SUGAR BEET HARVESTER TESTS 1938-1939

By

Roy Bainer1/

During 1938-1939, beet harvester trials were conducted in Colorado, Idaho, Utah and California. The work was carried on jointly by the United States Department of Agriculture and the California Agricultural Experiment Station, and supported in part by funds from the United States Beet Sugar Association.

The equipment tested consisted of commercial machines, farmer-built machines and machines developed at the Experiment Station. Many of the machines were not complete in the sense of doing an entire harvesting job. Some were toppers, others lifters, while in some cases the unit consisted merely of an element of an experimental machine. Most of the tests were run in California; first, because of the location of the cooperative agencies; second, because of the long harvest season, which starts in the Imperial Valley about April 15, and ends in Northern California about December 1.

Conditions in California during harvest are less favorable for machine operation than those encountered in the Intermountain States. Generally speaking, the quality of thinning is poorer, resulting in more beets in multiple combinations. Cultivation and irrigation of beets may be discontinued as much as 2 or 3 months in advance of harvest, resulting in more weeds and hard, cloddy ground. The clods, which are more numerous than beets and oftentimes much heavier, interfere with lifting and separating operations. Because of the absence of moisture the latter part of the season, top growth practically dies down, leaving a mass of dead leaves around the plant, thus hindering the operation of any machine that depends upon the leaves for lifting the beet. Experience to date indicates that any machine showing promise under California conditions should perform much better under the more favorable conditions found in the Intermountain States.

METHODS FOLLOWED IN TESTING

Toppers and Harvesters

After the machine was adjusted to do its best work, the beets and tops from 100 feet of row (usually selected in advance of machine operation) were collected for analysis. Notations were made of stand, variations in height and arrangement, such as multiple combinations.

The topping loss, due to topping the beet too low, was determined, by trimming from the crown, any portion that should have been left on the beet.

The beets were segregated into two classifications: those commercially acceptable and those commercially unacceptable. This was an arbitrary classification based upon the amount of leaves left on the beets. The beets thrown into the unacceptable group showed no signs of any cut through the crown, but in the majority of cases the leaves had been cut or pinched off.

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The beets were then trimmed for top tare. The tare was measured and recorded separately for each group, then added to make up the final report. Beets up to 3 inches in diameter were cut squarely at the leaf scar while those larger were cut 3/4 inches above the lowest leaf scar, then trimmed at approximately a 60 degree angle. Beets less than 1-1/4 inches in diameter were thrown out. Topping loss and tare were then added to give an index for rating machines.

In order to have something tangible with which to compare harvester tests, a test was made to determine the tare for an ideal job of hand topping. The beets were carefully topped with one straight cut across the beet at the leaf scar on 3 inch diameter or less beets, and 3/4 inches above the leaf scar on larger beets. In no cases were the beets topped in a manner to make them commercially unacceptable. The tare on these samples amounted to 3.03 per cent.

Checks were made of hand topping in California, Colorado and Idaho. A weighted average showed a topping loss of 1.83 per cent and top tare of 2.7 per cent. The sum of the two amounted to 4.53 per cent.

Machine Descriptions

Following is a description of the machines tested.

Scott-Urschel. This machine was developed by W. E. Urschel for the Scott-Viner Co. It consists of a single row, pulled type machine, operated through a power take-off from a 25 or 30 horsepower tractor. A pair of rubber-faced elevator chains grasp the beet top just as a single-point type plow, operating under the row, loosens the beet. The beets are elevated by their tops to a set of horizontal roller bars which position the beet for topping. A pair of rotating concave disks, set at an angle with each other to give a roof-like cut, do the topping. The tops may be windrowed or piled, while the topped beets are elevated directly to a truck or hopper.

The Scott-Urschel machine is no doubt the closest approach to a complete mechanical harvester available at this time. However, its operation depends upon adequate beet tops for lifting. The gathering points lack flexibility in getting over beets of uneven height. The method of gauging follows practically a straight relationship which means that if the machine is set to properly top average beets, too much material will be removed from small beets. The machine has the definite advantage of separating beets from the soil, saving tops and handling beets in multiple combinations. By following the machine with one or two men to pick up missed beets and trim improperly topped beets, the machine is able to do commercial harvesting.

Variable-Cut Topper. The Variable-Cut topper being developed at the California Experiment Station is still in the experimental stage. Its design is based upon data taken in California, Idaho and Utah, which show a definite correlation between thickness of crown and the height a beet grows above the ground. The machine is constructed with a ratio linkage connection between the finder and the knife so that a thicker crown cut is taken from a high beet than from a low one. The thickness of the cut is gauged by a self-centering finder as it passes over each beet. The topping is done by a flat vibrating knife, operated by a reaction drive mounted on one of the knife arms. This unique drive consists of an off-center slug rotated at 3000 revolutions per minute (field speed 3 miles per hour) by a flexible shaft connection to a gear box, driven from the ground wheels. The slug sets up a 100-pound lateral force on the knife and causes it to oscillate through 3/4 inch lateral strokes 100 times per second.

The flexible drive allows for quick raising and lowering of the knife without affecting its operation, and provides sufficient energy to force it underground. The unit is made light purposely to allow the finder and knife to be spring-loaded to hasten acceleration downward when passing from a high to a low beet.

The satisfactory performance of this unit depends upon the arrangement of beets in the field. For conditions of fairly uniform spacing, and with not to exceed 10 to 15 per cent of the beets in multiple combinations, the machine will do work comparable with hand topping. Where two beets of uneven height are growing together, the high one will be topped correctly, while the other will be missed or improperly topped. Due to its extreme flexibility and the rapidity with which the topping mechanism falls from a high beet, forward speeds up to 3 miles per hour are possible.

Devey Topper. This unit consists of a driven tandem wheel-type finder and a cutting disk for removing the crown. Each finder wheel or roll consists of four 6-inch flat disks, made of 1/2 inch steel plate, set 1-3/4 inches apart. One wheel dove-tails with the other to give a more continuous surface against the beet. The front roll is mounted about 3 inches higher than the back one to facilitate getting over high beets. The actual gauging is done by the back roll. An ordinary 16 inch or 18 inch disk harrow blade is used for the topping knife. The disk blade is driven at approximately 225 revolutions per minute. A short length of chain operating on a sprocket on the disk drive shaft and an idler sprocket, brushes the beet tops to one side as they are cut off. An adjustable linkage connection between the frame supporting the finder and the disk support makes it possible to change the relative position of the two to cut more or less crown from the beet. At the same time it provides a means for giving a ratio between the finder and the disk, in order to take a greater cut from a high beet than a low one. The machine, when tested had a variable cut ratio of 1.25 to 1. As many as four units may be mounted on the tool bar of a general purpose tractor, and driven from its power take-off.

The chief disadvantage of this type of design is excessive weight. The only possibility of spring loading the unit for accelerating its downward movement, is to reduce its weight considerably; otherwise, the beet is unable to withstand the force on it. The only alternative is to operate at low field speeds. During tests, the machine was operated at approximately 1.25 miles per hour. In one case where the beets were extremely high the machine was slowed down to 3/4 mile per hour to avoid skipping beets.

The wide roll finder made it possible to keep the topping loss low. There was no opportunity for the finder to slip off the beets, or pass between doubles, either of which would allow the knife to take an excessive cut. The machine also handles weedy conditions very well. Topping was satisfactorily done in a field badly infested with morning glory. Under heavy top growth conditions, some difficulty was experienced in getting through the top growth to low beets. Otherwise, the tops did not interfere with proper gauging.

Liberty Topper. This unit is mounted on the tongue of a horse-drawn lifter, so that the beets are topped just ahead of plowing. The gauging is done with a single blade-type finder which is made integral with the knife. The finder is sharpened on the under side so that it actually cuts into the top, splitting the crown just as the horizontal knife cuts it off. The knife consisting of two wings, set at an angle with the direction of travel, closely resembles the blades on the shovel of a duckfoot cultivator. Flat runners, on each side of the finder, tend to center it on the beet. The depth of cut is regulated by the relative height of the finder above the knife. This method of gauging, although simple, does not compensate for high and low beets. Under the dry soil conditions at Davis, the knife would not enter the ground, so that beets with crowns below the surface were not topped. However, this type of knife was employed on two toppers designed for use in peat soil.

John Zuckerman Topper. This topper consists of a 4-row self-propelled unit. Beets are topped in the ground by a "V" knife similar to the one used on the Liberty. A positively-driven pair of narrow-gauge wheels holds the beets in place while they are being topped. The machine employs a direct gauging ratio so that approximately the same cut is taken on each beet regardless of size. The tops are raked to one side by a side delivery rake.

Roscoe Zuckerman Topper. This machine differs from the John Zuckerman unit in that the gauge wheels are ground-driven and a variable ratio (1.1 to 1.4 to 1) was built in to compensate for high and low beets. The machine is of the pulled type. The preliminary trials with this machine were not satisfactory since the wheels tended to sink into the loose peat soil, and the whole machine rocked about its single axle.

Great Western Topper. This unit was developed by the Great Western Sugar Company several years ago. It tops 2 rows and consists of a positively driven wheel-finder with a horizontal knife attached immediately below it. The cut is fixed so that all beets are topped alike regardless of size. The finder wheel holds the top in place while the knife cuts through, which reduces the tendency toward breaking the beets. A side delivery rake attached to the topper moves the tops laterally, away from the two rows.

Lifters and Diggers

Topping beets satisfactorily, while in the ground, is only one step in the harvesting problem. An equally difficult task is that of lifting topped beets from the soil and separating them from clods. Ordinary lifters do not raise the beets sufficiently to be seen. Therefore, they cannot be picked up by hand without loss. Clod conditions found in California, and occasionally in the Intermountain States, prevent the use of machines that lift the beets and surrounding soil and then attempt to separate them on screens.

Many attempts have been made to build lifters, and, in some cases these have met local conditions. A brief discussion of some of these lifters follows:

John Zuckerman Digger Loader. Four rows of ground topped beets are picked up by means of spiked wheels. The wheels are approximately 3 feet in diameter. Each has four rows of spring-loaded sharpened spikes 5/16 inch in diameter, protruding 3 inches from the surface. The beets are loosened by conventional winged type subsoil plows ahead of the wheel. As the wheel rolls over the beets they are pierced by the spikes and carried to the stripper. They fall from the stripper to a cross conveyor and elevator which loads them into a truck. This unit worked on a commercial basis in peat soils. It should have had something like a Rienks roll screen in it to remove the surplus soil. Approximately 500 pounds of soil were loaded with each 8000 pounds of beets. The spikes, being radial to the wheel, change position while entering the beet. This does not bother so much where beets are grown in peat soils because the beets are loosely held by the soil and they can line up with the spikes. In sedimentary soils this is not true; therefore, more breaking of beets occurs. Approximately 20,000 tons of topped beets were handled in 1939 with this machine.

Roscoe Zuckerman Digger Loader. A four-row potato digger, developed for peat soil conditions, was rebuilt to handle beets. Conventional double blade lifters backed up by a lugged conveyor and potato chains loosen the beets and elevate them with the peat soil to a high-speed Rienks roll screen. The beets are bounced by the screen so that most of the dirt is removed and sifted out. They are then elevated to a truck which backs along behind the digger-loader. This unit will not work under sedimentary soil conditions. Zuckerman harvested on a commercial basis this year in peat soils using this topper and loader.

Devey Digger. Devey employs a bed type lifter that straddles two rows of beets. Rods extending back and up from the plow points guide the beets and soil to two transverse, horizontal square rods immediately behind the standards. The square rods are 6 inches apart and are equipped with picker fingers. They are driven so that the top of the rods rotate away from the plow. As the soil mass and beets move backward relative to the plow, the rods assist in maintaining an even flow. At the same time the picking fingers engage the beets, lifting them to the surface. A subsequent mechanical pickup operation has not been developed.

Braden Lifter. The Braden lifter consists of a double blade plow having long blades, which loosens the beets and elevates them into a moving "V" shaped elevator. The elevator is made of potato chain and extends from the plow points to a dump hopper at the rear. This machine works satisfactorily only if the soil is loose and friable. The open elevator permits loose soil and small clods to fall out as the beets are conveyed to the receiving hopper, which may be dumped when full. An extension on the elevators would make it possible to load directly into a truck in cases where dirt is satisfactorily removed.

Experimental Vibrator Lifter. A brief description of a rather novel elemental vibrating device for lifting topped beets to the soil surface may be of interest. It is necessary to point out, that most of these experimental devices are quite crude in their early development, but they illustrate possible methods of attack, and demonstrate principles, which in time may have practical significance in lifting beets and subsequently separating them from clods. The Vibrating unit consists of two horizontal rods joined to form a "V" with the open end extending in the direction of travel. The "V" is carried by four vertical supports which are driven by counterbalanced cranks. A small engine drives the cranks at 1500 revolutions per minute. The throw of the cranks is 1/2 inch, which gives a lifting stroke of 1 inch for each revolution. The unit is preceded by a double pointed plow for loosening the beets. The "V" engages the beet just below its bulge. Its action is first that of breaking up the soil adjacent to the beet; and secondly, raising the beet by successive short lifts. The beet is contacted as soon as the space between the rods is equal to the diameter of the beet, which means that as the machine is pulled forward along the row, each beet is contacted, regardless of size. Several preliminary runs have been made with this elemental device. All of the beets in the row were lifted to the surface and at the same time the clods were considerably reduced in size. Some of the tap roots were broken, due to lack of clearance and design of the "V". However, the experimental unit shows promise in its ability to lift beets free of clods. Further development work, making use of these principles, is in progress at the California Experiment Station.

Hand Topping into Mechanical Loaders

Two of these loader units were built and used in California the past season. One was built by Frank Alvos of Buttonwillow, California, the other by J. P. Rapetti, of West Sacramento, California. The latter only will be described.

The Rapetti Loader. This unit is built around the chassis of a Holt "45" tractor. A cross draper made of old belting 18 inches wide spans 11 beet rows (20 inch spacing). A cleated elevator, consisting of another length of belt, carries the beets from the conveyor into a bin. The back stop on the cross conveyor is interchangeable from one side to the other. This was necessary to operate the machine in either direction. This latter feature eliminated the necessity for turning completely at the end of the field. Power for driving the tracks, cross draper and elevator is furnished by an automobile engine. An auxiliary transmission between the engine and the final tractor drive makes it possible to operate the machine in either direction at approximately 1000 feet per hour. Topping is done by 8 men working on 12 rows. Two men top from 3 rows, throwing the topped beets onto the cross conveyor for loading. The bin over the chassis has a beet capacity of approximately 4 tons. The trucks used for hauling carried 8 tons per trip, so that 2 bin loads were required to make one truck load.

A summary of a field test on the machine follows:

Area of test plot (acres)	0.47
Yield on test plot (tons per acre)	16.8
Speed of topping and loading (miles per hour)	0.17
Area covered topping and loading (acres per hour)	0.41
Rate of topping and loading (tons per hour)	6.88
Beets per hundred feet of row (number)	109
Number of rows topped	12
Acres per worker - per hour	0.04
Tons per worker - per hour	0.69

Crew: 8 toppers
1 operator
1 man placing beets in bin. (Better design would eliminate this man.)

The time for transferring beets from the bin to the truck was 3-1/2 minutes. The same length of time was required for turning the machine at the end. The time for unloading could be eliminated by transferring beets without stopping the machine. The turning time could be reduced by providing a gear change for speeding up the machine at the end of the field. The lost time in turning once and transferring 8 tons to a truck cost the grower, in wages, $0.87 or approximately $0.11 per ton. The time lost, however, might be charged to rest periods. The labor cost for topping and loading a 16.8 ton crop with Rapetti's loader totaled $12.23 per acre. At the present rate, the cost for hand topping and loading, in the same area, would be $14.38. The labor saving amounted to $2.15 or 16 per cent reduction below the cost for hand work. This does not take into consideration machine costs.

Loading Hand Topped Vs. Machine Topped Beets.

A comparative test was run with the Alvos loader (similar to the Rapetti) in which beets were hand topped and loaded in one case; and in another machine topped beets, plowed with the ordinary beet lifter, were loaded by hand. The rate of loading, in the latter case, was twice that when the topping was done by hand. However, difficulty was experienced in finding topped beets. This practice would not be practical unless the beets were brought to surface visibility in the lifting operation.

Other Machines

Pueblo Harvester. The Pueblo harvester is a single-row unit. Untopped beets are pulled by means of a lifter of the double-blade type equipped with extension rods, and then elevated by means of a slatted draper to a sorting conveyor. The beets are picked from the conveyor by hand and fed into circular topping saws. The topped beets are then elevated to a hopper from which they are dumped in piles, while the tops pass through the machine on the conveyor and fall to the ground. Under California conditions a considerable amount of dirt was elevated with the untopped beets and this was mixed with the tops by the time they had reached the ground. Power for operating the machine as well as pulling it in the field was furnished by a 14 horsepower row-crop tractor. Considerable difficulty was experienced in keeping the machine on the row. This was partially due to an offset hitch on the overloaded tractor, and to the fact that there was no provision for steering the machine other than through the tractor.

Four operators were used; two picking untopped beets off the conveyor and laying them on cleated belts to feed the topping saws; and two positioning beets into the topping saws as well as picking up beets missed by the other workers. A tractor driver was required. At the rate traveled (1.06 miles per hour), 25.8 man-hours were required to lift, top and pile an acre of beets (24.6 tons). This is 28 per cent greater than the labor required to lift, top and windrow the same tonnage by hand under the same conditions. The topping knives on this machine are quite hazardous. They could not be adequately shielded because of the nature of the work. Operators had to be extremely cautious not to get their hands into the knives because of the unsteady footing furnished by the moving machine.

American Crystal-Oliver Buncher Loader: A discussion of this machine will be omitted since it is being covered in another paper.

Summary

Typical test runs made on several different harvesters are reported in Table I. The Scott-Viner and Pueblo are the only complete harvesters in the group. The others are "in place" toppers only.

The tare on the beets in run 4 amounted to only 1.6 per cent at the factory. Large beets were not tared to 3/4 inches above leaf scar by this company. Beets left in the field, run 5, amounted to 3 per cent by number. Run 6 was made in machine-thinned beets. In run 7 the factory tare (Colorado Standard) was 8.6 per cent. The field loss in run 8 amounted to 4.2 per cent which was partially due to horizontally-growing tops. While many beets in run 9 were judged unacceptable, the tare on these amounted to only 6.7 per cent.

The quality of work done by the variable-cut unit, runs 10 to 16, was rather consistent in each state where tests were made.

Run 17 is the average for 5 runs made with the Devey topper under very favorable conditions.

Runs 18 and 19 were made in a field badly infested with morning glory. The operation of the machine was not influenced by the heavy weed growth. No trouble was experienced with vines winding on the revolving parts. The beets in this field were quite large. Several beets in the test row weighed 12 to 15 pounds, with one weighing 24 pounds. In other words, these runs show performance under rather adverse conditions.

The field in which run 20 was made had a very heavy growth of tops with "pineapple" crowns. Many were 6 inches and 7 inches above the ground. Some difficulty was experienced in getting through the top growth and topping the low beet correctly. The heavy growth did not interfere with the gauging of the beets that had grown high above the ground. Speed had to be dropped to 3/4 mile per hour to allow time for the topping unit to fall from high beets. Factory tare amounted to 5.72 per cent.

Both Zuckerman machines, runs 21 and 22, were designed for operation in peat soils. John Zuckerman reported an average factory tare of approximately 4 per cent.

Run 23 represents the best performance rather than the average for this machine (3 runs). The operators knew that tests were being run so they did their best. The field loss amounted to 1.81 per cent.

TABLE I

SUMMARY OF BEET HARVESTER TRIALS 1938-39

Run	Machine	Location	Speed mph	Stand	Yield T/A	Acceptably topped % by wt.	Top Tare %	Top Loss %	Combined Tare and Top Loss
1	Liberty	Calif.	2.1	107	22	74.4	7.7	1.7	9.4
2	"	Utah	2.0	70	23.5	65.4	2.85	2.76	5.61
3	Gr.West.	Calif.	2.1	107	22	89.2	5.8	2.2	8.0
4	Scott-Urschel	"	2.05	96	22.5	100.0	2.63	0.92	3.55
5	"	"	2.94	94	25.5	95.98	2.76	1.54	4.3
6	"	Colo.	2.29	102	10.4	98.56	4.28	3.30	7.58
7	"	"	2.31	84	18.2	94.0	4.87	1.11	5.98
8	"	Idaho	1.80	93	20.6	86.2	3.46	1.03	4.49
9	"	"	2.0	95	28.3	74.7	3.30	1.94	5.24
10	Variable-Cut	Calif.	2.9	110	14.8	97.12	1.6	2.4	4.0
11	"	"	2.75	95	17.7	100.0	3.4	0.62	4.02
12	"	"	2.8	91	21.2	96.74	2.3	2.16	4.46
13	"	Colo.	2.75	102	10.4	99.46	2.5	0.96	3.46
14	"	"	2.75	84	18.2	99.86	3.2	0.68	3.88
15	"	Idaho	2.75	93	20.6	99.37	2.1	1.93	4.03
16	"	"	2.75	95	28.3	98.63	1.5	1.71	3.21
17	Devey	Calif.	1.25	93	27.3	97.7	4.14	0.30	4.44
18	"	"	1.26	86	26.7	95.8	2.47	0.10	2.57
19	"	"	1.20	93	45.4	95.5	4.70	0.11	4.81
20	"	"	0.77	127	44.0	92.4	5.14	0.48	5.62
21	Roscoe Zuckerman	"	1.87	127	23.8	94.5	2.35	5.06	7.41
22	John Zuckerman	"	2.25	88	23.0	90.6	8.25	1.34	9.59
23	Pueblo	"	1.06	103	24.6	100.0	1.13	1.14	2.27

SUGAR BEET SEED THRESHER AND CLEANING EQUIPMENT

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(Cooperative investigations with the American Crystal Sugar Company)

Machines constructed at Rocky Ford, Colo. for threshing and cleaning the relatively small lots of sugar-beet seed as obtained in sugar-beet breeding investigations were demonstrated, as follows:

(1) Combined thresher and cleaner. This machine was devised to thresh and clean seed of individual sugar-beet plants, or small group of plants, at one handling. The outfit as devised removes the seed from the stalks by means of a rotating cylinder equipped with teeth; the seed is screened through a coarse-mashed screen onto the draper; the draper removes leaf trash and small

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