

# The Status of Sugar Beet Harvester Development

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Mechanical harvesting of sugar beets is a practical reality even though beset with many difficult problems yet to be solved before hand work is entirely eliminated. In 1945 California growers harvested upwards of 400,000 tons mechanically, representing approximately 30 percent of the crop. Smith (4)<sup>2</sup> lists seven mechanical harvesters of importance for 1946 and nine in various stages of development. Of the seven listed as having significance for 1946 growers, three are commercially available through normal manufacturing channels, two are in the pre-production or engineering stage, and two are of the custom built type.

Mechanical harvester acceptance has been favorable from the standpoint of machine development. High wages, low labor supplies, and strong demand for sugar and sugar beet by-products have stimulated growers and processors to accept mechanically harvested roots under tare conditions which would have been unacceptable 10 to 12 years ago under different economic conditions. This influence has been most helpful in mechanization development and may be credited as a war benefit.

The immediate problem before the sugar beet industry is no longer one of feasibility of mechanization but one of programs of development which will bring to greater perfection the mechanization now established. One should not minimize the problems remaining, but on the other hand there are no good reasons for extreme pessimism. The ideal harvester is one that will harvest under any condition of soil, weeds, and weather with 100 percent root recovery and with a minimum of dirt and top tare, with the tops sorted out for convenient handling; all of these operations should be done by one machine, operated by one man, at any rate desired. Experience is telling us that ideals are not likely to be attained and no doubt several types of machines will find places in the market, each with superior performance for the area or condition in which it is predominantly used but none a completely perfect unit.

I propose to discuss briefly some of the trends in present-day design based upon recent developments as I did at the third general meeting of this Society in 1942 (5). I shall use the same general order of discussion for machine elements, viz:

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<sup>2</sup>Italic numbers in parenthesis refer to literature cited

1. Preparatory mechanisms such as coulters and disks.
2. Topping mechanisms including "in place" and "in machine" topping.
3. Plows or lifting devices.
4. Elevating mechanisms.
5. Soil-beet separation.
6. Root and top disposal.
7. Drive mechanisms and mountings.

Many present-day harvesters have some type of soil-working mechanism to prepare the beet for topping and lifting; particularly is this so for harvesters using the "in place" type of topper. The function of such mechanisms is to cut off leaf streamers; throw dirt away from the roots to make topping more accurate, fracture the soil adjacent to the roots to reduce clods, and in some cases, provide a more uniform surface for operating the automatic parts of the topping apparatus. The positioning of such mechanisms must be ahead of the topping and lifting units; for tractor-mounted harvesters these are near the front axle (Deere, international Harvester Company, and University of California types). Since such mechanisms must center on the row, and since the plow points likewise must follow on the row, when these two elements are far apart in a direction linear to the row any side draft in the harvester contributes to difficulties in holding the machine on row. Most "in machine" type toppers are able to avoid these mechanisms but where beets are topped "in place" coulters, disks, and jointers are generally used in pairs, singly, or in combination. These devices undoubtedly influence the problem of keeping on row, and it would appear this is related to the location of the mounting with reference to the guiding members and the linear distance between the preparatory mechanism and the lifter points. This distance should be as short as possible and preferably both units should be within the wheel base of the tractor with the topping unit between.

Row spacing influences the necessity for, and the difficulties with, preparatory devices used on "in place" topping harvesters. Generally speaking the closer the row spacing the greater the necessity for them. Yet the closer the row spacing the more difficult it becomes to operate such units. Row spacings of 20 inches or less are in the critical range. For this reason wider row spacings would be especially helpful for "in place" topping harvesters.

Topping beets mechanically may be accomplished in a number of ways, none of which is perfect, but a relatively large number of meth-

ods are now considered acceptable. It must be remembered that our standards of acceptance are much more tolerant than in years past, a favorable factor for machine development, but our programs for development should be directed toward better performance; viz ; a minimum of top tare with a minimum of top loss. Machine topping continues to be of two general types; (a) "in place" or ground topping, and (b) "in machine" topping. Of the seven machines listed by Smith (4) as having importance for 1946, there are "in place" toppers and four are "in machine" types. Of the three in commercial production, one is an "in place" type (John Deere) and two (Marbeet and Scott-Urschel) are "in machine" toppers.

Ground toppers are of the variable cut type, but these vary greatly as to types of finders and knives. Driven finders may be broad or narrow, track type, or small wheel series. In general, driven finders tend to support the beet against the cutting forces of the knife and also provide better resistance to the inertia forces of the movable topping mechanism. For these reasons, driven finders appear to offer advantages over shoe types in securing straight cuts perpendicular to the root axis, particularly where thin cutting blades are used, such as in the John Deere and University of California units. This type of construction, based upon field experience to date, appears to contribute to a superior quality of topping over a wider range of travel rates than toppers with revolving disk blades. The former, however, have more moving parts and are thus more vulnerable to fouling in wet and weedy fields. Furthermore, they require more linear space for mounting. Revolving disk toppers have been and are still popular for "in place" topping devices. These may be used with shoe finders (International Harvester) or track type finders (Catchpole, England). The attractive features of such units are simplicity of construction, compactness of design, ruggedness, and resistance to fouling. The type of knife (disk) requires good on-the-row control to maintain optimum topping. The inherent character of the design limits operating speeds to approximately 2 to 2 1/2 miles per hour for best results, after which topping tare increases rapidly. However, most "in place" type toppers do not permit very high travel rates for good quality of work.

Machine topping of roots has gained in impetus in recent years because of the development of new methods of engaging the tops of plowed beets, such as the Marbeet method, in addition to older systems of engaging beets by their tops as exemplified by the Scott-Urschel unit. Such topping units in themselves do not have so much to recommend them from the single standpoint of quality of topping, but mechanical beet harvesting is a combination of topping and recovery of beets. Because of this, "in machine" topping has gained in

prominence. Basically it is highly questionable if it is possible to position and remove tops from beets after lifting from the soil with as much precision as when the beets are held in place. The success attained by harvesters using "in machine" topping, particularly the Marbeet, when judged by rate of operation and recovery of beet's justifies support of this principle for harvester development. Improvements may be expected from greater use of such equipment, and these together with the perfection of milling procedures certainly place "in machine" topping in a position of economic importance.

The past few years have witnessed some design changes in plows or lifters. Generally speaking some modified form of the Colorado lifter is used more than any other single type. It is a favored type among the older established full-line implement concerns and it is well adapted to harvesters using the "in plau" type of topping mechanism. Powers<sup>3</sup> has worked out a modification of this general type of lifter with his introduction of the helical plow. This plow performs the dual purpose of beet lifting and soil fracturing, thus showing considerable promise in hard, dry soils. For harvesting under wet conditions further plow modifications may be necessary, or in other words different points may be necessary for use under different soil conditions. Fortunately this requirement need not be a serious deterrent, since point may be designed for quick removal and replacement.

Where "in machine" topping is used, the function of the plow is somewhat different. Here the plow loosens the beet from its soil environment in a way to permit its removal through some form of top engagement. The form of plow may vary considerably, as for example, a single-point tongue type is used in the Scott-Urshel harvester, while a double-standard chisel-type lifter is used on the two-row bed-type Marbeet harvester. The latter machine probably holds the record for the greatest tonnage of mechanically harvested beets in 1945. It is apparent many problems remain in plow design, both in the points themselves and in the positioning of these points in the machine with reference to other functioning parts of the harvester.

The method of engaging the beet by the tops other than between inclined chains is a recent development brought into commercial application in the Marbeet machine through the development of cycloidal spikes extending outward more or less radially from a large pickup wheel. This general idea has been used by others in various modified forms (Bingham-Holkesvig, Great Western, etc.). The necessity of bringing the untopped beet in close contact with the wheel rim

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so that the spikes engage the loosened beet firmly enough to permit radial lifting places a heavy load on the plow and wheel, thus contributing to heavy draft, but this contributes to a very satisfactory recovery of beets in soils ranging from moist friable to dry lumpy conditions. In very wet soils the wheels tend to "gum up" with the wet earth and the whole unit may become inoperative. While much progress has been made in the development of lifting devices for both moist and dry soil conditions there are many troublesome problems remaining for beet recovery from wet soils.

No one has yet found an entirely satisfactory method of removing plowed beets from the soil and discharging these into a conveyor system under desirable tare tolerances. Here again we are concerned with basic topping and beet removal procedures. Where "in place" topping is followed, the plowed beets may be forced into a cleaning system by one of a number of methods. The one most commonly tried is delivery into some form of chain type conveyor such as is used in potato harvesters. These may be flat types, or V-shaped, or combinations, with or without flights, and frequently in combination with Reinks rolls. In other cases flipper wheels may be employed, such as Deere, or converging wheel pickups of the Maynard (3) type. Hammer Brothers<sup>4</sup> used a similar principle as early as 1931. This principle has advantages for quick but incomplete separation of roots from earthy materials. Powers<sup>3</sup> has attempted to engage the roots at the heel of the plow and then drain the soil away. This method has shown promise under a fairly wide variety of soil conditions ranging from wet to dry. The International Harvester Company in their pre-production unit provide a preliminary cleaning over Reinks rolls and chain conveyors and finally resort to a sorting table for final separation when this is necessary. The sorting table idea is not new, but as now employed by this company in combination with other machine elements it puts to practical use an old idea. Armer (1) used this principle in development work as early as 1940 with some promise but felt at that time a more complete ground recovery of beets was essential before it could become economically feasible.

Beet losses from ineffective machine recovery continue to be troublesome. Generally speaking, some form of scavenging to reduce field losses continues to be profitable. Where "in place" topping is followed, losses tend to be somewhat higher than "in machine" topping types of harvesters like the Marbeet. The former, however, expose lost beets much better than the latter so that scavenging is not difficult, while with "in machine" topping harvesters losses remain covered up because of lack of tops for proper engagement of the roots to lift these from the ground. While beet losses in the field are frequently much too high, these losses are becoming progressively less.

<sup>4</sup>Harvestor demonstrated Longmont, Colo., ;1931, by Hammer Bros., Miller, Ohio.

Continued improvement in harvesters no doubt will eventually reduce these to a level where scavenging becomes uneconomical.

The elevating and conveyor mechanisms back of the plow and its related lifting devices serve the dual purpose of beet cleaning and delivery to bulk containers. Potato chain conveyors with flights are used more than any other single type because this type of construction permits easy fabrication and repair and provides at the same time fairly rugged construction with provision for drainage of unwanted dirt. Every advantage possible must be utilized to remove clods and adhering earth. In dry soils clods are the real problem, while in moist to wet soils adhering earth predominates. The sorting belt now used in pre-production models of the International Harvester Company unit; the free drainage system under experimental development by the University of California; the spike pickup system used by Marbeet and others, all tend to reduce the seriousness or the clod problem. In Great Britain a rotating slatted cage is being used as a supplementary cleaner after the form of the "Salleng" (2) harvester, a Danish machine developed 15 years ago. Such devices may have advantages in removing earth clinging to beets. It may be well, to point out that wet harvesting conditions present one of our greatest unsolved harvesting obstacles. Elevating mechanisms gum up under wet soil conditions and too much soil is carried with the beets to the bulking containers. It would be unfair to say no progress is being made in harvesting beets mechanically under sticky, wet conditions, but we should recognize the need of greater adaptability of harvesters to wet soils if we hope to make mechanical harvesting our sole harvesting reliance. To overcome this obstacle seems to require more engineering on plows, lifting mechanisms, soil drainage devices, and self-cleaning elevators.

Root collection systems must vary with the different types of harvesters. Where high rates of harvesting are possible, dired delivery to trucks is desirable and economic;)]. Large capacity machines, like the Marbeet two-row, function very well in this way, but fields have to be opened up for such machine operations. Various systems are used for single-row units. The pre-production International Harvester Company unit has a trailing bin with cleaning devices which serves as a container for limited quantities of roots and also as a cleaner and transfer bin for truck loading. This type of unit has definite advantages in opening up fields, in the reduction of dirt tare, and in adaptability for medium-sized field operations. The windrow disposal system used by Deere operates very well under favorable soil environments, but it requires a field loader as a complementary harvesting unit. The system of dumping in piles in the field has never received wide grower acceptance.

Top disposal, particularly in the intermountain areas, has always been a matter of grower concern. The Deere system is probably the most perfect of any yet devised. Disk topping units tend to mix earth with the tops and "in machine" toppers of the Marbeet type have similar disadvantages. Machines of the Scott-Urschel type deliver much cleaner tops. Top collection and recovery is still a secondary detail in the minds of most development engineers, even though it looms large in the minds of some growers. There is no reason to anticipate other than a satisfactory solution to this problem.

Harvesters as built today consist mainly of tractor-mounted and drawn units. The former undoubtedly will predominate in number since single-row units load up most wheel tractors to reasonable limits. In the drawn units power take-off drives may be and are used for single-row units, while the two-row types have independent motor drives. Large manufacturers seem to prefer to develop equipment which may be mounted on or used in connection with their own power units. Small manufacturers of necessity must build drawn equipment. There is plenty of room for improvement in both types, and at the moment neither type seems to possess any overwhelming advantages over the other.

In my 1942 paper I made some predictions relative to future development of field harvesters. Most of the statements I made then still hold. There are new developments today that did not exist 4 years ago. These developments, added to those of 4 years ago, seem to assure this industry an acceptable line of mechanical beet harvesters for practically all grower conditions in the active development years ahead.

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