beet production involves peak labour periods during the spring and fall season. Generally employment has been on an acre contract basis. Until the beginning of the second world war, wages have been relatively low and workers plentiful. Increased wages and a shortening supply of labour, a direct result of the war, brought out very forcibly the need for complete mechanization. The practice of contract employment has been a deterring factor against the adoption of machines, since workers have been reluctant to accept contracts for spring work alone. The complete use of harvesters has not been visualized by growers until such time as both spring and fall work could be handled by machinery.

Farm operators have been consistently urged by the industry to strive for, and maintain, a high level of proficiency in the topping of beets for delivery to the factory owned receiving station. Early model machines did not receive grower acceptance because of low daily output, and because of relatively poor topping. These units utilized horse drawn ground driven mechanisms.

The urgent need for mechanization intensified experimental investigations and gave rise to numerous commercial attempts to solve the problems encountered. This need softened grower resistence to the point that producers and processors co-operated with investigators in the development and introduction of new harvesters. The result of this co-operation has been an almost unparalleled switch to the use of harvesters in spite of some very decided faults.

The competitive factor has been at work, speeding up the use of field machinery. Beet sugar has had to compete in world markets with cane sugar. Neither crop has as yet been fully mechanized. The labour wage rate differential existing between the cane and beet areas favours the former. This handicap can only be overcome by complete mechanization of the sugar beet crop.

Scope of the Study

The study which forms the basis for this report was carried out during the 1946 and 1947 harvest seasons. The information covers work done by John Deere 54A harvesters, International HM-1 combines and to a limited extent the Keist topper and loader units. The John Deere beet loader and the "Robeco" or "Robin" Loader also enter into the picture.

Three major factors which contribute to successful mechanical harvesting have been studied in detail. These factors are discussed briefly under this heading.

The first factor is the efficiency of the topping units. In order for machine harvesting to expand and become popular with the growers it is essential that the quality of work done by the units be as good, if not better than, that expected from manual workers. The normal top growth on the crop is often somewhat greater than is obtained in other areas. It was felt, therefore, that factual data should be obtained to form a basis for answering questions relative to this subject. The procedure used was to visit machines in the field and to sample the work of the units as they were being operated and adjusted, by the farmer or his hired help. This phase of the study was carried out in 1946 and the majority of the tests were made on John Deere 54A harvesters. All machines included in the topping tests were under the care of first year operators. No effort was made by the author to improve the adjustments on the machines unless the operator specifically requested this aid. This happened in only two cases. The topping efficiency data represents the performance of the machines under field conditions as handled by relatively unskilled operators.

The second factor studied is that involving the ability of the machines to provide relatively clean beets. This portion of the work has been stressed strongly because of the problems encountered in various soil textures having various degrees of moisture content. The ability of harvesters to handle a wide range of soils and soil conditions plays an important part in determining their over all effectiveness. Hand labour harvesting operations provide reasonably effective soil separation except under very wet conditions. Past experience has shown that the heavier soils tend to produce lumps and clods which were difficult to separate from the beets by other than hand methods. This knowledge indicated that considerable attention should be paid to cleaning mechanisms on the machines. A survey method of study was adopted in which the total seasons dirt tare records of a number of operators were obtained from the beet receipt slips. The dirt tare study was carried out over a two year period to include the work of three makes of harvesting units in comparison with hand labour methods. The information was considered to be important because of its possible value in determining the conditions under which each machine would find its best use.

The third factor, cost of operation and seasonal performance, was studied over the two year period. The survey method was again used. In practically all cases the author visited the operator before or during harvest and solicited his aid in recording the necessary information. The records were collected from the growers following the completion of the harvest. The fundamental reason for collecting cost and field performance records was to obtain data which could be used as a basis for recommending the minimum and optimum acreage requirements of the machines. The minimum acreage on which a machine can be economically used is determined by first cost. The optimum acreage must also be determined by the length of the harvest season.

The author kept constant watch for field and crop management practices that would have an effect on the operation and efficiency of the machines. This was done to determine whether or not standard management practices should be revised to any extent to meet the needs of mechanical harvesting.

CHAPTER II.

A Brief History of Sugar Beet Harvester Development.

The introduction of mechanical harvesting equipment into Southern Alberta has been a direct result of the development of the units in the American beet growing areas. All but one of the units discussed in this study are of American design. Two makes of harvesters have found grower acceptance in Alberta. These are the John Deere and International machines. A third, the Keist topper and Keist loader, has seen only limited use up to the present time. This discussion of history and development will deal largely with the first two machines.

The John Deere 54A Sugar Beet Harvester.

In 1935 Walz, Claude, W. (1) started work on a machine to harvest his own beet crop. By 1940 the unit had developed sufficiently that it was used in the harvest fields with reasonable success. In 1941 Walz joined forces with the John Deere organization and three machines, identical to the original were constructed and put to use in the beet fields. In 1942, 15 machines were built and sold throughout the country. Improvements have been carried out to meet the needs of various districts but the basic design today is that of the original Walz machine. Smith, P.B.(2) estimates that a total of 2,800 54A machines would see service in the 1948 harvest. He also estimated that a total of 10,000 units would be used in 1948. This figure almost doubles the 1947 total and includes all makes of commercial harvesters and home made machines.

The first harvester to appear in Western Canada was used near Portage La Prairie, Manitoba. This was one of the original 15 units of

* Figures in brackets refer to the list of references.

the 54A model. It was used to a limited extent in 1942 and was sent back to the factory for revision and strengthening. It appeared again in 1943 in the lighter soils near Altona, Manitoba. It had been purchased by the Manitoba sugar refining company as an introductory measure. Paterson, J. J. (3).

Four 54A machines were sold in Southern Alberta in 1945. One went to the Picture Butte district; one went to the Coaldale (Chin) area; and two were sold into the Taber area. All four units were used successfully by commercial growers and as a result the John Deere organization began an orderly expansion of the harvester market in Southern Alberta. The 1947 harvest saw 53 of these units in operation, the majority doing a good season's work.

<u>The International HM - 1 Combine</u>

The history of the development of the International machine runs somewhat parallel to that of the 54A. Guelle, C. E. (4) states as follows:

"During 1939 and 1940 the existing patents were studied, farmers homemade efforts were investigated, and research studies being carried out at Davis, California were followed. For two years various principles were studied in a field of beets near Canton, Illinois. In 1943 the first machine was built and tested in the fields of the beet country. During 1944 and 1945, improved machines were further tested in the field and in 1945 the equipment was first operated by farmers and not company field men".

The rapidity of acceptance of these harvesters is indicated by Smith, P. B. (2) who states that of the estimated 10,000 machines in use in 1948, 2,700 would be the HM-1 model. The rest of the total was made up of smaller numbers of various other makes. Excluding the 54A, the most important of these were the Marbeet, the Scott Urschel, the Harval, and the beater types such as the Olson beater. It was indicated that in 1947 about 30 percent of the U. S. beet crop had been harvested mechanically and that the total number of machines in use in 1948 was almost double the figure for 1947.

In the fall of 1946, two HM-I units were brought into Southern Alberta for trial, one going to Taber, the other to the Picture Butte area. In 1947, 15 of these combines were used.

The Kiest Harvester and Others.

The Kiest harvester combination consists of two units. One is a four row topper, the other a 2 row digger loader. These machines were developed near Pocatello, Idaho. In the late fall of 1946, one of these units was brought into Southern Alberta for trial. Twelve were sold for the 1947 harvest but for various reasons only two did a reasonably full season's work.

There have been several local attempts to develop machines in Southern Alberta. The Sam-n-Andy unit had developed to the field experimental stage in 1947.

Smith, W. (5) indicates the growth of harvesting by machines in Table II. He also gives the distribution of the various makes in Table III.

Table II

Acreage Harvested Mechanically In Alberta.

Year	No. of Machines	Acreage Harvested Mechanically	Percent of Total Acreage Harvested Mechanically
1945	4	96	0.3
1946	21	482	1.6
1947	82	2, 251	7.69

Table 111

Distribution and Makes of Beet Harvesters (1947)

Make of Machine	District Coaldale	Picture Butte	Raymond	Taber	Total
J. Deere	7	26	7	13(3)	53(3)
I.H.C.	3	3	5	4(1)	15(1)
Kiest	-	4(4)	3(3)	5(3)	12(10)
Sam-N-Andy	-	-	-	2(2)	2(2)
Total	10	33(4)	15(3)	24(9)	82(16)

Note - Figures in brackets are the number of machines not operated, or not operated to any great extent.

It will be noted in Table 111 that some machines of each make are listed as not having been used to any great extent. This was due to various factors. One was that some growers purchased machines to offset a feared loss of contract workers. In many cases the anticipated labour loss (especially Japanese) did not materialize. The growers were in the position of having to use the machines on crops other than their own because of their contract with the workers.

Operating conditions such as excessive stoniness, excessive moisture and abnormal top growth are other reasons for the machines not having been used. The highest mortality was among the Kiest units. These machines developed mechanical trouble in the elevating mechanism. In addition, many of these units were sold in areas of heavy soil in which the Lifter Loader did not deliver acceptably clean beets. The use of one or more 54A units was discontinued because of small stones. The pebbles jammed the conveyor and elevating chains, causing considerable loss of time.

CHAPTER 111

Cropping Procedures and Hand Harvesting Methods

Constant reference to, and comparison with, the hand labour methods of harvesting will be made throughout this report. Therefore, it is felt that some discussion of the procedure is required for full understanding of many of the problems involved. Some general information on the crop itself is included to facilitate the discussion.

Some General Cropping Practices.

Each year the total area contracted to sugar beets amounts to about 30,000 acres. This acreage gives an average yield of about 12.5 to 13 tons per acre. Palmer, A. E. (6) puts the average sugar yield per acre as about 2 tons. Production such as this requires an intensive form of agriculture in which details become important.

Beets are seeded throughout the area in a standard row width of 22 inches. Seeding generally gets under way before the first of May and is usually completed by the 15th. Seeding dates later than June 1st usually result in a decrease in yield unless harvest conditions favour late digging. The seed is placed in well prepared seed beds using 4 or 6 row drills, horse or tractor drawn. The drills are equipped with fertilizer cans to permit the use of commercial fertilizer at rates up to 100 lbs. per acre. Some of the common drills place about 30 percent with the seed and divide the remainder into two bands above and to the side of the seed band. Phosphate fertilizer (11-48-0) is commonly used. Many growers supplement fertilizer with applications of barnyard and green manure.

Two types of seed are in use at present. Whole, unprocessed seed is sown at rates up to 10 lbs. or more per acre in order to ensure a thick even stand in the row. Processed seed (segmented), is becoming more popular. Some drills are equipped with special plates, others with "Cobbley" conversion units, to handle processed seed. Segmented seed is planted at rates of about 3 to 4 pounds per acre. The resultant stand contains approximately one plant every inch in the row with only a small percentage of double plants.

When the seedlings are about one inch high the crop is thinned to give one plant every 10 or 12 inches along each row. Thinning may be done completely by hand methods using hand hoes or by mechanical blockers followed by hand thinning. The objective in hand thinning is to obtain a 100 percent stand, of one beet per foot. Usually, because of gaps in the row, this objective is not reached. A 75 to 80 percent stand is considered reasonably good, that is 75 to 80 single beets every 100 feet of row length. Cultivators used for cross blocking, or"down the row" blockers such as the "Dixie" and the "Eversman", are capable of producing up to 80 percent stands if used in conjunction with precision drills. It is usual to follow these machines with hand thinning to eliminate doubles. A certain number of double plants in one spot in the row can be tolerated. An excessive number will result in a reduction of yield as well as poorer quality topping by mechanical harvesters.

Weed control during the growing season entails the use of row crop cultivators. Cultivation is carried out as often as necessary to eliminate weed growth between the rows. Mechanical cultivation stops once the plant leaves grow large enough to cover the space between the rows. On the final cultivation stroke, if not before, the cultivator is equipped with furrowing shovels to provide a shallow trench between the rows for irrigation purposes. Usually two applications of water are made. One during the growing season and one about 2 or 3 weeks before harvest. Dry seasons may require three or more applications of water to the crop. Excessive water erosion in the furrows is detrimental not only to the soil itself but to the operation of the mechanical harvesters which move up and down the rows with the tractor wheels in the furrows. During the growing season the crop is hand hoed twice, just after thinning and again after mechanical cultivation becomes impossible. This is necessary to control weed growth between the beets in the row.

Harvesting.

In Southern Alberta the beet harvest is delayed as long as possible in order that the roots may reach a maximum sugar content. The sugar in the beets is often as high as 18 percent. Harvest usually starts about the 20th of September and is in full swing early in October.

The first step in harvesting beets is to plough in, and level off, headland and contour ditches in the field. This is necessary to provide access to, and passage over, the fields by the various machines in use.

The second step is that of plowing or loosening the plants in the row.

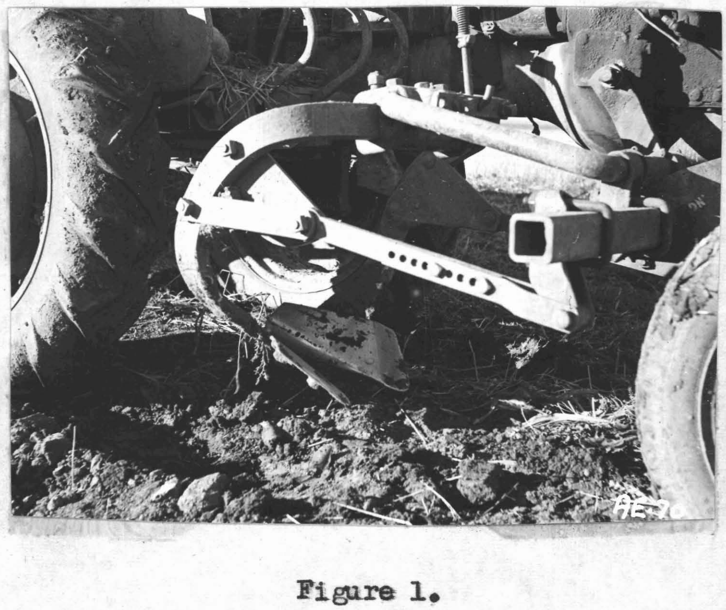


Figure 1.

Single row tractor mounted beet lifter.

Several types of beet lifters are in use, some are single-row horse drawn units, while the majority are single or double-row tractor-mounted machines. The business end of the lifter can be seen clearly in figure 1. The two shares are set about 7 inches apart at the front end and 2 inches apart at the heel. The shares and replacable points form a trough with the points set slightly lower than the heels. In operation the points run at a depth of 6 to 7 inches, which is deep enough to get well below the thick sections of the tap root. As the plow moves forward the shares apply an upward pressure against the soil next to the root. This loosens and partly lifts them from the soil. The effect of the shares on the root is clearly shown in figure 2. The shank supports are arched to provide an unhampered passage way for the leaves of the beet.

Figure 2.

Action of lifter shares on beet roots in the soil.

The third step in hand harvesting consists of the beet worker lifting the beets from the soil by hand. Two or more plants are grasped by their leaves, pulled free, and are thrown into piles or into windrows.

The most common practice is to pile four or six rows into one. The windrows are then topped and thrown together to form an 8 or 12 row windrow of topped beets.

In all cases where the windrow method is used it is necessary to run an "A" shaped drag between the windrows of untopped beets. This leaves a smooth shallow path four to five feet wide into which the topped beets are thrown. This operation is essential if a mechanical loader is to be used to load the beets into trucks. The use of the drag helps materially in eliminating clods, leaves, and trash from the load. Figure 3 shows a homemade type drag in action.

Figure 3.

A Homemade "A" Drag. The smooth trench greatly facilitates efficient mechanical loading.

Until the advent of successful mechanical toppers, all beets were hand topped. The worker uses a heavy bladed knife about the size of a large carving knife. A short 3 inch metal hook is usually rivetted to the end of the blade. The hook is used to pick up the beets from the pile or windrow and the top is severed from the root by a chopping motion of the knife. The correct topping point is at the location of the leaf scar at the base of the crown. On very large beets with ragged leaf growth on the crown, more than one stroke of the knife is used to completely clean off all green material from the root. The optimum topping job is one in which the smallest possible amount of root tissue is cut off with the tops, without leaving green material on the root. The farm operator and the factory field representatives have maintained constant watch on the quality of work done by contract workers.

Figure 4.

Hand Labour Methods. View on left shows single row lifter and a beet topper at work. The picture on right illustrates the windrow method of pulling beets. Note the stoop labour involved in both cases.

Topped beets are loaded from the windrow into trucks by hand forks or by mechanical loaders. The beets are hauled from the fields to the "Receiving Stations" or beet dumps. The stations are located along the rail lines at various strategic points within the beet growing area. At the dumps the load is weighed in and the truck is weighed out again after each load. The operator receives a receipt slip for each total day's deliveries. This slip shows gross weight, truck and dirt tare weights and net delivery.

At the beet dumps each load is passed through a large cleaning drum. The soil is knocked off the beets and passes down a chute. The truck picks up this dirt from the chute and the dirt is weighed out with the truck as part of the truck tare weight. As the beets tumble out of the cleaning drum onto a conveyer belt which carries them to the silo pile or rail car, approximately a 25 pound sample is taken from each load. The sample is cleaned, trimmed of any green on the crown, and is reweighed. The tare weight thus obtained is charged against the load on a percentage basis. Thus each load is charged with a haulback tare and with a dump tare. The former soil goes back to the field, the dirt represented by the dump tare goes into the factory or receiving station silo pile. The beets are stored in large silo piles and are carried to the factory by rail cars as required for processing.

Figure 5.

Portable Beet Pilers. Note the waiting line in the picture to the left.

Note method of unloading beets at the dumps. Special boxes are used on trucks for this purpose.

Note - the tare house, the large piling elevator, and the dirt chute.

CHAPTER IV

The Mechanical Beet Loader

The first major step toward mechanization of the beet harvest in Southern Alberta was taken in 1943. Canadian Sugar Factories Ltd., constructed about twelve loaders built after the general pattern of the American "Diamond" loader. These units were put into use in the fields that same fall. In 1944, "The Robinson Engineering and Development Co.," of Calgary, put approximately twenty "Robin" loaders into operation. These early models were pressed into service even though they were not completely out of the experimental stages of development. Mechanical difficulties were encountered on the first machines: however these troubles have been overcome so that at present the commercial units in use are giving good satisfaction. The "Robin" model has been replaced by the "Robeco" machine. In 1946 the John Deere organization introduced a loader as a companion unit to the 54A harvester.

The loaders in use today have the same basic principles of construction, differing only in some mechanical details. The machines are pulled in the field by tractors of 2-3 plow or greater capacity. Power is taken from the power take-off shaft on the tractor to operate the elevating and pick-up mechanisms. Field observations indicate that loaders have a capacity of up to 1½ tons of beets loaded per minute into the truck. Loading rates of one ton per minute are the general rule.

Figure 6.

A Beet Loader in Use. Note the care with which truck and loader speeds must be synchronized.

The beet loader is not unlike the sheaf loader in general design and appearance. The beets are picked up by a short elevator and are delivered to a cross elevator. The main elevator mounted cross wise at an elevated angle of about 35°, carries the beets sidewise and upwards to deliver them into the truck. The loader and truck, or tractor trailer unit, move together down the beet windrow at ground speeds not in excess of 2½ miles per hour. Ground speed is limited by the volume of beets delivered by the loader. Operations of this type require careful synchronization of forward speeds. The operation is generally more difficult when tractor trailer units are used, than when trucks are employed. The various machine elements in the loader are discussed briefly here to give a clear picture of how the loading operation is performed.

The throat of the loader contains two units, the crowder blades and the pick up beater. The crowder blades, or side wings, are forward extensions of the pick up elevator sides. The wings narrow in from a front width of over 3 feet on some units to an elevator width of just over 26 inches. The side wings serve to gather in the beets in the windrow and to crowd them onto the pick up beater. Some difficulty has been experienced on wet soils in getting the beets to slide against the sheet iron side wings. Rotary side wings have been employed to overcome this difficulty. The rotary wings consist of two, 18 inch diameter power driven steel discs with radial flanges. The rotary wings aid the movement of the beets toward the pick up elevator. Under most soil conditions it has been possible to do good work with both types of side wings.

Several forms of pick up beaters have been used. One form used on early model loaders is shown in figure 7. The pick up beater on the 1948 model Robeco loader is shown in fugure 7A. The beater is power driven and turns against the direction of ground movement of the loader. The pick up is adjusted so that the beater rides against the soil and gets under the beets in the windrow to lift the roots and move them back onto the open link potato chain type elevator belt. The John Deere beater, not illustrated here, consists of a one inch square shaft bent into the form of a crank shaft with throws in three planes.

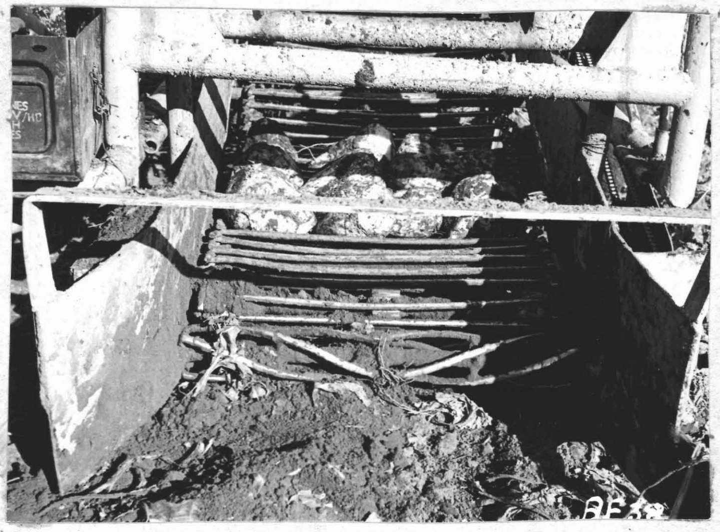


Figure 7.

Throat and Pick Up Elevator on an Early Loader

Note - Stationary side wings and a spiral form of beater is used.

Figure 7A.

Throat and Pick Up Elevator on Robeco Loader. Note- rotary beater, stationary side wings, steel rod potato chain type elevator belt.

Beets are elevated in two stages. The pick up elevator delivers the beets into a basket at the rear formed by the frame of the machine. Potato chain type carrier belts are used as illustrated in figure 7A. Open carriers are necessary to screen out soil that lifts with the beets. The cleaning action of the loader begins at this stage and continues throughout the loading process. The drive to the pick up elevator is located on the upper shaft. The belt is carried on spools at the lower end and bumper sprockets in the centre. Spools are necessary to eliminate stoppage caused by small stones. Carrier sprockets at the pick up end gave considerable trouble from this cause on early machines. The pick up elevator is adjusted from the tractor seat. The beater should run snug against the trench soil but should not dig deeply into the soil.

The main elevator utilizes the same type of carrier belt as does the pick up elevator. The belt extends under the basket to move the beets upward. On most loaders, (John Deere excepted), the drive is carried to the upper elevator shaft. Two wooden roller bumper guards are fitted just under the upper end of the elevator to protect the belt and elevator from catching on the truck box during the loading process.

The drive line from the power take-off on the tractor is carried through adequate slip clutches, power shafts, gear boxes and chains to the various components. The top end drive has proven most successful on both elevators. The John Deere unit, as indicated above, does not have an upper shaft on the main elevator. Power is transmitted to the elevator belt through the bottom shaft. This forms a push type drive that is a slight disadvantage in stony land. Small stones one to two inches in size fall through the belt and are carried downward to the sprockets. This has often caused considerable delay in the field. Spool type carriers help to eliminate much of this trouble at the lower end of both elevators.

Figure 8.

Loader Pick Up Unit in Action.

Note - the crowding of beets against the stationary side wings.

Figure 9.

Robeco Loader, 1948 Model

Note - the use of hydraulic pick up control, open link carrier belts, and roller type bumper guards under the main elevator frame.

Loaders have mechanized one of the heaviest jobs in the beet harvest. The use of an open belt type conveyer permits these units to deliver relatively clean beets into the truck. The short drying period between topping and loading is normally sufficient to enable the bumping action of the carrier belts to remove considerable soil from the beets. This is especially true under moist conditions on the lighter soils. The normal rate of one ton per minute enables the operator to keep his hauling trucks on the move. The high loading rate thus minimizes the delay in getting beets into the dump. It also decreases considerably the low gear mileage of trucks in the soft fields during the loading process. Another advantage for the high rate is that it helps to reduce weight loss by the root while lying in the open field.

Loaders are a relatively simple mechanism. Their use in the beet harvest has materially reduced the back breaking labour involved in digging and delivering beets during a season when outside work is often not very pleasant. Future trends in mechanization may supplant the loader, but they have to date been a useful tool for the beet grower.

An Original Loader At Work.
This load required less than six minutes total time and contained over 6 tons of beets.

Figure 10.

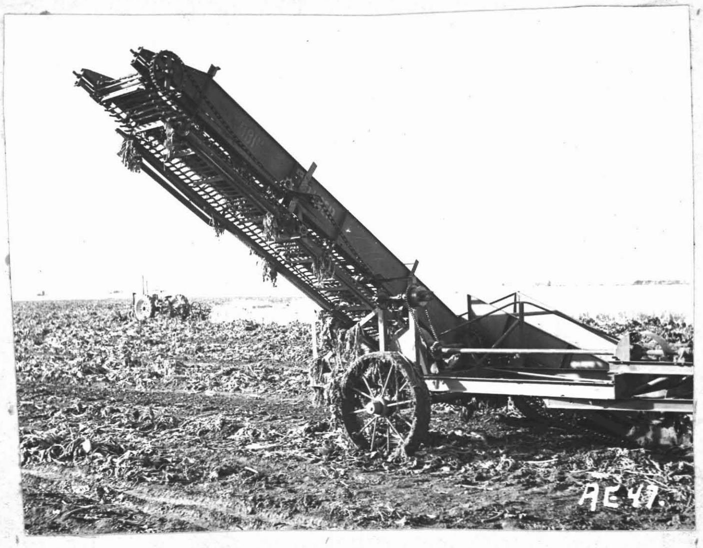


Figure 11.

An Early Model "Robin" Loader, Side View.

This power line is illustrated and the slip clutch on jackshaft drive to main elevator is easily seen. Carrier lugs were used on main elevator.

Figure 12.

Robin Loader at Work, Rear View.

Note basket at bottom of elevator.

CHAPTER V

Harvesters In Use In Southern Alberta

Two machines, the John Deere 54A and the International HM-1, have to date found the greatest grower acceptance in Alberta. The Kiest and the Sam-n-Andy harvesters have been used to a limited extent. This chapter will discuss the various machine elements used on each unit.

The John Deere 54A Sugar Beet Harvester.

The 54A harvester is a single row tractor mounted unit. It is mounted on the John Deere Model "A" tractor. The Harvester tops the beets in the ground, windrows the tops, and digs and windrows the beets. A mechanical loader is used to load the beets from the windrow into the truck.

Figure 13.

The 54A Harvester.

The windrows of beets and tops can be seen. Normally two operators are not required.

Figure 13 illustrates a 54A unit in use in the field. The machine is designed to require only one operator, however, under short row conditions, some time can be saved through the use of an additional man. The harvester operates up and down one side of the field.

Two rolling coulters each carrying a small jointer are mounted in front of the tractor. The discs are flat and are set about 10 inches apart. The function of the discs and jointers is to cut away withered leaves or stems that lie along the ground. Since the row of beets passes between the discs a clear path is left on each side of the row. This is necessary to prevent fouling the knife with trash or other material. The discs and jointers can be seen in figure 20.

The topping unit, the top pick up drum, and the cross elevator are mounted just behind the front wheels of the tractor. The drum and topper are mounted 18 inches to the right of the tractor centre line. These units sever the tops from the beets, pick up the tops and place 4 rows into one windrow.

The finder mechanisms on the topper consists of 7 feeler wheels. Four are mounted on the lower shaft and three on the upper shaft. The wheels or discs are notched around their periphery. They are about 6½ inches in diameter and ¼ inch thick. The shafts are so placed that the discs inter run with about one inch space between adjacent discs. The finder is power driven at just slightly more than ground speed. The discs find their way through the leaves onto the crown of the beet as the unit moves down the row. Spring loading is applied through the knife linkage to aid the discs in gauging the thickness of cut using the crown of the beets as the measuring point. The finders are linked mechanically to a sliding knife and through this linkage control the thickness of cut. The knife is crescent shaped with an overall radius of 10 inches. Turnbuckle adjustment is provided to change the thickness of slice as desired. In addition a hand lever adjustment is provided for wide changes of cut. The mechanical links provide for manual selection of 4 ratios of movement. These ratios are: ¾ to 1, 1 to 1, 1¼ to 1 and 1½ to one, approximately.

Thus if the finders raise $1\frac{1}{4}$ inches the knife will raise 1 inch. The topping mechanism can be seen in figure 14.

Figure 14.

Topping Unit and Top Pick Up Drum (54A). Note the notches on the finder wheels.

Two arms support the knife in position just under and slightly behind the finders.

The tops are raked off the knife by the pick up drum. Seven back rake fingers are used to hold the tops against the drum fingers as the tops are carried backward, upward and over to be deposited on to the cross conveyer. The drag apron can be driven to the right or left and the conveyer platform can be shifted to any position from the extreme right to the extreme left. This enables the operator to place 4 rows of tops into one windrow as the machine moves up and down the field.

Figure 15.

Pick Up Drum Deposits Tops on Conveyor.

Note the cross conveyor clutch control rod running across the face of the fly wheel.

Figure 16.

The Tops Conveyor Windrows the Tops.

The next stage in the harvesting process consists of lifting, elevating, and windrowing the topped beets.

Lifter points of standard design are mounted just behind and slightly under the tractor rear axle housing. The lifters have long heel extensions. The beets are lifted and grasped by a pair of kicker wheels which move the roots back onto a short elevator. The kicker wheels are spring loaded so that they will spread apart to handle any size beet. The kickers are of open cage construction and are power driven in opposing directions. In addition to moving the beets backward the kickers help to break up the soil ribbon that is lifted with the beets. The short elevator delivers the beets into the basket formed by the frame of the long beet conveyor. The elevator and the beet conveyor utilize carrier belts of open steel rod construction. The conveyor can be swung through an arc of 180 degrees behind the tractor and can take up any intermediate position of that arc. The operator utilizes that feature to place the beets from 8 rows into one windrow.

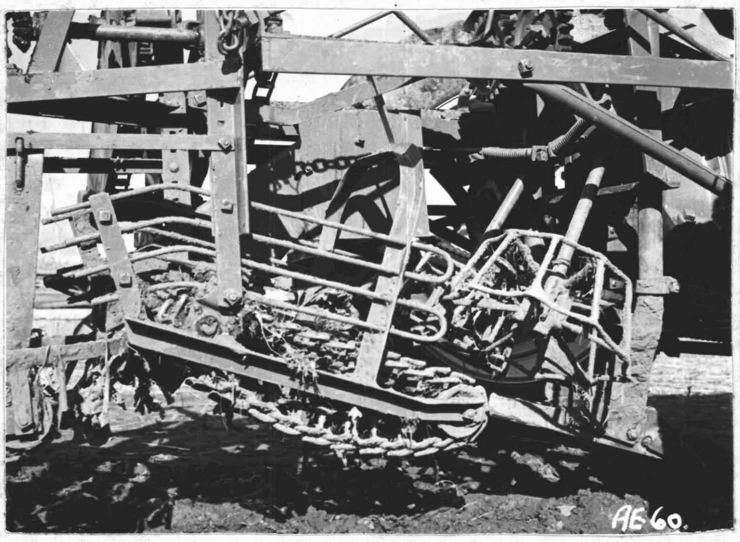


Figure 17.
The Digging and Elevating Unit. Note the cage like kicker wheels, the lifter points and the short elevator.

Figure 18.

Soil Load on Elevating Unit.

Soil screening is important.

The 54A harvester carries an integral "A" frame mounted behind the rear axle of the tractor and left of centre. The "A" frame is constructed of metal and when lowered to the ground on the 7th row of each windrow, prepares the shallow trench required for the succeeding windrow. The frame can be seen in figure 19.

Figure 19.

54A Harvester "A". Frame.

This frame is the only element raised and lowered by a hand lever. The wings have a spread of 36 inches.

The harvester digging and elevating mechanisms overhang the rear of the tractor. This reduces the weight on the front wheels and interferes with steering. To off-set this, a large weight box is mounted on the front of the radiator. Ballast must be placed in the box to hold the front wheels down for proper steering. The weight box can be seen in figure 20.

Normally the 54A harvester places the beets into windrows in the field. Figure 20 illustrates one unit in which the beet conveyor control cables have been remodelled to enable beets to be elevated directly into a truck. Carrier lugs were welded onto the conveyor chain and bumper guards placed under the elevator. Two such units were found in the field during the 1946 survey. The harvesters were remodelled in an effort to cut overhead costs by eliminating the need for a mechanical loader. On an acre basis this method of use requires slightly over 4½ miles of low gear truck operation in soft field conditions. The cost considerations involved are discussed later in this report.

,<u>The 54A Harvester Self Loading Into a Truck.</u> Note the trampled condition of the field and the failure to conserve the tops for feed.

Figure 20.

Power to drive the various components of the 54A harvester is taken from the tractor power take-off shaft. Numerous chain and shaft drives are utilized to transmit the power. Spring loaded slip clutches are provided at various points to protect the mechanisms from overload damage. All units, except the "A" frame, are raised or lowered by linkage to the hydraulic rockshaft of the tractor. The beet conveyor is swung through an arc of 180 degrees by means of a large pivot ring and friction lever. Hand lever depth control is provided for the lifter points, also the lateral spacing of the points is adjustable. Since the harvester uses an "in-place" topping mechanism, ground speed is limited to not over 2 miles per hour. The performance of these machines in the field will be discussed in a later chapter.

The International HM-1 Combine

The HM-1 harvester is a true combine in that one trip down the row completes the harvesting operation. The unit is mounted on a Model H, M, or MD International tractor and harvests one row at a time. An "in-place" topping mechanism, a set of conventional lifter points, a cleaning trough, and an elevator that delivers the beets to a trailer cart, comprise the functional elements on the machine. The various mechanisms will be discussed in the order in which the beets are handled by the harvester.

The topping unit is mounted 18 inches off centre on the tractor and just behind the right front wheel. The gauging element is a multiple bar (finger type) sliding finder that rides over the crown of the beets and controls the thickness of cut taken by the knife. The finder is about 6 inches wide and is linked to the knife in such a manner as to provide movement ratios between the finder and the knife of 1 to 1, and $1\frac{1}{4}$ to 1. Early models provided a third ratio of $1\frac{1}{2}$ to 1. The linkage is essentially a parallel arm mechanism. The knife is an 18 inch concave disc blade mounted at an angle of 36 degrees to the horizontal. The disc is power driven running at a speed of approximately 275 r.p.m. A power driven receding finger type flinger is used to clear the tops from between the disc and the finder. The flinger throws the tops sideways under the tractor and against a windrowing deflector curtain. On the models encountered in this study only single row windrows could be formed. Under heavy foliage conditions, a metal cone is mounted around the shaft above the disc. The cone prevents the leaves from wrapping around the shaft. The topping unit is provided with six main adjustments. Each adjustment has a direct effect on the quality of topping. The first of these is a slotted hole adjustment in the finder mounting bracket. For normal size beets 5 to 6 inches in diameter the bolt should be about midway in the slot. The position of the bracket in the slot controls the measured distance between the edge of the disc and the tip of the finder fingers. The second adjustment is a large,disc angle,adjusting turn-buckle. The operating angle of the disc should be 36 degrees. In other words the disc should be $10\frac{3}{4}$ inches higher at the rear edge than at the leading edge. Thirdly a counter balance spring is used to control the static load of the finder on the beet. This load should be about 50 pounds for average conditions.

Figure 21.

HM-1 Topping Unit.

The finder, disc and various adjustments are easily seen. Three movement ratios are provided for on this machine.

The thickness of cut can be adjusted by means of a screw crank located convenient to the tractor driver. The crank can be operated while the machine is in motion and controls the cut within a range limited by the screw thread. The screw crank and finder are linked by a bell crank and a small turn buckle. Holes on the bell crank into which the buckle is pin connected, make possible the selection of the movement ratio which provides for differential topping by the unit. The turn buckle is used to change the cutting range available through the screw crank. The topping unit provides a wide range of adjustments to meet varying field conditions. Figures 21, 22 and 23 show the working parts of the unit and show it in action in a stand of beets having very light foliage.

Figure 22.

Improved HM-1 Topper

Note the screw crank control, and the cone on the disc. Two movement ratios are provided in this unit.

As the machine moves down the row the topped beets are loosened by the lifter points. A pair of notched coulters straddle the row ahead of the lifters. The coulters reduce the size of the soil ribbon entering the machine. The lifter points are of the conventional two-bladed type having extended heels to raise the beet clear of the soil.

Figure 23.

HM-1 Topper in Action

Note the extreme abuse to which the disc is subjected.

A cleaning trough, which contains a "Rienks" screen, is mounted just behind the lifters and conveys the beets backward at the same time breaking up and screening out clods and soil. The screen consists of 4 power driven shafts cross mounted on $8\frac{1}{2}$ inch centres. Kicker wheels, 10 inches in diameter, are fixed on the shafts and rotate at about 200 r.p.m. against the direction of travel. A total of 30 kickers are used in the screen. The net spacing between the wheels along the shaft is about $2\frac{3}{4}$ inches. Heavy baffle curtains hang into the trough to hold the beets and soil down on the rolls. The beets are subjected to rough handling which takes off most of the adhering dirt under light soil conditions. The cleaning trough delivers the beets to the elevator to be elevated into the cart or onto the sorting belt.

Figure 23A.

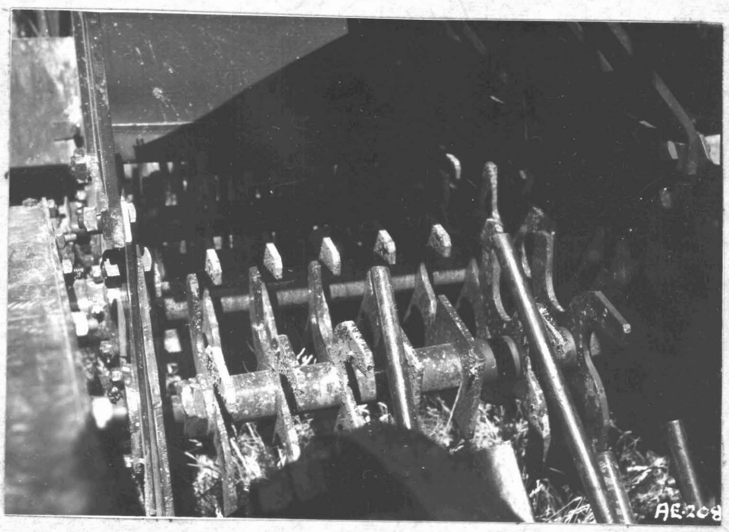
The HM-1 Harvester in the Field.

Normally two men are required at the sorting belt.

The beet cart combines the functions of a storage tank and a loader. The cart has the capacity to store about $1\frac{1}{2}$ tons of beets. The unloading elevator utilizes an open rod conveyor belt which runs across and forms the bottom of the cart.

Figure 24.

The Digging and Cleaning Mechanism. On the left a bird's eye view of the lifter points and kicker wheels is shown. The lower photo indicates the shape of the kicker wheels and the general make up of the cleaning trough.



The cart can be unloaded at the end of the rows or while in motion in the field. Unloading requires about one minute. The open link chain on the cart provides additional cleaning during the unloading process. A platform and railing is located on the cart for use when the sorting belt is required.

Figure 25.

<u>Power Line to HM-1 Beet Cart.</u> The power take-off drive to the cart and the relationship of the beet elevator and cart are shown. The sorting belt can be seen on top of the cart.

A wide continuous rubber sorting belt is mounted across the top of the cart. The belt is driven rearwards at about $\frac{1}{2}$ ground speed. The belt provides a clod elimination feature in that beets can be manually picked off from the belt and dropped into the cart. Clods, rocks and other undesirable material pass over the back of the cart and fall on to the ground. Some hand trimming of poorly topped beets can be done during the sorting process. The belt can be raised out of position if desired and the beets dropped directly into the cart.

Figure 26

HM-1 Sorting Belt.

Note the soil adhering to the roots and the clods on the belt.

The HM-1 unit is designed to work the beets out in lands. Ground speeds of about 2 miles per hour are advisable. The topper, lifter and elevating mechanisms are powered from a sprocket mounted on the belt pulley. The hydraulic "Lift-All" is used to raise and lower the units. The operating depth of the lifter points is adjusted by a screw crank mechanism. The beet cart is driven from the tractor power take-off shaft and the sorting belt from one wheel of the beet cart. All mechanisms are well protected by slip clutches.

Figure 27

Rear View of Beet Cart.

Figure 28.

Unloading the Cart.

Note the soil under the cart.

This report deals primarily with the early model harvesters. It is thought advisable to indicate one or two of the major changes made on 1948 models. In addition to such changes as heavier chains and general strengthening, there have been two revisions that involve principles of operation. Hipple, J. L. (9), reports that the baffle curtain mounting has been revised to enable the operator to place 4 rows of tops into one windrow. This change will off-set one objectionable feature in the harvester. The same author indicates that the top flinger is to be placed on a flexible mounting so that the flinger can clear itself more easily of extremely heavy top growth. These changes will materially improve the performance of the harvester, especially in those areas where it is desired to utilize the tops for feed.

The Kiest Bell Topper and Victory Loader.

The Kiest harvesting units were tried in Alberta on a small scale in 1946. Two operators did a reasonable season's work during the 1947 harvest. Some of the basic principles used on these machines represent a definite effort to provide the large acreage grower with a mechanization program suitable to his needs. For this reason a short description of the machines is included here. Two separate units are used to complete the harvest. The first is a 4 row topper, the second is a 2 row lifter loader.

The Bell Topper consists of 4 topping heads mounted within the one frame. Each bell is rotated in an opposite direction to its mate so that the tops are picked up by two short pick up elevators. The short elevators deliver the tops to a cross conveyor. The cross conveyor terminates in an elevator designed to deliver the tops directly into a cart or truck. The topper frame is mounted directly on the rear axle housing of the towing tractor. The mechanism is driven by an auxiliary motor of from 12 to 15 horse power capacity, consequently, a small tractor of the Farmall A size can be used to pull the unit. The rear of the topper is carried on two castoring air wheels to facilitate "down-the-row" steering, and turning.

A solid shoe type sliding finder having a 7 inch flat base and an upward curved leading edge controls the ground topping mechanism. The shoe rides down the row sliding onto and bending over the tops. Thus the gauging point is the bent over leaf stems rather than the crown of the beets. The shoe is mounted under spring tension so that it will ride easily onto the beet yet exert pressure on the stems. The shoe finder is connected solidly to the angle iron arms that carry the topping knife. Vertical and horizontal bolt adjustment is provided for the throat clearance between the knife and heel of the finder.

Figure 29 .

The Kiest Bell Topper.

This view shows the general layout of the machine.

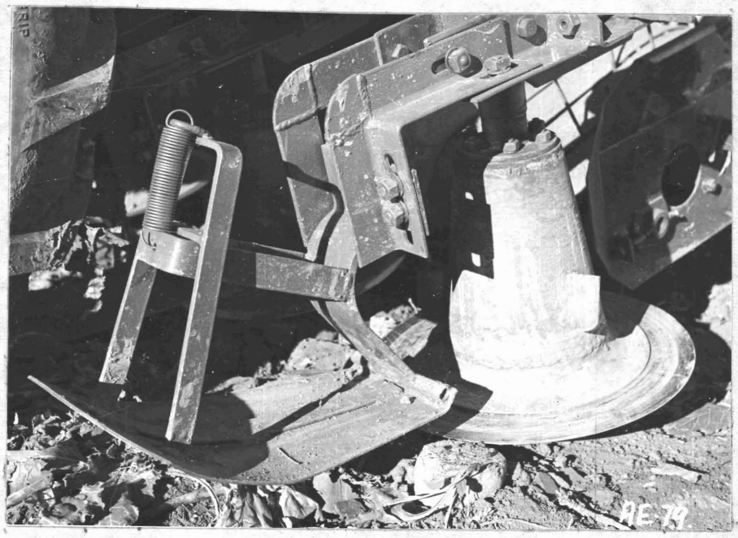


Figure 29A.

The Kiest Bell Topper

This picture illustrates the component parts of one topping head.

The topping knife consists of a hollow bell shaped housing mounted at an angle to the horizontal. The bells carry about a 2 inch knife rim around their mouth and are driven by a V belt through an axial shaft and a pulley. Angular mounting of the hollow bell is necessary to permit the bell to drop down to a low beet after topping a high one. A flat disc would ride on the crown of a high beet and could not fall down to the proper level for topping the next lower beet. Each bell is carried on a pair of long arms pivoted at the back of the frame and counter-balanced by two heavy coil springs. The location of the springs on the arms behind the pivot shaft is adjustable to provide topper head weight selection, to meet various conditions of top growth.

Figure 30.

Kiest Topper

The main elevator has been removed on this machine.

Figure 31.

Rear View of the Kiest Topper

The 4 row topper does not lift the beets from the soil. This is left for a subsequent operation. The possibility exists that some difficulty might be encountered in finding the rows when the lifter loader is used. In general this is not true as can be seen in figure 32. However, where all beets tend to have their crowns below ground level, some difficulty might be encountered. For this reason operators try to keep the lifter loader working not more than one day's work behind the topper.

Figure 32.
Field Conditions After Topping. The rows of topped beets are clearly defined. Some crown breakage and green stringers can be seen on the beets in the foreground. Normally there are no tops lying in the field.

The Kiest Victory Loader.

The Victory Loader is a 2 row lifter loader designed to work as a companion unit to the Bell Topper. Ground speeds of 3½ to 4 miles per hour are obtainable with the loader. The frame of the loader is rigidly mounted to the tractor axle housing and castoring air wheels are used to carry the back of the frame. Two pairs of conventional lifter points dig the roots from the soil and deposit them onto a short elevator. Potato chain type belts are used on the short elevators. A "Rienks" roll similar to that used on the HM-1 harvester moves the roots to the right onto a large elevator. The cleaning trough is used to screen out soil, to break up clods, and to whip off any green stringers on the crown of the beets. Flap boards are provided to hold the beets down on the rolls and retard the movement of the beets toward the main elevator. The main elevator is very similar in construction to those found on the mechanical loaders described in chapter four.

Power is obtained from the tractor power take off shaft. A two-three plow tractor is the smallest unit usable for towing. The lifter points are controlled through the tractor hydraulic unit or through a hand operated hydraulic pump on the loader. Roller chain drives are used to carry power to the cleaning trough and the short elevators. The main elevator is driven from a gear box by a power shaft and universal joints. The drive is carried to the top of the main elevator. Slip clutches are provided on the main drives throughout the machine. Figures 33 and 34 give the general layout and construction of the loader.

Figure 33.

The Victory Loader at Work.

Some detail of the drive lines can be seen. The reader should note the excessive amount of soil in the load on the truck. The soil in this field was too heavy and too moist for successful operation of the lifter loader.

Figure 34.

<u>Detail of the Victory Loader</u>

The top picture shows the two pair of lifter points mounted below and behind the tractor rear axle. The lower picture shows the short elevators and a portion of the "Rienks" rolls. Beet movement is to the top and the left in this illustration.

Sam-n-Andy Topper and Robeco Windrower.

Attempts have been made in practically all beet areas to develop harvesting equipment to meet the demands of that area. Southern Alberta is no exception. Following is a brief description of one unit that is a result of the efforts of local growers. Mr. Andy Briosi developed a 2 row topping unit during the early war years. This original unit with some modification was produced in 1948 for experimental purposes by the Robinson Engineering and Development Company of Calgary. No performance data on the unit are obtainable at the time of writing. This discussion is included since the machine reflects the needs of the growers in the district.

The 2 row topping unit utilizes in-place topping heads. The tops are picked up and delivered into a truck for immediate storage as feed. The topping head carries power driven finder wheels connected by a fixed linkage to the power driven 16" concave topping disc. Turn buckles are provided in the linkage to adjust the throat spacing between the finders and the knife. No movement ratio is obtainable within the linkage to meet extreme conditions. The unit is drawn by a small row crop tractor. The various components are driven from the power take off shaft on the tractor. Figures 35 and 36 indicate the general layout of the topper. Figure 37 illustrates the original Briosi 2 row topper.

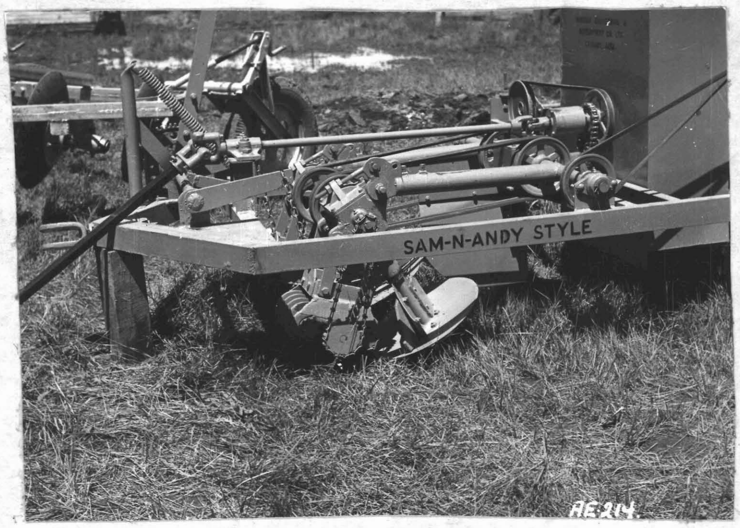


Figure 35.

Sam-n-Andy Topper. The topping head, the drive, and the hitch arrangement are shown.

Figure 36.

The Top Pick Up and Elevator.

The pick up chain flips the tops into the basket. The elevator carries them upward into a truck. Note the pickup height adjustment on the wheel mounting.

Figure 37.

Original Briosi Topper

This machine used a power driven disc and a roller chain crawling finder. The topper was of the fixed cut type. The tops were elevated into the trailed wagon. Beets were left undisturbed in the soil.

The Robeco windrower was developed as a companion unit to the two row topper. The windrower was designed to handle either topped or untopped beets. It is a single row machine utilizing a conventional set of lifter points to lift the beets. The roots are carried back by a short elevator of open steel rod construction and are deposited on a cross conveyor. The conveyor belt can be driven in either direction and the platform can be shifted, by power, to any position from the extreme right to the extreme left. The unit is capable of windrowing 8 rows of beets. The small farm tractor of 10 to 15 drawbar horsepower will handle the machine without too much trouble in most field conditions. The elevators are driven by the power take-off. A double reduction hand screw is provided for depth control of the lifters. A measure of cleaning is obtained through the use of open link belts and a rubber cover belt over the cross conveyor. This belt rides on the beets and imparts a rolling action that aids somewhat in removing adhering soil.

The basic purpose in the design of the topper and windrower is to provide a harvesting combination within the price range of the small acreage grower. A mechanical loader will be necessary to complete the harvest. Future development of this line of harvesting equipment will be watched with interest since it provides for maximum utilization of the tops as feed.

Figure 38

The Robeco Windrower.

Note the beet paddle mounted just above the lifter blades.

Figure 39.

Right Side View of Robeco Windrower.

CHAPTER VI

The Basic Principles of Mechanical Harvesting

The Importance of Topping and of Dirt Removal.

Growers have placed considerable importance on the quality of topping obtained during harvest. There are two basic reasons for this. The first arises from the fact that the correct topping plane in the beet is located very near to the plane of maximum root diameter. Careless work by hand labour, or by machines, can easily result in an appreciable loss of root tissue. The lost tissue remains on the severed crown. This condition might be termed "over topping". On the other hand "under topping", which involves cutting a crown slice that is too thin, will result in some green material being left on the beet. An excessive amount of green material increases the difficulties involved in processing the roots. The difficulty arises from the existence of certain salts in the crown and leaves of the beets. In practice the location of the topping plane on the root must be kept very close to the optimum from the viewpoint of the grower and of the processor.

The farmer and the processor benefit when clean beets are delivered to the receiving station. Excessive soil in the load represents an additional hauling cost to the grower. The beets are normally handled from the dump to the factory by rail, hence the processor pays heavier freight charges per ton on a clean basis. The beets are washed in large sluice boxes at the factory just before they are sliced for processing. It has been stated that more than 10 percent dirt on the beets may result in overloading the washing facilities.

Dirt, and leafy material have a detrimental effect on beets while in storage in silo piles. Since the storage period may extend over a two or three month period the piles must be watched for spoilage. A certain amount of air circulation is required to carry off excess moisture and keep the roots in a sweet condition. Leaves and dirt block air movement and are a contributing factor to losses in the storage piles.

The Principles of Mechanical Topping.

In all mechanization programs it is first necessary to study the characteristics of the crop involved before successful machine elements can be devised to do the desired work.

The sugar beet is a broad leaved plant. The leaves are carried on thick heavy stems which terminate in the crown of the tap root. The leaves and stems vary in height and density. In Southern Alberta the top growth often reaches heights of 12 inches or greater. An average root is about 5 to 7 inches in diameter at a point 1½ to 2 inches below the peak of the crown. A dead leaf scar found on the crown represents the correct topping plane for the beet. Mechanical damage during cultivation, and off type beets, result in a ragged crown condition in which leaf growth is found below the optimum topping plane. This makes both hand and mechanical topping more difficult. Figure 40 illustrates the ragged crown and clean crowned condition in beets. It is possible with mechanical toppers to adjust the linkage to remove sufficient tissue from the crown to eliminate green stringers. This may result in a substantial yield loss. It is often economical to utilize hand labour to trim the poorly topped beets rather than remove excessive meat.

Figure 40.

Crown Conditions in Beets.

Note the side growth on the 2 beets to the left.

The weight of tops varies somewhat, but often runs as high as 75% of the weight of the roots. The green material and the root tissue on the crown form a valuable feed for cattle. It is generally recognized that the tops deteriorate rapidly in feed value if allowed to dry out in the field. The most effective method of conserving tops is to silo them as soon as they are cut from the roots. Tops are often pastured-off by cattle turned into the fields after the harvest is completed. It has been stated that, based on alfalfa at $14.00 per ton and barley at 60¢ per bushel, the tops from one acre of beets have an equivalent feed value of nearly $20.00.

Powers (13) has enunciated certain physical and material characteristics of beets that govern the design of mechanical toppers. He states: "Approximate linear relationships were found between beet height, greatest diameter, and crown thickness (distance from top of a beet to its lowest leaf scar)". These relationships may be expressed more fully as follows:

(1) The larger the diameter of a beet, the thicker will be the cut for optimum topping.

(2) The larger the diameter of the beet the higher it will normally grow out of the soil. The height being measured to the top of the crown.

(3) The larger the diameter of a beet the higher its correct topping plane, as indicated by the lower leaf scar, will be found above ground surface.

It does not necessarily follow that the area of greatest diameter of a beet will be located above ground level. Usually it is found that the area of greatest diameter is below ground surface. Often the correct topping plane is located at or slightly below the surface of the soil. Machine toppers lift the beets from the soil and then top them. This type of mechanism is restricted to the diameter - thickness of cut relation as a means of measuring the amount of cut to be taken. Ground toppers must utilize the relation between the height of the beet above ground and the thickness of cut required.

Powers has also discussed two other characteristics that have a decided influence on topping mechanism. In light soils beets often grow to a height of 4 to 6 inches above ground surface. These beets do not have great overturning resistance to a finder mechanism pressing against them. By experimental methods Powers found that few beets would be overturned if the horizontal component of the force of the finder on the beet did not exceed 6o pounds. The second factor arises out of normal thinning practice. The beet spacing of 10 to 12 inches along the row makes it necessary for a ground topping mechanism to return to ground level very quickly after topping a beet. At speeds of 2 miles per hour the mechanism must handle nearly 4 beets per second.

One more factor must be discussed before a full understanding of ground toppers can be reached. The beet root is normally very turgid and brittle. When a thin edged knife is drawn through the root a shear plane develops along the horizontal surface just ahead of the knife. This shear force often results in a tension break along a 45^{o} plane below the shear area. The result is a breaking down of the root after topping is about half completed. Powers (13) indicates that this difficulty can be overcome in one of two ways:

(1) By using a topping disc, power driven, to impart a velocity component to the cutting action of the knife and at right angles to the direction of travel.

(2) By using a very thin sliding knife actuated by a crawling finder.

The finder imparts a counteracting rearward thrust to off-set the shearing action of the knife. In order to be effective the finder must be connected to the knife by some form of slip linkage that enables the finder to hug the crown of the beet during its entire time of contact with the root. This slip link also enables the finder to proceed immediately to ground level without loading the knife onto the beet. The sliding knife can then remain horizontal in the beet until topping is completed.

The considerations just discussed are related to the topping mechanisms encountered in this thesis as indicated below:

The HM-1 harvester uses a ground topping mechanism, thus the crown of the beet becomes the gauging point for topping. The sliding finder is of the finger type to enable the fingers to work through the leaves onto the crown. A power driven disc is used at such an angle that it presents the thinnest possible cross sectional depth to the beet. The velocity component and knife section requirements are thus fulfilled. Mounting the disc at an angle enables the disc to return to ground level as soon as each beet is topped. No slip link connection is used between the finder and the disc. The movement ratios of 1:1 and $1\frac{1}{4}$:1 enable the mechanism to satisfy the ground-height relationship of the beets in the field. The amount of cut taken by the knife is manually adjusted. The movement ratios provided compensate this setting to the size of beet. This is done by the linkage increasing or decreasing the cut above and below the set value as the finder encounters different sizes of beets in the field. The topping head is quite heavy, consequently a tension spring relieves some of the load on the beet, yet it can be adjusted so that sufficient weight remains to return the mechanism to the ground. It will be remembered that the static load on the beet as measured at the finder was given in Chapter V as about 50 pounds.

The John Deere 54A topper is of the in-place, variable cut type. The finders are thin in width to enable them to work through the stems onto the crown. The variable cut feature is provided through four movement ratios that enable the mechanism to adjust the cut about some manually set value as governed by the height of the beet. The thin crescent shaped knife drops off the beet quickly. The notched power driven finder wheels hug the crown of the beet and hold it back against the shearing action of the knife. A slip link connection enables the knife to remain horizontal in the beet while the finders return to ground level. The mechanism is quite light hence spring pressure is used to hold the finders down to their work. Overturning is avoided by keeping the net pressure on the beet at a sufficiently low value, and by the use of the crawling, notched finder wheels.

It has been indicated that top disposal is an important feature of the topping mechanism. Both the 54A and HM-1 units make some provision for top utilization. It will be realized that the method employed by the Kiest and Robeco units is somewhat more favourable from the viewpoint of conserving feed value than that used by other models discussed.

Soil Screening and Root Disposal

The severity of the soil screening problem in sugar beet harvesters has been indicated by Powers (13) who estimates that a single row unit operating at $2\frac{1}{2}$ miles per hour lifts 2.72 cubic yards of soil per minute or about 480 tons of soil per acre. Assuming a 20 ton crop and that one load does not contain more than five percent of loose dirt it becomes apparent that a harvester must be 99.8 percent efficient in separating soil from the beets.

Two methods of root disposal are found on the machines encountered in this study. These methods and their corresponding system of soil screening will be discussed.

The 54A unit utilizes the windrow storage method of root disposal. In this method the roots are stored for a short period before being loaded onto the truck. During the storage periods the beets are subjected to drying in the daytime, and, unless covered by tops, the beets may be frozen at night. The drying feature aids somewhat in soil removal during the loading process. On the other hand excessive drying for an extended period may result in a loss in tonnage. Thus the loading process should be kept up reasonably close to harvesting. Palmer,A.E. (10) reports that the loss in weight during storage in well covered piles on a farm basis has averaged 8 percent in tests conducted during the period 1932 to 1936. In these tests the beets were piled in large piles and covered with tops to prevent shrinkage. The storage period normally lasted until harvesting was completed. It is reasonable to assume that shrinkage may be as high as 8 to 12 percent if the beets are left in small uncovered windrows for a period of 48 hours or more. Soil screening on the 54A is accomplished through the use of open link potato type conveyer belts. The kicker wheels aid in breaking up the soil ribbon. No provision is made on this machine for clod removal or for positive cleaning action.

The direct delivery method of root disposal as found on the Kiest and International units represents a more complete grouping of functions in one machine. Direct delivery into trucks after the beets are lifted avoids loss by shrinkage. On the other hand, no drying action is permitted on the soil adhering to the roots. This might result in more soil being delivered into the truck with the beets unless special screening provisions are made.

Dirt and clod removal is generally combined with the function of transporting and elevating beets within the machine. The process of soil elimination begins with the lifters. On the HM-1 harvester a pair of notched rolling coulters are used to limit the size of the soil ribbon. The lifters should fracture the soil so that clods do not form. While special forms of plows are being developed for this purpose, the Colorado plow as illustrated earlier in this report is the standard form presently used in Southern Alberta.

The "Rienks" screen found on the International and Kiest units presents a reasonably successful form of cleaning mechanism. As will be shown later, they have not performed up to the standard suggested by Powers. The sorting belt used on the HM-1 provides successful clod elimination for those soils in which clod formation is a problem.

In summarizing this discussion on the principles of beet harvesters it might be well to indicate basic requirements. These are:

(1) Highly efficient topping is necessary.

(2) The top disposal method must permit efficient utilization of the tops as a food.

(3) Root recovery from the soil must be nearly 100 percent. The method of root disposal should facilitate hauling with the least shrinkage

loss possible.

(4) The machine should screen out clods and loose soil, and should remove soil adhering to the roots to the extent that the total dirt tare does not exceed about 10 percent.

(5) The harvester must be capable of operating under a wide range of soil, crop, and climatic conditions.

(6) The machine should be sufficiently simple that it can be easily handled by average farm labour.

Walker, H. B. (7) lists the machine elements that will be required in a successful harvester:

(1) Preparatory mechanisms such as coulters and discs.

(2) Topping mechanisms for "in-place" or "Machine" topping.

(3) Plows or other lifting devices.

(4) Elevating mechanisms.

(5) Soil beet separating mechanisms.

(6) Machine elements for root and top disposal.

(7) Driving and mounting elements.

Some of the basic requirements listed above are met in part by mechanisms now found on harvesters. Also in some cases the functional requirements are taken care of by dual purpose machine elements. Thus the elevating mechanisms are relied upon to effect efficient soil drainage. In 1944 Walker, H.B. (8) indicated that harvesters then in use had not reached completely satisfactory development. He stated:

"Machines now commercially available are operating in the field with sufficient success to keep them going, but these are also sufficiently faulty to create a desire for improvements. Topping, top recovery, and removal of roots without excessive breakage, appear to be the bottlenecks for a more satisfactory product at the dumps (factory)".

CHAPTER VII.

Topping Efficiency Studies.

The introduction of any new machine always brings questions into the minds of prospective users, and others, as to the ability of the machine to meet present standards. A field survey study was undertaken to answer these questions. Two methods of obtaining the data were considered. The first was to procure one or more units and put them to work in a field where all possible variables could be controlled. The second method was to study commercial units in the field as operated by owner-operators or farm labour. The latter method was adopted. It was felt that data obtained in this way would give a clearer picture of what might be expected in commercial use. Accordingly, as many machines as possible were visited during the 1946 harvest season. In each case data were taken on the work of the machine and on the work of contract labour in the same field.

A full discussion of the necessity for quality topping was given in Chapter VI. It was hoped that the topping efficiency studies would provide data that would be of value in estimating probable losses.

The Method of Collecting Data.

The procedure used to collect the information was basically the same for all machines, however some modification had to be made between different makes. The method used for the 54A harvester was relatively simple.

A length of about 100 feet of beet row was marked off. The beets at each end were dug by hand to give a 10 to 15 foot marker gap. Spaces were cleaned of all tops and beets beside the test row. As far as possible the test row was typical of the field itself. As the harvester came into the front gap it was stopped and all beets and tops were cleaned from the mathine . The top conveyor and beet conveyor were shifted to place the tops and beets in the cleared space beside the row. The machine then harvested the test row stopping in the marker gap at the/other end. Beets and tops were collected from the machine and from the space along the row into which they had been dropped. In this manner the beets and their tops were collected for weighing and study.

The HM-1 was tested in a similar manner. Here it was necessary to clear out the beet cart and to clear a ground space for the tops.

The Kiest topper was handled in a similar manner to the others. It was necessary to dig the beets by hand rather than wait for the Lifter Loader.

Sample material was collected from work done by hand toppers following the basic need of obtaining beets and the tops from those beets. In fields where the beets were topped from small piles it was relatively simple to obtain the sample. Where windrow topping methods were in use it was necessary to set aside a pile of beets and have them topped separately. The first sample of hand topping obtained in this way had to be discarded. The crew exercised great care in topping the pile. The result was that a representative sample of their days work was not obtained. This difficulty was overcome by giving a suitable reason for asking that a pile be topped separately and there-after a representative sample was gathered. Hand toppers have the power of conscious selection of the correct topping point on each beet as it is picked up. As the day progresses their work becomes more and more mechanical. If conscious selection was maintained throughout the day it would likely not be possible fOr mechanical harvesters to do equal quality work compared to hand labour. To offset any bias resulting in a step up in quality of hand work it was felt advisable to give aid in machine adjustment. Such aid was given only when the operator expressed dissatisfaction at the quality of work being done and requested that the machine be readjusted. This occurred in two cases in which the machine was obviously in bad adjustment.

Treatment of the Sample.

The beets and tops were cleaned of all soil and weighed. Cleaning was done with a wire brush, and with water wherever obtainable. Each beet was then inspected and any green material found on the crown was cut from the root. This material was weighed and was designated as "parings from the beets". Each top was treated in a like manner. Retopping in each case was done as nearly as possible to the theoretical topping point on the crown. Material taken from the tops was weighed and was designated as "parings from the tops". The weights of material thus obtained were applied to a formula devised to give the percent efficiency, by weight, on each sample.

The Topping Efficiency Formula

The general efficiency formula $\frac{\text{output}}{\text{input}}$ applies with some modification to this study. In order to validate the formula used we must consider the two sources of waste involved in the study. The first source arises from the condition earlier described as overtopping. In this condition an excessive amount of root tissue is left on the top. This excessive tissue is a form of waste in so far as the quality of topping is concerned.

It might be argued that the material is not wasted when the tops are used as feed. This arguement is not valid in that so far as the machine or hand worker is concerned the optimum cut was not taken. Material cut from the tops is therefore one form of waste. The second condition, "under topping", also produces waste. It will be remembered that, as each load of beets goes through the cleaning drums at the dumps, a tare sample is taken. Dirt is cleaned from this sample. In addition any green material found on the crowns of the beets is cut off. This green material is weighed along with the dirt. The resultant tare is applied to the load on a percentage basis. Thus the condition of "under topping" produces a second form of waste which is not recoverable for any use.

The formula used in this study is based on an optimum sample weight. This optimum weight represents the yield from the beets assuming 100 percent accuracy in topping. In other words it is the true input to the machine. The input is the optimum sample less the total waste. The efficiency formula becomes:

$$\frac{\text{Optimum} - \text{waste}}{\text{Optimum}} \times 100 = \text{Percent efficiency.}$$

where:

Optimum = original sample weight of beets - parings from the beets + parings from the tops.

Waste = parings from the beets + parings from the tops.

The output of the machine or hand worker has been designated in the tables as the net weight where:

Net weight = Optimum - waste.

Topping Efficiency Data.

Table IV

Topping Efficiency Data on Mechanical Harvesters, Southern Alberta, 1946

Test No.	Sample wt.lbs.	Parings, lbs. Beets	Parings, lbs. Tops	Optimum lbs.	Net lbs.	Efficiency %
1	149.6	3.5	5.6	151.7	142.6	94.0
2	139.1	0.5	6.6	145.2	138.1	95.1
3	124.5	3.2	5.6	126.9	118.1	93.1
4	122.3	1.5	2.5	123.3	119.3	96.8
5	93.1	0.9	1.6	93.8	91. 3	97.3
6	112.0	1.3	2.4	113.1	109.4	96.7
7	88.6	2.3	1.9	88.2	84.0	95.2
8	64.1	2.1	1.1	63.1	59.9	94.9
Average						95.4
3A	115.6	Nil	11.0	126.6	115.6	91.3
6A	107.8	2.6	9.4	114 .6	102.6	89.5

Note:- In tests 3A and 6A the machines were obviously out of adjustment. Corrections were made and the machines retested. The new results are recorded as tests number 3 and 6.

Table V

Topping Efficiency Data on Contract Labour, Southern Alberta, 1946.

Test No.	Sample wt.lbs.	Parings, lbs. Beets	Parings, lbs. Tops	Optimum lbs.	Net lbs.	Efficiency %
2	162.9	3.2	1.4	161.1	156.5	97.1
3	129.2	2.0	1.4	128.6	125.2	97.4
4	139.0	4.3	1.7	136.4	130.4	95.6
5	98.6	1.0	3.6	101.2	96.6	95.5
6	110.0	2.0	1.5	109.5	106.0	96.8
7	118.0	2.0	1.6	117.6	114.0	96.9
8	60.8	0.1	3.0	63.7	60.6	95.1
Ave.						96.3

Note: Sample 1 was discarded. Samples of corresponding numbers to those in table IV were taken in the same field and on the same day.

The efficiency data is summarized in table VI. The two sources of waste are expressed as a percentage of the optimum sample.

Table VI

Comparison of the Topping Efficiency of Hand Labour and Mechanical Harvesters, Southern Alberta, 1946.

Test No.	Hand Labour			Machine		
	% Parings		Efficiency	% Parings		Efficiency
	Beet	Tops	%	Beet	Tops	%
1	-	-	-	2.31	3.69	94.0
2	1.98	0.87	97.1	0.34	4.54	95.1
3	1.55	1.09	97.4	2.52	4.42	93.1
4	3.15	1.24	95.6	1.21	2.02	96.8
5	0.99	3.55	95.5	0.96	1.71	97.3
6	1.82	1.37	96.8	1.15	2.12	96.7
7	1.70	1.36	96.9	2.61	2.15	95.2
8	0.16	4.71	95.1	3.32	1.74	94.9
Ave.	1.62	2.03	96.3	1.80	2.80	95.4
Range	2.99	3.84	2.3	2.98	2.23	4.2

Discussion

In considering the information contained in tables IV, V and VI it must be kept in mind that the tests were not taken on the basis of the best possible job from each group. Rather they have been taken in such a way as to give a picture of the overall performance.

This study shows that the machines have averaged 0.9 percent less efficient than manual workers. The machines were operated by relatively inexperienced men. Two operators had previous experience in the 1945 season. It should be stated that in all cases operators had received beneficial advice from field representatives of the implement companies concerned. Secondly, while an effort was made to overcome the possible bias in favour of hand work that could exist in a sampling test, the effort may not have been entirely successful. The author does not attach significance to the difference found in the results. Some thought was given to the applicability of statistical analysis to these data. Each test represents a different group of hand workers and a different machine. Although there is some comparability in that each paired test was taken under nearly identical field conditions, it is felt that statistical analysis could not be legally applied. Insufficient data are available to remove any bias caused by differing groups of workers.

A study of the tables indicates that the highest efficiency values are nearly equal. The difference lies in the lower values. It will also be noted that the greatest source of loss from machines has been due to overtopping. This is indicated by an average percent parings from the tops of 2.8 percent as compared to 2.03 percent for hand work. Consideration of the range of values and of the extremes of values justifies the conclusion that machine topping has been equally as efficient as hand topping in this study.

The evaluation of the quality of work done has relied entirely on weight data. No attempt was made to place a scale value on appearance. Loads of beets from machine harvested fields generally are not as nice in appearance as those from hand harvested fields because of stringers on a relatively few beets. Mervine, E. M. (11) discusses the quality of harvester topping as follows: "The quality of topping was little more than 1% better than customary hand topping. This means that the grower sells 1% more of his total tonnage. Based on a 12 ton crop he sells 240 lbs more beets per acre which at $9.00 per ton means $1.08 more per acre". The existence of green stringers on the harvested beets requires some hand trimming. This has not proven too serious in Southern Alberta. Once operator experience reaches the level indicated by Mervine as being possible, the amount of hand trimming may well be negligible. At the present experience level hand trimming is justified on the basis of the net gain in yield.

Figure 41.

Tops from Hand and Machine Work.

The top row was topped by machine, the bottom row by hand.

The greatest loss has occurred because of overtopping. This loss is recoverable in two ways. First through the utilization of the tops as feed. Secondly the loss can be recovered by plowing down the tops thus returning some fibre to the soil. The former method is preferred since the barnyard manure resulting from the feeding of cattle, if applied to the soil, will likely be more beneficial from the stand point of future yields and soil conservation. The average loss due to overtopping on a 12 ton crop is about 672 lbs. per acre. Assuming one ton to be worth $10.00 this is equivalent to $3.36 per acre. It would appear worth while for the farm owner to assure himself of efficient operation at all times.

Tests 3A and 6A have not been included in the averages but are shown in table IV because of their illustrative value. In each case the apparent fault was overtopping. The same remedy did not apply to both. In test 3A the machine was set to do a reasonably good job on small beets but was considerably overtopping the large beets. No great height variation was evident in the growing beets. The remedy was to decrease the thickness of the slice taken by the knife. This correction increased the efficiency by 2 percent and could have been carried farther. In test 6A the difficulty lay in not using the correct movement ratio. Considerable variability in beet crown height above ground was found. A double correction was made. The knife cut was increased very slightly to improve the quality of work on small beets. The movement ratio was narrowed down to decrease the overtopping on large beets. The resulting increase in efficiency was 7.3 percent. These two tests and the corrections made are discussed to illustrate the necessity for the operator studying the field conditions, and the machine, to obtain the best performance.

Conclusions

The topping efficiency study reported above leads to four conclusions.

(1) In this study machine topping has been equally as efficient as hand topping on a weight basis.

(2) A definite tendency toward overtopping exists in both machine and hand work.

(3) Good quality machine topping will require a clear understanding of the principles involved.

(4) Good quality topping requires that the operator check machine adjustments and field conditions frequently.

CHAPTER VIII

Dirt Tare Studies

The Problem.

The separation of dirt from the beets during harvest presents a problem that has not been solved entirely. Two factors contribute to this. The first is due to the development of root hairs on the beets (see figure 40). The soil is imbedded firmly about the hairs and is difficult to remove. Good hand labour practice calls upon the worker to knock this soil from the beets by bumping two or more roots together after pulling the beets from the ground. Machines must be so designed that the beets are handled very roughly during harvest, and the soil thus removed must be drained away. The second factor is the moisture content of the soil at time of harvest. Generally the lighter soils are more friable than the heavier soils, and break down easily under the action of the lifter points and under rough handling. The heavier soils when dry tend to form clods that come up with the beets and are very resistant to crumbling. These clods are apt to get into the windrow and into the truck. This increases the percent dirt in the load. In addition the cleaning drums at the receiving stations are not fully effective in breaking up clods. This increases the amount of dirt that is hauled from the storage piles to the factory. On the other hand excessive moisture in practically all soil textures results in a muddy condition that is difficult to handle. It would appear that there is some optimum moisture content for each texture. At present no accurate information is available as to the moisture content that will give least tare. The general harvest condition is that of too little moisture. In order to avoid clods it is generally recommended to the farmer that he watch his soil closely and apply water about two weeks prior to harvest if dryness is expected.

Method of Study

The discussion on hand harvesting methods given earlier in this work indicated the delivery procedure followed in the beet harvest. It will be remembered that each load of beets is weighed, cleaned in cleaning drums, and the loose dirt weighed out again with the truck. In addition a twenty-five pound sample is taken as the beets come out of the cleaning drums and a 2nd tare herein called "dump tare", is made on the load. All weights are recorded on the daily receipt slip that the grower receives for each day's delivery.

In the early stages of this work, data on the dirt problem were obtained from the topping efficiency study. It was soon apparent that some other method would be required to give the overall seasonal picture. Since all necessary information, except the completely empty truck weight, is contained on the receipt slips it was decided to utilize this information. During the winter of 1946-47 and again in 1947-48 data were collected from as many individual operators as possible. The information gathered was as follows:

(a) The daily receipt slips for the season's operation. Each operator receives duplicate copies of the slips. The author found the growers very co-operative in providing the slips and other information.

(b) It was necessary to obtain the completely empty tare weight of each truck used during the season. In most cases it was possible to identify the loads that were hauled by each truck or trailer unit. In many instances commercial haulers did all or part of the work.

Such loads were usually marked on the receipt slips. Unfortunately some excellent information had to be discarded because either the truck weight or the identity of the load could not be established.

(c) It was necessary to know the method of harvesting employed for each load. In cases where hand and machine methods were employed in the same field the data were used only when positive load identity could be established.

(d) The land description, referred to soil maps, provided the necessary soil texture infomation

From the above it was then possible to determine the total weight of beets and the total weight of dirt hauled with each load. The data were calculated on the basis of the total daily delivery and has been summarized by weekly and seasonal periods. The information includes the total percent dirt hauled with the load, and the percent dirt going into storage piles or rail cars. The information covers various harvesting methods on several soil textures.

Dirt Tare Data, 1946.

The information given in the tables below is the result of an analysis of 625 loads of beets from 14 operators. In most cases it covers the complete season's harvesting operations. Two comparisons are made in table Vll . The first compares the results obtained through the use of mechanical loaders with that of the hand fork methods of loading. The second compares machine topping with hand topping; here the effect of loading methods are averaged out. The effect of texture is indicated in table Vlll.

Table VII

A Comparative Summary of the Percent Dirt Tare From Two Methods of Loading and Two Methods of Topping. Figures are Averages for the 1946 Season.

Practice	Total Tare	Tare at Dump	No. of Operators
A. Method of Loading			
Mechanical loader	17.7	5.6	7
Hand fork	24.7	8.2	7
Difference	7.0	2.6	
B. Method of Topping			
* Machine	21.2	6.8	9
Hand knife	22.0	7.3	5
Difference	0.8	0.5	

* All machine topping was done with 54A harvester.

Table VIII

Effect of Soil Type on Tare. All Beets Machine Topped and Machine Loaded. Figures are the Average Percent Tare Values For the 1946 Season.

Soil Type	Total Tare	Tare at Dump	No. of Operators
Silt Loam Soil	23.0	7.5	2
Fine Sandy Loam	16.0	5.6	2
Difference	7.0	1.9	

Table VII indicates that, on a seasonal basis, the use of the mechanical loader has resulted in 7.0 percent less dirt tare that the hand fork method of loading. It has been generally observed that the mechanical loader delivers cleaner beets. These data support that observation. There is also a carry over effect as illustrated by the lower dump tare value for the loader. It is reasonable to expect cleaner beets from the loaders in view of the tumbling action to which the beets are subjected as they pass up the elevating chains. During the loading process considerable soil is screened out and can be seen falling to the ground below the elevators. Loaders in their present form have not proven themselves capable of breaking up clods that have found their way into the windrow. Labourers on the end of a beet fork can in theory exercise considerable care in selecting out clods. In actual practice they do not do this effectively, especially when loading from a windrow.

The serious nature of the clod problem can be illustrated by observations made during the 1946 harvest. One operator using a 54A harvester and a loader, employed two labourers to remove the clods from the windrow. The "A" frame on the harvester had been extended to make an extra wide trench. The beets and clods were deposited along one side of the trench. The labourers used topping knives to pick each beet out of the windrow and toss it to the other side of the trench. The clods were left outside of the path of the loader. The labourers were able to improve the quality of topping at the same time by trimming the odd poorly topped beet. A second case was found where the beets were placed in thin wide windrows by the 54A harvester. Two sections of lever harrows, trailed in tandem behind a light tractor, were pulled along the windrow to knock soil from the beets and to break up clods. The operation was only partially successful.

The relationship between soil texture and dirt tare is indicated in table VIII . The small number of machines in use in 1946 did not permit a wide scale study of this factor. For the most part the machines were used only on the lighter soils. However the differences of 7 percent and 1.9 percent do indicate that greater tare is associated with heavier textured soils. Since the machine tare data are based on the work of the 54A harvester, the suggestion is that this unit will find its best use on lighter soils. It will be remembered that there is no special provision for clod removal on this harvester.

1947 Tare Data

The 1947 survey was carried out to obtain comparative information on the HM-1 combine, the Kiest units, and hand labour methods. The above harvesters have special screening and clod removal mechanisms. For this reason the survey was concentrated primarily on the heavier soil areas. No attempt was made to obtain direct comparative data between machines. Rather it was hoped to evaluate their suitability. The summarized data are the result of the study of 1,329 loads of beets. This represents all, or part, of the season's deliveries from 15 operators. The data are given in table IX.

The distribution of the total loads and number of operators within each group is given as part of table IX in order that a better interpretation of the results may be made. The reader should refer to the tables in appendix B if he wishes to study the seasonal distribution of the data.

The records for the HM-1 harvester give a very clear picture of the influence of soil type on dirt tare. These records indicate a positive correlation between tare and increasingly heavy soil textures. This

Table IX Summary of Percent Total Tare, and Percent Dump Tare Data, on Various Methods of Harvesting in Several Soil Textures, Southern Alberta, 1947.

Harvesting Method	Loam		Silt Loam		Silty Clay Loam		Clay Loam		Ave.	
	Total	Dump	Total	Dump	Total	Dump	Total	Dump	Total	Dump
HM-1 Harvester	11.1	4.8	13.3	6.2	19.0	6.9	22.3	12.0	16.4	7.5
* Kiest Topper and Loader	26.3	10.0								
Hand Top - Machine Load	17.3	5.8					22.9	7.6	20.1	6.7
Hand Top - Hand Load			30.9	6.0			37.8	12.0	34.3	9.0
									23.6	7.7

* Not included in average

Distribution of Number of Loads and Operators in The Groups in the Table. Number of Operators Shown in Brackets.

	Loam	Silt Loam	Silty Clay Loam	Clay Loam
HM-1	145 (2)	49 (1)	142 (2)	189 (2)
Kiest	227 (2)			
Hand Top - Machine Load	111 (1)			278 (2)
Hand Top - Hand Load		39 (1)		104 (2)

supplements the indication given by the 1946 data. In each record the sorting belt on the beet cart was used to help eliminate clods. Therefore it can be concluded that increasingly heavy texture results in increasing tares because of adhering soil.

Earlier it was suggested that 5 percent loose dirt in the load was a probable optimum for soil screening. This value has only been reached once on a seasonal average basis. The HM-1 harvester operating on loam soils shows a total tare of 11.1 percent and a dump tare of 4.8 percent. This means that the loose dirt in the load was 6.3 percent.

It is interesting to note that in each method of harvesting a tare increase is found associated with an increase in texture. The heaviest average season's tare is found with the hand loading method of harvesting. This may be due to moisture content which has not been evaluated accurately in this study. Observations by the author and by the operators indicate that the heavy tare is also due to clod formation.

A comparison of methods is best made in the loam and clay loam columns, table IX. The HM-1 shows the lowest tare in the loam soils while the Kiest units show the highest. It will be of interest to know that the Kiest and machine loading records on loam soils were taken from adjacent 80 acre tracts. This land was all quite moist in the early stages of harvest and was subject to the same intensities and frequencies of rain. The HM-1 records fall within a radial area of about 6 miles from the Kiest records. Thus it is reasonable to make comparisons on these data. The "Rienks" screen and the sorting belt on the HM-1 explain the low tare in these records. The Kiest Victory Loader, in spite of its use of the "Rienks" screen has not proven efficient in this soil. This is apparently due to lack of elevator capacity and to the material passing over the screen too rapidly to provide cleaning. Figure 33 shows the Victory Loader in action in a moist clay loam soil. A large amount of dirt can be seen in the load.

The 1946 data indicated beneficial results in lessening tare through the use of the mechanical loader. This fact is also brought out in table IX. It will be noted that the highest tare is shown in the table under the clay loam soil where hand loading was practised.

Moisture Content and Dirt Tare.

No effort was made to get accurate information on the moisture content of the various soils involved in this study. Some broad indications may be obtained from a consideration of average weekly tare throughout the harvest season, in comparison with the total weekly rain fall. In studying the data it should be realized that heavy rains will cause a cessation of harvest. The result of the increased moisture on the tare will show up over the next few days. In a comparison of weekly values, therefore, the effect will be seen in tare figures for the same week or for the week following the storm. This will be dependant to some degree on whether or not the storm occurred at the beginning or at the end of the week.

Table X

Total Precipitation and Average Total Tare Values by Weekly Periods, Southern Alberta, 1946.

Period	Total Precipitation inches (rain or snow)	Average Total Percent Tare. Machine Loaded	Hand Loaded.
Sept.15-21	0.11		
" 22-28	0.74	16.8	
" 29-Oct. 5	1.69	17.3	
Oct. 6-12	0.17	23.8	30.1
" 13-19	0	16.2	23.6
" 20-26	23.4 (S)	14.7	24.1
" 27-Nov.2	0.31	19.0	31.5
Nov. 3- 9	0	15.4	23.4
" 10-16	0.28	-	21.1
" 17.25	20.1 (S)	-	-
Dec. 1- 7	-	-	19.7

Note: Tare data is based on harvesting with 54A and machine or hand fork loading. Precipitation for period September 1 to September 14 inclusive was 1.12 inches.

Table XI

Total Precipitation and Average Total Percent Tare for Weekly Periods from Beets Harvested with the HM-1 Harvester on Various Soils, 1947.

Week Ending	Precipitation Rain or Snow	Loam	Silt Loam	Silty Clay Loam	Clay Loam	Ave.
Sept.12 to Sept. 21	1.14 R. 22.9 S.					
Sept.28	0.26					
Oct. 4	0.11	14.1	19.1	22.5	18.1	18.5
Oct. 11	Nil	10.7	12.5	16.0	16.1	13.8
Oct. 18	Nil	10.1	12.0	10.5	15.8	12.1
Oct.25	6.1 S.	8.8		14.8	31.5	18.4
Nov. 1	Nil	9.0		15.1	34.1	19.4
Nov. 8	0.70 S.			14.0	24.6	19.3

Note: The 1947 harvest season was comparatively open and dry except for early September moisture.

The 1946 and 1947 harvesting seasons were considerably different in precipitation characteristics. The 1946 season had heavier than average precipitation while the 1947 season was slightly drier than usual during the harvest. However heavy snow and rain fell during the early part of the month of September, 1947. Therefore comparisons of the records between the two seasons have not been made. Some common characteristics show up in the tables. The heaviest tare for the 1946 data occurred within the two weekly periods ending October 12 and November 2. It will be noted in table X that heavy precipitation occurred during the week just preceeding, that is, in the weeks ending October 5 and October 26. The dry spell just before the heavy snow of October 25 and 26 is associated with lower tare values which have carried on into the snow period. Harvesting came to a stand still after the snow, hence the effect of the moisture shows up in the week following that in which the snow fell. The 20 inches of snow recorded November 25 does not show as marked effect since partially frozen soil cleans fairly readily from the beet.

The 1947 data as given in table XI indicates some effect of moisture on tare. The pre-harvest moisture of 3.43 inches has resulted in heavy tare early in the season. As the soil dried out the tare values show a decrease in all textures. A 6 inch snowfall occurred over the period October 19 - October 21. The amount of moisture from this snow that would effect the tare is something less than 0.60 inches. This would have no large effect on the averages for the week.

Conclusions.

The tare data as presented for the 1946 and 1947 harvest seasons leads to the following conclusions.

(1) Soil moisture content at the harvest time has a very marked

effect on dirt tare.

(2) Excessive moisture results in unclean beets, and a lack of moisture results in an intensification of the clod problem; therefore some optimum moisture content for minimum tare must exist.

(3) * The high tare values from machine and hand harvested beets indicates that a tare problem of sufficient magnitude to justify intensive research exists.

(4) High tare values are normally associated with the heavier soil textures.

(5) The HM-1 harvester is generally better suited to the heavier soil areas than the other machines involved in this study.

(6) The 54A harvester will give good results when followed by a mechanical loader and used in soils having no clod elimination problem.

(7) The Kiest harvester unit is at present better adapted to the lighter soils. Improvements in design may widen the scope of its usefulness.

At this point it is of interest to note the results obtained in other areas. Mr. Rowland M. Cannon (12) reports these results as follows: "For the most part, the use of various types of machines has been dependent upon soil conditions and other variables, with one machine finding greater favour under one type of condition, and another fitting in better somewhere else.

* The reader should refer to the tables in appendix B which shows the large amounts of soil that are being moved yearly to and from the beet dumps.

The John Deere harvester has proven to be most satisfactory in lighter soil types. Its use has been almost completely discontinued in soils that tend to break up cloddy, due to its inability to separate clods from the beets.

The International topper was introduced for large scale use in the fall of 1946 and found immediate acceptance in practically all the areas having heavier soil types.--- In heavier soil types it has been necessary in practically all cases to use the sorting belt.--- In lighter soil types, it has not been necessary to make a hand separation of the beets from the dirt which of course has resulted in somewhat lower separating costs.---

A number of Kiest harvesters was distributed through much of the intermountain area for use in the 1947 harvest season.--- There were very few cases where the lifter loader delivered acceptable beets in the heavier soil types."

The experience in Southern Alberta agrees quite closely with that of other areas in regard to machine adaptation to soil texture.

CHAPTER IX

Field Performance.

Survey Method

Performance records from as large a number of machines as possible were collected at the completion of the 1946 and 1947 harvest seasons. It was felt desirable to collect this information in order to obtain some basis for estimating the probable yearly acreage that could be expected from the harvesters. In many cases it was found that the operators' records were none too complete. It was possible to arrive fairly closely at the desired information by checking beet receipt slips, records of payments of wages and other cost items. Information on total tonnage and total acreage was obtained quite accurately. In most cases the total days of operation taken to the nearest half day were easily obtained. It was rather more difficult to arrive at the total hours of machine operation, consequently some estimation had to be made on this factor. The hours of labour were taken on a basis of a 10 hour day, the hours of machine use on a basis of an 8 hour day. In other words it was estimated that about 2 hours per day were required for normal servicing, machine adjustment and travelling time to and from the field. In several instances the operators' records showed the actual servicing and maintenance time and it was found to check out fairly closely to the 2 hour value.

The 1946 data covers the use of the 54A harvester only. In all records included in the 1946 summary table the time shown is that required to place the beets into the windrow. The 1947 data carries the records a step farther in that the time includes that required to place the beets in the trucks ready for delivery. Hauling has not been included in the records. It was necessary to consider loading time in the 1947 records since the HM-1 combine, and the Kiest units, by virtue of their design, carry the operations to this stage. Table XII gives a summary of the average seasonal performance of three makes of harvesters. The individual records are included in appendix C.

Data

Table XII

Summary of the Average Field Performance of the Various Makes of Harvesters in the 1946 and 1947 Seasons, Southern Alberta.

	1946	1947		
Item	*54A (Hand load)	*54A Machine load.	HM-1	Kiest
No Records	13	11	11	2
Ave. Acres	27.7	37.9	38.8	67.8
Ave. Total Tons	380	489	453.5	1141
Tons/acre	13.7	12.9	11.7	17.1
No. days	14.2	18.5	17.2	20.5
Acres/day	1.95	2.0	2.26	3.31
Tons/day	26.8	26.4	26.4	55.7
Machine hours.				
Per acre	4.1	3.90	3.55	2.42
Per ton	0.30	0.30	0.30	0.14
Man hours				
Per acre	6.15	9.8	11.3	10.2
Per ton	0.44	0.76	0.97	0.61

* 1946 - harvesting into windrow only, 1947 includes loading time and some time for hand trimming.

Discussion

In studying table XII it should be realized that the average run for a season does not necessarily reflect the full capabilities of the machine. In most cases the records are based on first year operation. This is strictly true of the HM-1 and the Kiest records. The 1946 data for the 54A is first year information, while most of the 1947 records are second year data. However in several cases the actual operators were first year men. Under these circumstances it is to be expected that the machines' field performance will be considerably below the theoretical potential.

Performance is given on a basis of acres per day and tons per day. The single row units show remarkable similarity in their average tonnage output of 26.4 tons per day in 1947. The 54A shows 26.8 tons per day in 1946. The multiple row Kiest units show an output of 55.7 tons per day, just slightly more than double that of the single row machines. On the average basis the HM-1 shows some advantage, which is the result of operation on slightly lower yields. The Kiest unit does not show as great an advantage as would be expected on an acreage basis. This is a result of a certain amount of mechanical trouble and of the small labour staff employed in comparison with that required for full time operation.

The general relation between the machines carries through into the comparison available on the basis of machine hours per ton and per acre. Some differences show up in labour requirements. The lowest value is found in 1946. This does not include loading labour as do the 1947 figures. Also part time trimming of the beets was more general in 1947 than in 1946. The use of the sorting belt on the HM-1 of necessity raises its labour requirements.

Some thought should be given to the maximum daily performance of a machine when considering utility. Such information serves as a guide for setting an objective toward which an operator can strive. Many cases were found where the daily acreage output of a single row machine was slightly more than 3 acres per day. In some of the high yield areas, daily tonnage outputs of 60 tons were not uncommon. On more than one occasion the Kiest units surpassed the 70 ton mark. The highest daily delivery found in Kiest beet receipt slips was 86 tons from just under 5 acres.

The total seasonal output of the various machines is of interest. The highest seasonal average found in the survey was 54 acres for the 54A and 57 acres for the HM-1. Smith, W. (5) reports one 54A machine as doing 96 acres in 1947. This was accomplished in 25 days with an average daily output of 43.9 tons. It is known that extra long hours were necessary to do this work.

Data available from the United States indicates considerable variation from area to area. Cannon, Rowland M. (12) discusses the performance of machines in the American beet growing districts as follows: "---- In the Chinook factory district of Montana, 33 International Machines harvested an average of 89 acres each, as compared to an average of 58 acres for all machines in the Intermountain area. Seven of these machines harvested almost 1000 acres. One machine harvested 125 acres of beets in the period from October 1 to November 2.---

Throughout the Intermountain area, countless machines have harvested in excess of 100 acres in an average harvest season. Attaining this record requires considerable planning and necessitates working long hours, but it is certainly within the province of any beet grower to attain production of this sort from a mechanical harvester".

Conclusion

(1) It is possible to expect an average daily output of from 2 to 2.25 acres per day. Assuming 25 working days as an average length of harvest, the machines should handle better than 50 acres per season.

(2) There is little essential difference in field capacity between the single row units.

Factors Affecting Performance.

Four factors that have a direct influence on the performance of a harvester are discussed briefly here. These factors all come under the control of the grower and attention to them throughout the year will have a material effect in facilitating the harvest.

The first factor is labour management and organization. Frozen beets are hauled to the dumps only as called for. This enables the company to send them direct to the factory for processing to avoid spoiling in storage. The operator should therefore attempt to deliver his beets on the day they are harvested. Failing this the beets should be covered with tops or otherwise protected from frost if they must lie overnight in small piles or in the windrow. Good organization of the delivery facilities is therefore important. In addition, supplementary hauling or storage facilities should be provided on the farm. In rush delivery seasons, trucks may be forced to wait in line for some time at the dumps. Supplementary storage in the form of extra wagons, racks or silo piles may be necessary to keep the harvester in operation.

The operator should provide himself with extra knives and minor repairs. Knives must be changed as often as twice daily and in some soils more often than this. Sharp knives should always be on hand so that the change over can be made with minimum delay. This practice also applies to small repair items that have been found, by experience, to be needed on short notice. The operation of the harvester is not complicated, however, to obtain good performance and high quality work with a minimum of delay, the operator should be thoroughly familiar with the principles of the machine, and should apply them by analyzing the field conditions in which he is working.

The second factor involves proper field layout at time of seeding. The 54A harvester will give better results on long rows than on the short rows. This is because of the time required to reset the top conveyor and beet conveyor at the beginning of each row. The time required for turning may vary to slightly over one minute. This is equivalent to harvesting 150 to 200 feet of row. The harvester is therefore at a definite disadvantage in small fields with short rows. In addition, some space should be available for easy turning. The HM-1 harvester does not require resetting on each row but does require up to a 30 foot headland for easy handling at the ends of the rows. The headland can be provided by planting about 20 cross rows at each end of the field. The cross rows are harvested first, thus providing proper headland space. Frequently fields are bordered by permanent ditches, consequently some thought should be given to space requirements when the crop is seeded in the spring. Two possible unloading procedures are available with the HM-1. The machine may be unloaded while on the move in the field or it may be unloaded on the headland. The former method imposes a heavier hauling strain on the trucks especially under very soft or muddy field conditions. The latter method requires that the field be planted with headlands across the field at spacings of correct length to fill the cart on one or more complete rounds. This procedure facilitates hauling under heavy field conditions. The operator who expects to get the most out of his machine must see that field design fits the requirements of his harvester.

Proper cultural practices during the growing season constitute a third factor. Beets are irrigated by running water down the furrows between the rows. Experience has shown that where severe soil washing has occurred, because of careless irrigation practices, considerable trouble has been encountered with harvesters. This arises in two ways. First, deep ruts increase steering difficulties, often necessitating slow forward speeds over such areas. The lifter units on the 54A and HM-1 harvesters are mounted 18 inches off centre. The side draft produced, coupled with furrows that do not follow the centre line between the rows, make accurate steering very difficult. Secondly "in-place" toppers gauge the thickness of crown slice on the basis of the height relationship between the beet and the soil surface in the row. Deep uneven furrows cause excessive up and down tractor movement. This movement becomes another variable in the accuracy of the gauging mechanism. Rough fields may require that the operator select a 1 to 1 movement ratio in the topper linkage to nullify the results of undesirable topper frame movements. This may result in poorer quality work than would otherwise be obtained if footing conditions were uniform.

Heavy weed growth in the fields at harvest time is not normal in Southern Alberta. Where it does occur, the sliding knife will plug up quite easily; the disc topper plugs up much less frequently. All machines do better work in weed free crops than they do in weedy crops.

In several cases it was found that contour irrigation ditches across the field caused trouble. The ditches were usually weedy before being plowed in for the harvest. Improperly levelled ditches, weeds, and beets not properly buried in the ditch, caused considerable annoyance.

It was found generally that better progress was made in the more uniform fields. Uniformity here refers to evenness of stand and to size of beets. Poor stands often required considerable retopping because of the wide range of beet sizes found in such fields. Doubles made up of a small and a large beet were seldom properly topped. Uniformity can be influenced materially be proper seeding, thinning, cultivation and irrigation practices.

The fourth factor is that of soil condition. In several instances the presence of small stones has caused trouble. Stones of the 1 inch variety catch in the conveyor sprockets or in the kicker wheels of the cleaning trough. This factor is not, strictly speaking, under the control of the grower. It will influence his decision as to the feasibility of using mechanical harvesting.

On heavy soils the possibility of clod formation exists. The remedy, at present, is to provide sufficient moisture in the soil at harvest time to facilitate soil screening by the machine.

This discussion of factors has included many practices that have a decided influence on yield as well as on machine operation. Therefore it is logical that the grower who pays particular attention to many details while husbanding his crop through the season, will obtain maximum returns from the crop and from the use of the machine.

CHAPTER X

Cost of Operation

Method of Study

Data on the cost of operating mechanical harvesters and loaders, was collected for the 1946 and 1947 harvest seasons. In practically all records the farm operator was contacted prior to, or during, harvest and asked to keep the necessary information. At the completion of harvest these records were collected along with the dirt tare data. The questionaire forms used were made up to give a reasonable breakdown of the cost and performance figures.

1946 records cover the use of the 54A harvester. Most growers were using the hand loading method. Only four records were found in which the costs of operating the loader could be separated out to give the comparison between the two loading methods. Two records were found in which the 54A unit had been slightly rebuilt to enable the machine to elevate the beets directly into a truck.

The 1947 records on the 54A harvester included the use of the loader. The records on the HM-1 can be compared to those of the 54A for 1947 since each harvester carried the operation to the same stage. Eleven records were obtained in each case. Although there were 52 John Deere units in use, no attempt was made to collect all of these records because of time limitations. Some information on HM-1 units was too confused to be of any value.

A complete discussion of the method of cost analysis is contained in appendix C of this report. Included in appendix C are the individual cost and performance records on each machine for 1947 and a summary table of the 1946 data. It might be pointed out briefly here that the basis of comparison is the hand labour contract costs of harvesting. These costs are: \$1.90 per ton for pulling and topping, \$1.00 per ton for hauling, (distance neglected) and 50¢ per ton for hand loading. Wages, fuel and oil, have been charged against the harvesters, as used, and annual cost factors have been worked out (including repairs). The basis used was 10 years at 50 acres per year for the harvesters, and 15 years at 100 acres per year for the loaders. The annual values worked out to 17 percent plus 6 percent interest on the half value for the harvesters and 12 percent plus 6 percent on the half value for loaders. Suitable values were used for tractors and, where applicable, for trucks.

Data

Table XIII gives a summary of the average costs per acre of harvesting sugar beets as determined from the 1946 and 1947 records. Comparative hand labour costs are included.

Table XIII
Average Costs Per Acre of Harvesting Sugar Beets in Southern Alberta Using Mechanical Harvesters, 1946 and 1947.

	1946				1947	
	54A Hand Load	54A Self Load	54A Hand Load	54A Machine Load	54A Machine Load	HM-1 Harvester.
No. records	13	2	4	4	11	11
Acres	27.7	28.5	34.7	34.7	37.9	38.8
Tons	380	340.7	483	483	489	453.6
Tons per acre	13.7	12.3	13.9	13.9	12.9	11.7
Days	14.2	15	17.75	17.75	16.6	17.18
Operating Costs (dollars)						
Fuel, oil, grease	1.20	3.13	1.25	1.85	1.50	1.30
Wages	4.30	11.33	3.58	4.28	7.14	7.91
Hauling	20.55	-	20.88	13.92	12.90	11.70
Annual Costs (dollars)						
Harvester use	3.66	3.66	3.66	3.66	3.66	5.81
Tractor use	1.80	1.85	1.80	1.80	1.71	1.52
Loader use	-	-	-	1.19	1.13	-
Tractor use	-	-	-	0.22	0.22	-
Truck use	-	0.32	-	-	-	-
Tractor, trailer use	-	0.49	-	-	-	-
Total Costs (dollars)						
Cost per acre	31.54	20.78	31.17	26.92	28.26	28.24
Cost per ton	2.30	1.74	2.24	1.93	2.19	2.41
Hand labour costs (dollars)						
Costs per acre	49.64	43.64	50.33	50.33	46.87	42.78
Costs per ton	3.62	3.65	3.62	3.62	3.63	3.66
Saving through use of Harvesters (dollars)						
Savings per ton	1.32	1.91	1.38	1.69	1.44	1.25

Note: Column 2 is not directly comparable to the remaining data. Loading has been charged as an actual cost in column 2 and not an assumed cost as in all other columns.

Columns 3 and 4 are directly comparable, as are columns 5 and 6.

Discussion

Table XIII contains a direct comparison between the use of the harvester with and without the loader in 1946. The 1947 data contains a direct comparison between two makes of harvesters. A direct comparison between the various machine combinations and contract labour costs is given at the bottom of each column.

The 1946 records indicate that the use of the 54A harvester and the hand fork method of loading has resulted in a direct saving of $1.32 per ton or 36.5 percent over the contract labour method. Columns 3 and 4 indicate an increased saving of 31¢ per ton for a total of 45 percent over the hand methods of harvesting.

Column 2 indicates that the conversion of the harvester into a self loading unit results in a saving of $1.91 per ton. It must be remembered that the two records in this column included true hauling charges for a hauling distance of one mile. It is not advisable therefore to make a direct comparison with other data. The information is of some value in that it indicates that this use of the 54A harvester has some merit under certain conditions. The operator must be prepared to accept heavier than normal operating costs on the hauling units. Annual use values should be increased to compensate for the wear and tear on trucks operating in low gear over long distances in soft fields.

The 1947 data indicate that for complete mechanization the saving over hand labour costs has been $1.54 per ton or 42.5 percent for the 54A, and $1.25 per ton or 34.2 percent for the HM-1 harvester. The difference of 19¢ per ton between the two machines is primarily due to the heavier annual use charge against the HM-1, and to a lesser degree, to the use of the sorting belt. The HM-1 does not require a separate loading unit. As a result there has been some saving in fuel costs which do not offset the heavier depreciation charges. The new value of the HM-1 is greater than that of the 54A plus either of the loaders. There is one factor that was not evaluated on a dollar basis and that is the lower hauling costs that result from lower dirt tares obtained by the HM-1 machine. Such a saving may be appreciable over a season's harvest, especially on the heavier soils.

It will be noted that the average acres of use has been somewhat lower in 1946 than in 1947, yet the fixed charges are equal. The annual costs were based on 50 acres per year over a 10 year period. The resulting charge per acre was included at a fixed value regardless of acres of use in one year. This procedure was followed in order to provide comparative data in which differences would be mainly attributed to operating variables rather than annual use variables.

Cannon, Rowland, M. (12) reports on costs of operation in other areas as follows:

"An extensive survey conducted by the Utah-Idaho Sugar Co., on mechanical harvester operation indicates that 296 machines harvested 216,395 tons from 15,500 acres at an average <u>direct</u> cost of 83 cents per ton. These records represent about 87 percent of the total number of harvesters in operation within the areas served by the company in the five states in which it operates".

<u>Optimum Acreage Requirements</u>

One of the basic purposes of the cost phase of this study was to obtain information that would lead to a recommendation as to the optimum acreage requirements of the harvesters. There are a considerable number of growers in Southern Alberta who handle from 10 to 20 acres yearly and relatively few who grow more than 60 to 80 acres. The high cost of the machines and their relatively low capacity compared to other types of harvesting units such as the grain combine indicates a need for custom work or co-operative use of the harvesters by the small grower.

A graphical method of study has been adopted in order that the lowest feasable yearly acreage could be determined. In addition the graphic method was used to locate the optimum range; i.e. that range within which fixed annual costs have a least effect. The method of developing the study is given in detail in appendix C. It is sufficient to note here, that the basic assumption of a 10 year lifetime was maintained, and that it was considered that one third of the depreciation over this period would be due to obsolescence. Direct costs, interest charges, and a wear value were calculated into the chart at a fixed per acre value.

Figure 42 gives the results of the calculations in chart form. Hauling charges have not been included since for any one farm this cost would be relative constant for any method of harvesting used. The loading charge is included at 50¢ per ton for hand loading and hand topping has been charged at $1.90 per ton. A charge of $3.00 per acre has been included with the two values above to make up the cost lines for contract labour. The operating costs used on the harvester curves are based on the survey results which are on crops averaging about 12 tons per acre. Strictly speaking the comparison is accurate only at the 12 ton level. It is felt that some use can be made of the 10 and 15 ton cost lines for contract labour since harvester costs of operation would be more nearly proportional to the number of acres covered per day than to the number of tons harvested per day. Some slight variation will occur because of yield.

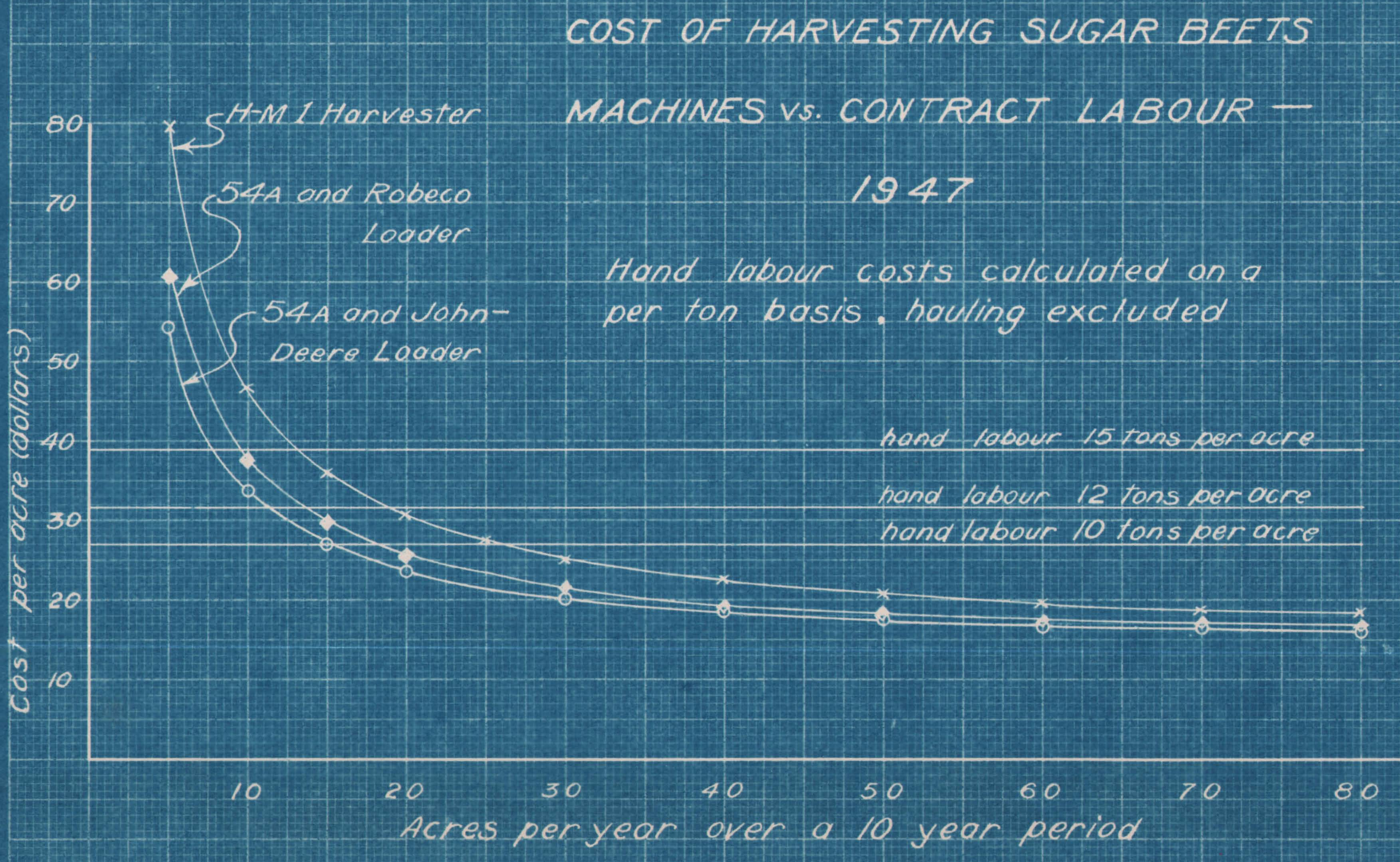

COST OF HARVESTING SUGAR BEETS
MACHINES vs. CONTRACT LABOUR —
1947
Hand labour costs calculated on a per ton basis. hauling excluded
H-M 1 Harvester
54A and Robeco Loader
54A and John-Deere Loader
hand labour 15 tons per acre
hand labour 12 tons per acre
hand labour 10 tons per acre
80
70
60
50
40
30
20
10
Cost per acre (dollars)
10
20
30
40
50
60
70
80
Acres per year over a 10 year period

FIGURE 42

The following facts are indicated by the chart based on the 12 ton level by contract costs. The HM-1 harvester will provide little or no savings over contract work unless it handles at least 18 to 20 acres per year over the basic 10 year period. The 54A harvester, because of lower initial price, will operate at a total cost equivalent to hand labour on 13 to 15 acres per year over the 10 year period. The harvester cost curves become practically straight lines with a very slight downward slope at about the 30 acre per year level. This indicates that for nearly maximum overall savings, over contract labour, the machines should harvest 30 acres or more annually. It is interesting that Gualle, C. E. (4) considers the HM-1 harvester as suitable for growers having from 20 to 60 acres or more per year.

The 10 and 15 ton contract cost lines provide some information. Since the intersection points of the curves with these lines fall on the medium sloped sections of the harvester curves, the effect of yield is indicated. Subnormal yields will require larger yearly acreages from the machines for economical operation. A grower who produces much below the 10 ton level will find it impractical to utilize mechanical harvesting methods.

The graphic analysis has been based on certain assumptions that cannot be substantiated by experience. It is felt necessary to study the effect of these assumptions. The chart values have been calculated for two additional life periods. One set of calculations assumes that in 10 years the machine will be completely worn out and therefore discard will not be due to obsolescence. The original values for 10 years of life to one third obsolescence, i.e. 15 years to wear out, are shown. A third set of values assumes 20 years to wear out, i.e. one half obsolescence if discarded in 10 years. The calculations have been made for the HM-1 harvester operating on from 10 to 25 acres per year and are given in table XIV .

Table XIV

A Comparison of HM-1 Harvester Costs with Contract Labour Costs Per Acre at Three Levels of Obsolescence in Ten Years of Use on Small Acreages.

Acres/year for 10 years	No Obsolescence	1/3 Obsolescence	1/2 Obsolescence	Contract Costs. 12 tons/ acre.
	$	$	$	$
10	47.70	46.84	46.60	31.80
15	36.76	35.91	35.41	31.80
20	31.29	30.44	30.02	31.80
25	28.00	27.16	26.72	31.80

Table XIV indicates that the redistribution of the wear and obsolescence factor as a cause for depreciation has no serious effect on the location of the intersection points for the HM-1 harvester. The total shift is not greater than about one acre above or below the intersection point on fugure 42. The shift is not sufficiently serious to warrant any change being made on recommendations based on the chart. It will be realized that variations in operator efficiency will require that only broad recommendations be made.

Conclusions

(1) The use of mechanical harvesters has resulted in substantial savings when compared to contract hand labour methods. These savings have varied from 34.2 percent to 42.5 percent for complete mechanical harvesting, depending on the harvester used.

(2) Total harvester costs will not be much lower than contract labour costs unless 20 acres or more are harvested per season.

(3) The machines studied should be used on 30 acres or more per year for economical results.

CHAPTER XI

General Summary and Conclusions

This report has discussed data obtained during the 1946 and 1947 sugar beet harvests in Southern Alberta. Information has been obtained on four phases involved in a study of harvester performance. These phases were:

(1) The efficiency of the topping units as operated under commercial conditions. The efficiency of the units has been compared on a weight basis with the work done by contract labourers in the same fields.

(2) The ability of the machines to harvest the beets with a minimum of dirt tare. The tare is found in two forms. The soil hauled back to the field and the dump tare on the beets as they go to the factory or into storage piles.

(3) The field capacity of the harvesters in relation to acreage and tonnage output per day and per hour. This data has also indicated the man hour labour requirements of the harvesters.

(4) The cost of operating the machines has been studied and compared throughout with the common contract labour costs.

In order that a full understanding of the various factors involved might be reached this report has discussed other related matter. The climatic and soil conditions of the area in which the study was made has been given briefly. General information has been included on cropping practices with emphasis on the hand labour method of sugar beet harvesting. The various harvesters involved in the study have been described and illustrated. The functional machine elements on each harvester have been discussed with space being alloted to the basic principles of mechanical harvesting. It is the author's hope that this material has helped the reader to arrive at a better understanding of the problems involved in the development of mechanical beet harvesters.

Conclusions

The basic conclusions arising out of this study are as follows:

(1) The quality of mechanical topping, under commercial use, has been equal, on a weight basis, to that of hand topping. Some hand trimming of machine topped beets has been necessary to remove green stringers.

(2) Soil moisture content and soil texture has had a marked effect on dirt tare. Higher tare has been found to be associated with heavier textures. There appears to have been some optimum soil moisture content at which tare was a least value. Average total tare has been found to vary from a low of 11.1 percent to a high of 23.0 percent for mechanical harvesters. A tare problem, of sufficient magnitude to justify intensive research, still exists.

(3) The use of a mechanical loader with either hand harvesting or machine harvesting, has resulted in a beneficial reduction in the total amount of soil hauled to and from the beet dumps.

(4) The International HM-1 combine has shown itself to be suitable for use over a wide range of soil conditions because of the cleaning and clod elimination features found on the machine.

(5) The John Deere 54A harvester has found its best use, at the time of the study, in the lighter soil areas.

(6) Kiest harvesters have been found to do work of a barely acceptable nature on medium to light soils. Improvements in design may widen their scope of usefulness.

(7) Single row ground toppers have averaged from 2.0 to 2.26 acres per day on the season's run. The machines are capable of handling 50 acres or more per season in Southern Alberta.

(8) There is little essential difference in field capacity between the single row units.

(9) The use of mechanical harvesters has resulted in savings, over contract labour costs of 34.2 percent for the HM-1 and 42.5 percent for the 54A and loader combination, in 1947.

(10) The single row units studied here should harvest 30 acres or more per season for highly economical results. Annual use on 20 acres or less has not been shown to provide substantially lower harvesting costs than normal hand labour practice.

The mechanical harvesting of sugar beets has become an accomplished fact in Southern Alberta; although it is not a completely accepted practice. Problems still exist, but with patience on the part of the farm operator, and with diligence on the part of the research worker, these will be solved.

Appendix A.

Daily weather records as recorded at the Dominion Experimental Station, Lethbridge for the 1946 and 1947 sugar beet harvest seasons.

Table 1. Daily Records for September, October and November, 1946.

Table 11. Daily Records for September, October and November, 1947.

Table 1. Appedix A.

Precipitation, Temperatures and Hours of Sunshine, 1946.

Day	September				October				November			
	Precip. Ins.	Temp. °F. max.	Temp. °F. min.	Sun. hrs.	Precip. Ins.	Temp. °F. max.	Temp. °F. min.	Sun. hrs.	Precip. Ins.	Temp. °F. max.	Temp. °F. min.	Sun. hrs.
1		70.5	44.0	11.6	0.50	60.0	41.9	1.0	2.20 S.	37.5	27.0	1.6
2		82.5	39.0	9.7	1.19	41.5	41.0	-		41.5	12.0	8.6
3		78.0	50.6	3.5		50.5	33.5	3.5		47.0	11.6	7.2
4	0.20	66.0	52.0	3.3		53.0	30.5	8.4		55.0	28.5	8.2
5	0.30	49.0	44.0	-		48.0	31.0	9.5		58.5	30.5	6.7
6	0.41	49.5	40.0	-		51.0	23.0	9.3		48.0	42.0	0.2
7	0.13	50.0	41.0	0.2		47.5	26.0	8.8		36.5	27.5	-
8	0.08	51.5	43.0	-	0.12	59.0	23.0	4.0		42.5	19.0	3.3
9		73.0	39.5	10.8		58.5	32.0	5.0		46.0	21.0	7.2
10		76.0	43.0	11.0		48.0	27.5	4.6		37.5	27.0	-
11		77.5	45.0	11.1	0.05	67.5	24.0	4.0		41.0	19.5	7.8
12		77.5	51.0	9.5		62.5	33.0	1.6		54.5	20.0	7.8
13		79.2	51.0	7.5	0.08	60.5	26.5	6.9		57.5	27.0	8.0
14		81.0	45.2	10.5		35.0	29.5	0.6	1.20 S.	49.5	29.5	4.0
15	0.03	68.0	49.6	6.2		37.0	19.5	8.2	0.30 S.	25.0	24.0	0.6
16		50.5	49.6	-		54.0	20.0	8.9	1.30 S.	21.0	3.0	-
17		58.0	42.0	6.7		59.5	24.0	9.0		14.0	7.0	-
18		63.5	36.0	9.9		58.5	24.0	8.4	6.00 S.	1.0	0.0	-
19		69.5	36.0	10.0		54.8	35.0	4.8	3.70 S.	-4.0	-8.0	-
20	0.07	68.5	49.0	5.2		61.5	31.5	4.5	3.00 S.	-6.0	-8.0	-
21	0.01	57.0	41.0	4.1		54.5	41.0	8.7	2.00 S.	4.00	-24.0	7.5
22		57.5	39.6	9.2		56.0	32.0	0.1		14.5	-26.0	-
23		74.0	25.0	9.3		53.5	36.5	4.9	0.40 S.	13.5	5.5	0.2
24		75.5	39.5	2.7	0.14	59.5	35.5	1.9	1.50 S.	35.0	5.5	2.8
25	0.06	54.5	43.0		14.0 S.	33.5	31.5	-	3.50 S.	39.0	-9.0	1.5
26	0.67	51.0	43.0	-	8.0 S.	29.5	26.0	-		16.0	8.0	1.5
27	0.01	53.0	38.5	3.9	0.9 S.	32.5	18.5	-		21.5	-6.0	1.6
28		59.6	29.5	9.9		32.0	-2.0	4.0		24.0	3.0	-
29		78.5	32.0	8.6		35.0	17.0	6.8		40.0	-6.0	3.6
30		74.0	43.5	2.8		36.0	17.0	8.7		34.5	10.0	6.6
31						41.0	22.0	6.2				
	1.97	65.8	42.2	5.9	4.37	49.4	27.5	4.9	2.51	31.5	10.7	3.2

Note - Total precipitation is shown as inches of water. Snowfall has been recorded in inches and converted to water equivalent in the total. Average maximum and minimum temperatures and average daily sunshine are shown.

Table 11. Appendix A.

Precipitation, Temperatures and Sunshine, 1947.

Day	September				October				November			
	Precip. ins.	Temp. °F. max.	Temp. °F. min.	Sun. hrs.	Precip. ins.	Temp. °F. max.	Temp. °F. min.	Sun. hrs.	Precip. ins.	Temp. °F. max.	Temp. °F. min.	Sun. hrs.
1		79.0	52.0	12.1		72.5	66.0	9.5		68.0	34.0	3.6
2		81.5	48.5	7.9		66.0	37.0	2.7		46.0	31.0	1.0
3		80.5	49.0	11.6		73.0	49.5	9.3		51.0	24.0	7.1
4		82.0	47.5	10.8	0.24	69.8	50.0	7.1		35.5	28.6	4.3
5		70.0	40.5	9.8		55.6	39.6	6.7		36.0	15.6	8.0
6		62.0	38.5	3.0	0.01	43.0	20.7	0.3		37.5	14.0	4.8
7		63.0	39.5	1.6	0.09	44.5	33.6	-	0.10 S.	43.8	19.0	6.2
8		63.0	44.5	9.9		55.6	38.0	1.7	0.60 S.	32.0	19.5	-
9		68.5	48.0	5.6	0.01	62.0	39.0	7.3		21.0	14.5	5.0
10		67.0	48.0	9.5		59.5	41.5	4.3	2.00 S.	35.6	9.0	-
11		78.0	42.5	11.3		60.0	31.6	10.1	0.10 S.	18.5	10.0	0.9
12	0.19	77.0	46.0	6.1		66.0	37.8	1.1		36.5	9.0	2.5
13	0.01	55.6	38.6	4.1		72.0	48.5	6.7	0.30 S.	42.0	16.8	0.3
14		59.0	35.0	10.5		68.5	37.0	7.7	1.70 S.	21.0	19.0	-
15	0.24	61.0	43.5	4.5		66.5	33.5	3.0	1.60 S.	19.0	14.0	-
16	0.66	43.0	38.0	-		66.0	46.0	5.3		21.0	6.0	6.2
17	8.50 S.	34.5	29.0	-		55.6	36.4	8.2	1.00 S.	32.0	-6.0	1.1
18	13.20 S.	33.3	30.1	-		57.0	40.7	4.5	0.50 S.	15.8	11.0	0.7
19	1.20 S.	45.5	31.5	-	3.30 S.	59.5	41.0	5.0	0.30 S.	22.5	10.0	0.1
20	0.04	67.5	32.0	6.7	2.20 S.	37.5	31.0	-	0.30 S.	16.5	13.0	1.2
21		54.5	40.0	3.4	0.60 S.	37.0	31.2	0.6		26.5	-6.0	5.1
22		80.0	40.0	9.5		44.0	19.5	7.9	0.16	35.0	-6.5	-
23		70.0	48.0	5.5		52.2	25.6	6.9		38.0	25.5	1.9
24		51.6	42.2	-		54.3	29.1	8.3		40.5	26.0	-
25		57.0	42.0	0.7		66.5	35.0	8.7		47.5	33.0	-
26		65.5	39.0	7.5		56.0	42.0	8.8		43.0	35.0	5.9
27		70.8	42.0	10.0		64.5	29.0	7.2		45.6	19.0	5.7
28		46.0	41.5	0.2		64.4	36.0	3.5		44.5	19.0	3.5
29	0.02	51.0	36.8	0.1		51.0	37.2	3.3		50.5	23.0	4.5
30		64.0	31.5	9.9		56.0	23.8	4.5		38.0	29.0	-
31						53.0	28.5	1.7				
	3.45	62.7	40.4	5.7	0.96	58.3	35.9	5.2	1.01	35.3	17.0	2.7

Note: Total precipitation is shown as inches of water. Snowfall has been recorded in inches and converted to water equivalent in the total. Average maximum and minimum temperatures, and average daily sunshine are shown.

Appendix B.

Individual Dirt Tare Data.

List of Tables

Appendix B

Table 1. Per cent Dirt Tare Figures obtained from Several Operators showing the effect of various methods of harvesting on the amount of dirt handled. Figures are weekly averages for all records, Southern Alberta, 1946.

Weekly Period	Machine Loaded Beets (No. of Operators)				Hand Loaded Beets			
	4		3		5		2	
	Machine Topped		Hand Topped		Machine Topped		Hand Topped.	
	Total Tare	Dump Tare	Total Tare	Dump Tare	Total Tare	Dump Tare	Total Tare	Dump Tare
Sept.22/ 28	16.8	6.7					17.5	5.8
Sept.29/ Oct. 5	17.3	5.9						
" 6/ 12	23.8	8.5			30.1	9.4	25.0	11.1
"13/ 19	16.2	5.0			23.6	8.0		-
"20/ 26	14.7	4.6			24.1	6.2	31.0	9.6
"27/Nov.2	19.0	5.5			31.5	14.7		
Nov. 3/9	15.4	3.8	17.9	5.7	23.4	5.1		
"10/ 16			18.6	4.7	21.1	5.0		
Dec. 1/7					19.7	6.9		
Totals	122.8	39.6	36.5	10.4	173.5	55.3	73.5	26.5
Ave.	17.5	5.7	18.3	5.2	24.8	7.9	24.4	8.8

Appendix B

Table 2. Effect of Soil Type on Dirt Tare. All Beets Machine Topped and Machine Loaded. Figures are Seasons Averages from Several Operators, Southern Alberta, 1946.

Operator No.	Silt Loam Soil		Operator No.	Fine Sandy Loam Soil	
	Total Tare	Dump Tare		Total Tare	Dump Tare
1	32.9	11.1	3	14.5	5.6
2	13.3	4.8	4	19.4	5.5
Total	46.1	15.9		33.9	11.1
Average	23.0	7.5		16.0	5.6

Appendix B

Table 3. Weekly Average Dirt Tare Records from Beets Harvested by the Hand Topping and Hand Loading Methods, Southern Alberta, 1947.

Record No.	10		11		12	
Week ending	% Dump Tare	% Total Tare	% Dump Tare	% Total Tare	% Dump Tare	% Total Tare
Sept. 27						
Oct. 4			6.0	30.4		
Oct. 11					6.5	31.5
Oct. 18			6.0	31.1	7.3	37.2
Oct. 25					6.3	33.5
Nov. 1	18.6	45.8				
Nov. 8	15.0	22.9				
Seasonal Average	17.1	41.1	6.0	30.9	6.8	34.4
Total Dirt Tons	19.25		58.62		163.7	
Total Loads	8		39		96	

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Table 4. Weekly Average Percent Dirt Tare Records From Beets Harvested by Hand Topping and Machine Loading Methods, Southern Alberta, 1947.

Record No.	13		14		15	
Week ending	Dump Tare	Total Tare	Dump Tare	Total Tare	Dump Tare	Total Tare
Sept. 28						
Oct. 4	6.4	20.5	8.3	18.2		
Oct. 11	6.8	17.1	7.6	18.1	10.9	33.2
Oct. 18	4.3	14.5	5.7	15.5	8.2	29.3
Oct. 25	6.2	16.9	4.3	10.1	5.2	23.7
Nov. 1			10.2	28.5	5.1	22.2
Nov. 8						
Season Average	5.8	17.3	7.2	17.6	7.9	28.2
Total Tons Dirt	107		131		225	
TOTAL loads	111		139		139	

Appendix B

Table 5. Weekly Average Percent Dirt Tare Data from Beets Harvested by HM-1 Combine, Southern Alberta, 1947.

Record No.	3		4		5		6		7	
Week ending	Dump Tare	Total Tare	Dump Tare	Total Tare	Dump Tare	Total Tare	Dump Tare	Total Tare	Dump Tare	Total Tare
Sept. 28										
Oct. 4	6.5	13.8	9.2	19.1	6.6	23.0	9.7	25.3	8.7	22.4
Oct. 11	6.8	12.7	6.2	12.5	6.4	15.1	5.7	20.5	8.9	19.6
Oct. 18	6.9	12.0	5.1	12.0	3.0	9.0	-	-	3.1	18.9
Oct. 25	-	-	-	-	5.9	14.8	-	-	14.7	31.5
Nov. 1	21.0	33.2	-	-	6.0	15.1	-	-	11.7	35.1
Nov. 8	17.0	24.6	-	-	3.5	14.0	-	-	-	-
Season Average	12.1	19.7	6.2	13.3	6.0	15.0	7.7	22.9	11.9	24.8
Tons Total Dirt	127.5		38.7		135.6		40.3		111	
Total loads	108		49		157		35		81	

Appendix B.

Table 6. Weekly Average Percent Dirt Tare Data from Beets Harvested by HM-1 and Kiest Machines, Southern Alberta, 1947.

Record No.	1 (HM-1)		2 (HM-1)		8 (Kiest)		9 (Kiest)	
Week ending	Dump Tare	Total Tare	Dump Tare	Total Tare	Dump Tare	Total Tare	Dump Tare	Total Tare
Sept. 28								
Oct. 4	5.5	14.0	5.0	14.2				
Oct. 11	5.2	11.7	3.8	9.6	6.2	22.3		
Oct. 18	5.3	11.4	4.4	8.7	6.3	23.2	11.3	28.8
Oct. 25			4.4	8.8	-	-	12.7	36.4
Nov. 1			4.3	9.0	10.2	28. 4	13.5	25.8
Nov. 8								
Seasonal Average	5.3	13.1	4.3	9.2	7.2	22.2	12.7	30.5
Total tons beets	208		431		474		988	
Total tons dirt	28		22.4		136		332	
Total loads	45		95		97		130	

Note: Seasonal Averages worked out on basis of daily tare values and number of days included, not on basis of averages for the week.

Table 7. Appendix B.

Soil Textures for Various Records Included in 1947 Dirt Tare Study. The Harvesting Method is Included.

Record No.	Texture	Harvesting Method
1	Loam	HM-1
2	Loam	HM-1
3	Clay loam	HM-1
4	Silt loam	HM-1
5	Silty clay loam	HM-1
6	Silty clay loam	HM-1
7	Clay loam	HM-1
8	Loam	Kiest
9	Loam	Kiest
10	Clay loam	Hand Top, Hand Load
11	Silt loam	Hand Top, Hand Load
12	Clay loam	Hand top, Hand load
13	Loam	Hand top, Machine load
14	Clay loam	Hand top, Machine load
15	Clay loam	Hand top, Machine load

Appendix C.

The appended material in this section includes:

1. A detailed discussion of cost accounting procedures.
2. Individual performance records for 1946 and 1947. (Tables I, II and III).
3. Individual cost records for 1946 and 1947. (Tables IV and VII)

List of Appended Tables.

Appendix C

The Price Structure and Method of Cost Analysis.

Basis of Comparison

The costs of harvesting beets mechanically have been compared with contract hand labour costs. Undoubtedly there are labour and machine combinations in use that would fall intermediate in cost, but it was felt that the contract labour basis would be most suitable since it represents the most common standard practice.

Contract Hand Labour Prices.

Contracts are drawn up between the grower and labourers for the complete year's hand work or for either the spring or fall seasons. In this study only the contract prices for harvesting labour are used. The quoted price in 1946 was $1.80 per ton for hand pulling and topping. However, most growers had to pay $1.90 per ton. In 1947 the price was $1.90 per ton. Contract prices have not varied over a wide range for a number of years, consequently the value above is quite representative of costs over a period of years as well as for the 1946 and 1947 seasons.

The ploughing operation, performed by the grower, has been charged at a rate of $3.00 per acre. This includes the cost of dragging out the windrow trench for mechanical loading. The tractor or team used on the plow normally did bbth operations.

Various custom rates for loading and hauling were in vogue throughout the area. A uniform hauling charge of $1.00 per ton has been used for all records. The distance factor has been disregarded. The use of a uniform hauling charge will not enter into the comparative picture but only serves to present overall harvesting costs. In many instances the operator did all or a part of his own hauling. In order to avoid complications in the study, arising from variations in custom rates and in the hauling distance, the uniform value has been used. Hand loading was charged at 50¢ per ton. This represents an average value for rates being paid throughout the district. Instances of rates of about 40¢ per ton were found but because of the nature of the labour involved these were not weighed too heavily in the average.

Tractor Use.

Fuel and oil as used has been charged against the tractors. Depreciation, repairs, interest , and housing, have been charged on a basis of 2.5¢ per $100.00 of new value per hour of use. This rate is based on a lifetime of 10,000 hours and would seem adequate for tractors in the three plow power class.

Labour

The machine operator's labour has been charged at a rate of $7.00 per 10 hour day. This represents a low average. Some growers would willingly pay much higher wages for proficient operators.

Mechanical Loaders

No definite information is at hand on the lifetime of mechanical loaders. The machines in use are capable of loading 1.0 to 1.5 tons of beets per minute. Many loads, timed in the field, were found to require 5 to 6 minutes total time. Assuming a 15 ton crop, and at most 5 loads per acre, the normal loader use per acre would be about 30 minutes. Depreciation and repairs have been charged at 12%. Interest has been charged at 6% on the half value. The basic assumption is that one loader should handle 100 acres per year for a 15 year period.

Two makes of loaders were used. The John Deere cost $615.00 and the

"Robin" (or Robeco) loader cost $900.00. A few homemade machines were found and were considered as being equivalent to the "Robeco". The charges were calculated as follows:

John Deere	12% x 615.00	=	$ 79.80	
	6% x ½ x 615.00	=	$ 18.44	
	Total charge	=	$ 98.24	per 100 acres per year.
	Charge per acre	=	98¢.	
Robeco	12% x 900.00	=	$108.00	
	6% x ½ x 900.00	=	$ 27.00	
	Total charge	=	$135.00	per 100 acres.
	Charge per acre	=	$ 1.35	

The beet cart on the HM-1 harvester has basically the function and mechanism of a loader. It has been treated as such in the price structure and the charge per acre has been calculated as follows:

12% x $1715.00	=	$205.80	
6% x ½ x 1715.00	=	51.45	
Total charge	=	$257.25	per 100 acres per year.
Charge per acre	=	$ 2.57	per acre.

Trucks

Two records were taken in which the actual hauling costs were used rather than the assumed cost. In both cases the fields were located within about one mile of the receiving stations. Fuel and oil was charged as used. An annual charge of 5¢ per mile was made. This value is a bit higher than normal use would require, however since a great deal of the mileage involved low gear operation in soft fields, the value has been weighed accordingly.

Harvesters

One question asked each operator during the survey was his opinion as to the probable lifetime of his harvester. The values given ranged from 5 to 10 years averaging about 7½ to 8 years. The author feels that some weight should be given to the opinions of the commercial users, but that their opinion has been influenced too much by income tax deduction values. The case history of one HM-1 harvester operated throughout California and adjacent states is of interest here. The unit started in the California harvest in May and continued operation through November. It harvested over 5000 acres in alltypes of soils averaging 2½ hours operating time per acre at 6½ tons per acre. (Hipple, J. L., The International Sugar Beet Harvester, A.S.A.E. Journal, Vol. 29, No. 11, November 1948). This record would seem to indicate a large life period. Such a record is not valid as a basis for life estimation. No repair cost data is available. Secondly the machine was operated by factory personnel and not by average farm help. The survey results indicated that practically all machines used in Southern Alberta did less than 50 acres per year. The results also showed that in a normal year 50 acres was not too much to expect from one single row machine considering field performance and seasonal limitations.

The author has used the following basis for charging annual costs:

(1) It was considered that at 50 acres per year the machine would be worn out in 15 years. In arriving at the 15 year value the machines were compared to potato machinery. D.C.D.A. publication 750, (farmers bulletin 118), indicates a 15 year lifetime or 500 acres for potato diggers.

(2) The factor of obsolescence was weighed fairly heavily. The rate at which research and improvement work has been carried out indicated that present models would be obsolete in 10 years. The average operator opinion value of 7 to 8 years was considered but this was felt to contain too high an obsolescence

factor. The value chosen was 10 years at 50 acres per year. The charge basis then contained a factor of 2/3 wear and 1/3 obsolescence at the assumed time of discard.

(3) In the cost studies a uniform charge per acre has been used regardless of the actual acreage harvested in each record. Insufficient records were available at the time of the survey to enable cost curves to be plotted. The uniform charge has been used to establish a basis for a calculated cost curve.

(4) Depreciation rates are charged at 10% per year.

(5) Housing and off season repair labour has been charged at 2%.

(6) Repairs have not been charged as given by the operator. A yearly rate of 5% was assumed. Actual repairs averaged nearly 2% for the first year of operation. This figure would have to be weighted upward to cover total repairs for the lifetime of the machine. Some thought was given to the use of 7%. One record in which the pick up drum on the 54A was badly damaged by abuse, showed a repair bill of only $65.00. This was about equal to the 7% value which was considered to be too high.

(7) Interest was charged at 6% on the half value.

Based on the above, the annual use charges per acre have been calculated as follows:

<u>John Deere 54A</u>

17% x $915.00	=	$155.50	
6% x ½ x 915.00	=	27.45	
Total charge	=	$182.95	on 50 acres per year.
Charge per acre	=	$ 3.66	

John Deere 54A and John Deere loader
= $3.66 + 98¢ = $ 4.64 per acre.

John Deere 54A and Robeco loader
= $3.66 + $1.35 = $ 5.01 per acre.

International HM-1 harvester

17% x $810.00	=	$137.70	
6% x ½ x 810.00	=	24.30	
Total charge	=	$162.00	on 50 acres per year.
Charge per acre	=	$ 3.24	
Plus charge on cart	=	$ 2.57	
Total	=	$ 5.81	per acre.

Cost Curves

One of the basic purposes of the study has been to obtain information as to the optimum and minimum acreage requirements of the machines. The results have been given in the body of the report in figure 42. The following is the basis on which the graph curves have been plotted.

The basic assumption of 10 years of life at 50 acres per year has been maintained. This value has been indicated as containing 1/3 obsolescence and 2/3 wear.

Depreciation due to wear was calculated $\frac{2 \times \text{new value}}{3 \times 500}$ = wear charge per acre.

Obsolescence calculations:

$$\frac{\text{New value} - (\text{Wear/acre} \times \text{acres year})}{10 \times \text{acres per year}} = \text{charge/acre.}$$

Interest was charged at a fixed annual value:

$$\frac{3\% \times \text{new value}}{\text{acres/year}}$$

Repairs were taken at a fixed charge per acre. The repair rate will be influenced primarily by acreage per year more than tons per year because of the large amount of soil passing through the machine. Repairs should therefore become a fixed charge per acre. Housing has been included.

$$\frac{7\% \times \text{new value}}{50} = \text{repair charge per acre.}$$

To the above fixed and variable charges have been added:

(a) Tractor use charges on the basis of the 1947 survey results.

(b) Wages on basis of 1947 survey averages.

(c) Cost per acre of fuel, oil and grease as given in the 1947 survey.

Mechanical loaders have been added into the cost curves using a method similar to that for the harvesters. The basis of 15 years at 100 acres per year was maintained. It was assumed that the loader or cart would be discarded with the harvester. Thus for the 10 year period of use a 2/3 wear out and 1/3 obsolescence factor was used. Interest at 6% on the half value and repairs at 5% have been calculated as in the original data.

Contract hand labour prices were used as in the original data. Hauling was not charged in the cost curves. This was a uniform charge per acre and was constant for hand and machine methods.

Tables I to VI inclusive are appended and give the individual performance and cost records. Table VII gives the average values for all records in each group. Column 2, table VIII contains 4 records taken out of column 1 for the purpose of comparison with column 3. These are identical records in which it was possible to distinguish loading costs from harvester costs.

Appendix C.

Table 1. Individual Performance Records on 54A Harvesters Delivering Beets into the Windrow, Southern Alberta, 1946.

Record number	1	2	3	4	5	6	7	8	9	10	11	12	13	Average.
Acres	32.0	30.0	22	25	22	25	17	16	30	24	30	50	26.7	27.7
Total Tons	450	375	287	350	308	407	221	176	560	300	420	600	485	380
Tons/acre	14.1	12.5	13.0	14	14	16.1	13	11	18.6	12.5	14	12	13.4	13.7
Number of days	14	17	13	12	11	14	7	7.5	15	16	15	21	22	14.2
No. of operators	2	1	1	1	1	1	1	2	1	1	2	1	1	1.2
Acres per day	2.28	1.76	1.69	2.08	1.57	1.79	2.43	2.13	2.00	1.50	2.00	2.38	1.67	1.95
Tons per day	32.10	22.0	22.10	29.20	28.00	29.10	31.60	23.50	37.4	18.80	28.00	28.60	22.10	26.80
Machine hours/acre	3.50	4.54	4.73	3.84	4.00	4.48	3.30	3.75	4.00	5.33	4.00	3.36	4.80	4.10
Machine hours/ton	0.25	0.36	0.36	0.27	0.29	0.27	0.25	0.34	0.21	0.43	0.29	0.28	0.36	0.30
Man hours/acre	8.70	5.70	5.90	4.80	5.00	5.60	4.10	9.40	5.00	6.70	10.00	4.20	6.00	6.15
Man hours/ton	0.62	0.45	0.45	0.34	0.36	0.34	0.32	0.85	0.27	0.53	0.71	0.35	0.45	0.44

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Table 2 Individual Performance Records of 54A Harvester and Mechanical Loaders, Southern Alberta, 1947. Beets Loaded Into Trucks.

Record No.	27	28	29	30	31	32	33	34	35	36	37	Average.
Number of acres	49	32	34	33	39	39	45	26	45	54	23	37.9
Total Tons	692	552	523	385	321	428	660	300	510	765	243	489
Tons/acre	14.1	17.2	15.4	11.7	8.2	11.0	14.7	11.5	11.9	14.2	10.6	12.9
No. of Days	19	17	14	16	25	21	24	10	21	26	10	18.5
No. of Operators	3	2	2	2	2	2	2	2	2	2	2	2
Ave. Acres/day	2.60	1.90	2.40	2.10	1.50	1.90	1.90	2.60	2.00	2.10	2.30	2.00
Ave. Tons/day	36.40	32.50	37.40	24.10	12.90	20.40	26.50	30.00	24.30	29.40	24.30	26.40
Machine hours/acre	3.10	4.25	3.29	3.88	5.12	4.31	4.26	3.08	3.90	3.85	3.48	3.90
Machine hours/ton	0.22	0.25	0.21	0.33	0.62	0.39	0.29	0.27	0.33	0.27	0.33	0.30
Man hours/acre	11.60	10.60	8.20	9.70	12.80	10.80	10.70	7.60	9.80	9.60	8.70	9.80
Man hours/ton	0.82	0.61	0.53	0.83	1.56	0.98	0.73	0.67	0.82	0.68	0.82	0.76

Appendix C

Table 3. Individual Performance Records of HM-1 Harvesters and Two Kiest Units, Beets Loaded into Trucks, Southern Alberta, 1947.

Record No.	16	17	18	19	20	21	22	23	24	25	26	Ave.	38	29	Ave.
No. of Acres	19	50	31	32	57	53	50	18	32	38	47	38.8	58.6	77	67.8
Total Tons	214	605	345	352	832	544	521	148	450	443	535	453.5	1154	1128	1141
Tons/acre	11.3	12.1	11.2	11.0	14.7	10.3	10.4	8.2	14.1	11.6	11.4	11.7	19.6	14.6	17.1
Days	8	21	15	16	23	18	24	8	15	18	23	17.2	23	18	20.5
No. of Operators	3	3	2	3	4	3	1	2	2	3	2	2. 55	2.5	4.5	3.5
Acres/day	2.37	2.38	2.06	2.00	2.48	2.94	2.08	2.25	2.14	2.11	2.04	2.26	2.55	4.28	3.30
Tons/day	26.75	28.80	23.00	22.00	36.20	30.20	21.70	18.50	30.00	24.60	23.20	26.40	50.20	62.70	55.70
Machine hrs./acre	3.37	3.36	3.87	4.00	3.22	2.72	3.84	3.56	3.75	3.79	3.92	3.55	3.14	1.87	2.42
Machine hrs./ton	0.29	0.28	0.35	0.36	0.22	0.26	0.37	0.43	0.27	0.33	0.34	0.30	0.16	0.11	0.14
Man hours/acre	12.10	12.60	9.70	15.00	16.10	10.40	4.80	8.90	9.40	14.20	9.80	11.30	9.90	10.50	10.20
Man hours/ton	1.07	1.04	0.87	1.36	1.10	0.98	0.46	1.08	0.67	1.21	0.86	0.97	0.50	0.72	0.61

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Table 4. Individual Cost Records, 54A Harvesters 1946, Nos. 1 to 13 Inclusive Used Hand Loading, Nos. 14 and 15 Loaded Directly Into Trucks. Records With Letter "A" Loaded with Mechanical Loaders.

Record No.	1	2	3	4	5	6	7
Acres	32	30	22	25	22	25	17
Total tons	450	375	287	350	308	407	221
Tons/acre	14.1	12.5	13.0	14	14	16.7	13
No. of Days	14	17	13	12	11	14	7
No. of operators	2	1	1	1	1	1	1
Costs on Harvesters							
Fuel, Oil, Grease	30.50	36.60	25.60	30.50	27.95	27.00	20.60
Wages	196.00	119.00	91.00	84.00	77.00	98.00	49.00
Costs on Loaders							
Fuel, oil, grease							
Wages							
Costs on hauling							
Fuel, oil, grease							
Wages							
Repair Costs	18.00	30.00	28.25	12.00	12.00	65.00	5.00
Total Running Costs	226.50	155.60	116.60	114.50	104.95	125.00	69.60
Costs/acre	7.08	5.19	5.30	4.58	4.77	5.00	4.09
Costs/ton	0.50	0.41	0.41	0.33	0.34	0.31	0.31

Record No.	8	9	10	11	12	13	14	15	3A	9A	12A	13A
Acres	16	30	24	30	50	36.7	30	27	22	30	50	36.7
Total tons	176	560	300	420	600	485	300	331.5	287	560	600	485
Tons/acre	11	18.6	12.5	14	12	13.4	10	14.5	13	18.6	12	13.4
No. of Days	7.5	15	16	15	21	22	16	14	13	15	21	22
No. of operators	[illegible]	1	1	2	1	1	1	2	1+	1+	1+	1+
Costs on Harvesters												
Fuel, Oil, Grease	19.10	37.00	29.40	36.25	59.00	52.50	40.00	30.30	25.60	37.00	59.00	52.50
Wages	[illegible]	105.00	112.00	210.00	147.00	154.00	114.00	196.00	91.00	105.00	147.00	154.00
Costs on Loaders												
Fuel, oil, grease									12.66	17.90	31.50	21.00
Wages									15.40	21.00	35.00	25.69
Costs on hauling												
Fuel, oil, grease							58.65	49.50				
Wages							182.00	153.90				
Repair Costs	2.00	7.50	25.00	5.00	25.00	6.00	(Repairs not edded into totals).					
Total Running Costs	124.10	142.00	141.40	246.25	206.00	206.50	394.65	429.70	144.60	180.90	272.50	253.19
Costs/acre	7.76	4.73	5.89	8.21	4.12	5.63	13.15	15.91	6.58	6.03	5.45	6.90
Costs/ton	0.71	0.25	0.47	0.59	0.34	0.43	1.32	1.13	0.50	0.32	0.45	0.52

Note: Charge contract hauling at $1.00 per ton, hand loading at 50¢ per ton.

Note: "A" series records - mechanical loader operators wages proportioned - rest of time worked on plowing, etc. for contract labour.

Appendix C.

Table 5. Individual Operating Cost Records on HM-1 Harvesters, Southern Alberta, 1947.

Record No.	16	17	18	19	20	21
Acres	19	50	31	32	57	53
Tons	214	605	345	352	832	544
Tons/acre	11.3	12.1	11.2	11.0	14.7	10.3
Days	8	21	15	16	23	18
No. operators	3	3	2	3	4	3
Operating costs						
Fuel, oil, grease	21.30	56.90	41.26	46.94	67.74	54.64
Wages	168.00	441.00	210.00	336.00	645.00	378.00
Cost/acre	9.96	9.96	8.11	11.97	12.68	8.16
Cost/ton	0.88	0.82	0.73	1.09	0.87	0.80

Record No.	22	23	24	25	26
Acres	50	18	32	38	47
Tons	521	148	450	443	535
Tons/acre	10.4	8.2	14.1	11.6	11.4
Days	24	8	15	18	23
No. operators	1	2	2	3	2
Operating Costs					
Fuel, oil, grease	76.00	22.60	41.40	66.85	60.40
Wages	168.00	112.00	210.00	378.00	322.00
Cost/acre	4.88	7.48	7.86	11.71	8.14
Cost/ton	0.47	0.91	0.56	1.00	0.71

Table 6. Individual Cost Records on 54A Harvesters Used with Mechanical Loaders 1947, Southern Alberta.

Record No.	27	28	29	30	31	32
Acres	49	32	34	33	39	39
Tons	692	552	523	385	321	428
Tons/acre	14.1	17.2	15.4	11.7	8.2	11.0
Days	19	17	14	16	25	21
No. Operators	3	2	2	2	2	2
Operating Costs						
Fuel, oil, grease	63.00	48.40	52.64	50.50	56.76	64.00
Wages	399.00	238.00	196.00	224.00	350.00	294.00
Cost/acre	9.43	8.95	7.31	8.32	10.43	9.43
Cost/ton	0.67	0.52	0.47	0.71	1.27	0.86

Record No.	33	34	35	36	37
Acres	45	26	43	54	23
Tons	660	300	510	765	243
Tons/acre	14.7	11.5	11.9	14.2	10.6
Days	24	10	21	26	10
No. Operators	2	2	2	2	2
Operating Costs					
Fuel, oil, grease	68.00	29.40	62.80	82.00	36.15
Wages	336.00	140.00	294.00	364.00	140.00
Cost/acre	8.95	6.52	8.30	8.26	7.66
Cost/ton	0.61	0.56	0.70	0.58	0.72

Table 7. Summary of Costs of Operating Mechanical Beet Harvesters, Based on Average Values in 1946 and 1947, Southern Alberta.

	1	2	3	4	5	6
Machine	54A	54A	54A	54A	54A	HM-1
loaded by	Hand	Hand	Loader	54A	Loader	-
Year	1946	1946	1946	1946	1947	1947
No. of Records	13	4	4	2	11	11
Ave. Acres	27.7	34.7	34.7	28.5	37.9	38.8
Ave. Total Tons.	380	483	483	340.7	489	453.6
Ave. tons/ Acre	13.7	13.9	13.9	12.3	12.9	11.7
Ave. Days	14.2	17.75	17.75	15.0	16.6	17.18
Operating costs						
Fuel, oil, grease	33.23	43.53	64.29	89.22	56.70	50.55
Wages	119.00	124.25	148.52	322.95	270.45	307.09
Hauling	570.00	724.50	483.00	-	489.00	453.60
Annual Costs						
Deprec. Harv.	101.38	126.91	126.91	104.31	138.71	225.43
Tractor.	49.98	62.48	62.48	52.80	64.92	59.11
Dep. Loader	-	-	41.38	-	42.91	-
Tractor	-	-	7.68	-	8.46	-
Dep. Truck	-	-	-	9.17	-	-
" Tractor & Trailer	-	-	-	14.04	-	-
Total Costs	873.57	1081.67	934.01	592.49	1071.15	1095.38
Cost/acre	31.54	31.17	26.92	20.78	28.26	28.24
Cost/ton	2.30	2.24	1.93	1.74	2.19	2.41

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