Harvester for Green Asparagus

successful mechanical harvester field tested during 1952 season uses principle of set-level cutting

Robert A. Kepner

Results obtained with an experimental harvester during the 1952 season indicate mechanical harvesting of green asparagus is feasible—mechanically and economically.

The principle of set-level cutting—in which all spears are cut at a given level—was chosen for use in the experimental harvester because of the inherent complication of a selective machine which would attempt to duplicate the present hand operation. Also, one set-level machine, with cuttings at five- to seven-day intervals will handle five or six times as much acreage as a selective machine.

Most of the experimental work was to be done in a 3-year-old direct-seeded field at Davis, so the 1952 test harvester was designed to cover a row width of only 15″. The design can be expanded readily to cover the 30″ to 36″ row widths of old bed plantings.

The entire harvester assembly—frame, pick-up units, band saw and pulleys, conveyor, and hopper—was built as a unit to be attached to the rear of a wheeled tractor by means of a 3-point parallel-lift mounting. A gage roller at the rear of the machine controls the depth of the band-saw cutting blade below the top of the planting bed. Three heavy coil springs attached to the lifting linkage were adjusted so the gage roller supports only 30 to 60 pounds of the total weight.

Close-up front view with harvester removed from tractor. Each pick-up unit covers 2½″ of row width. Note spears of various lengths and diameters being held by grippers.

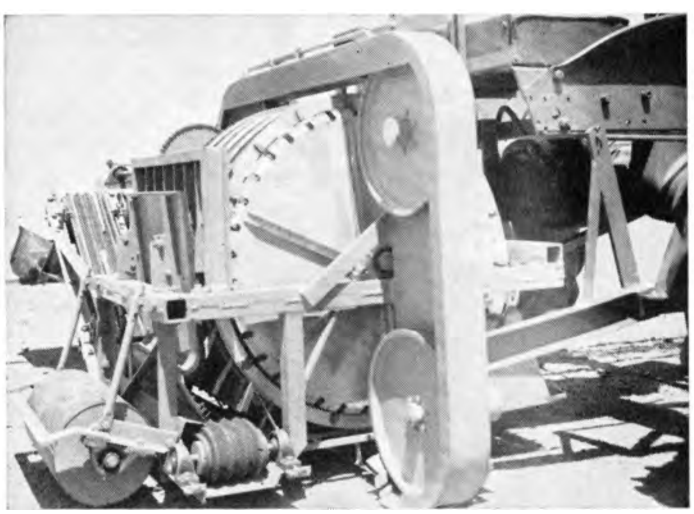
A series of pick-up units, each covering a row width of 2½″, grip the spears just before they are cut. Each gripper unit consists of two 24-gage sheet metal rings—30″ outside diameter, 28½″ inside diameter—faced with 7/16″ diameter sponge-rubber-core weather stripping. The grippers are supported by spring-wire spokes which allow lateral movement and provide the gripping force. The spokes are enclosed between sheet-metal disks attached to the wheel hubs, so the asparagus spears will not catch in them. The pick-up ring assembly rotates in the same direction as the tractor wheels, at a peripheral speed slightly greater than the forward speed of the machine.

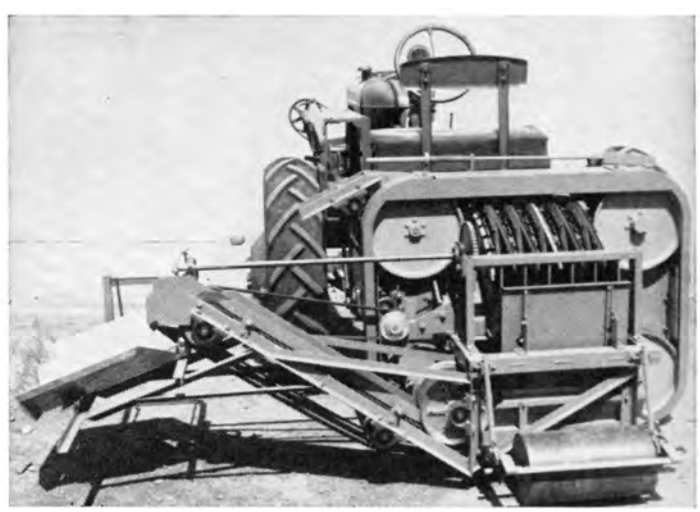
Cutting is accomplished by means of a band-saw type of blade, 3¼″ below the bottom of the pick-up rings and about ¾″ behind the axis of the rings. The blades used in the 1952 season were all made from 24-gage wood-cutting band-saw blade stock, ¾″ wide, with scallops of various sizes and spacings punched out by hand. During most of the tests the blade speed was 5,000 feet per minute.

The gripper rings are held apart in front where the standing spears enter, and are opened again in the rear after the spears have been cut and raised through an angle of approximately 75°. Three pairs of stationary shoes in front and two pairs in the rear are used to hold the grippers of each pick-up unit open. About 15° before each spear is released, the butt end—which projects about 3¼″ beyond the rings—strikes a rubber-covered tripper plate. The spears then drop onto a conveyor belt, butt first, which carries the spears from all pick-up units over to the left-hand side of the machine, elevates them, and deposits them in a V-shaped

Continued on next page

Left: **Side view of harvesting unit, showing spears being elevated by right-hand pick-up unit. Spear at bottom has just been cut and is still on blade. Butt of spear just below main frame has contacted tripper; grippers are about to release this spear so that it will drop onto the conveyor belt below. A divider and its spring-mounted point can be seen at right, beneath tractor.** ***Right:*** **Rear view of harvester. Pick-up units were temporarily at 3″ spacing when this photo was taken (normal spacing is 2½″). Band-saw blade passes around the 4 large pulleys shown inside of the blade guards.**





ASPARAGUS

Continued from preceding page

hopper. Most of the spears in the hopper are oriented with the butts against the outer end, although a few are deflected in dropping onto the belt so that they go up head first.

A dual-hopper setup was tried out during the 1952 season to investigate the possibilities and problems of transferring hoppers during operation.

A series of hoppers in the form of an intermittent-moving conveyor could be used to further elevate the asparagus to a suitable height and location for hand removal and boxing.

To channel the spears into the various gripping devices of the test harvester, sheet-metal dividers are used, as shown at the lower right in the side view and in the front close-up view illustrations. Straddling the lower front corner of each divider is a spring-mounted V-point, which can move laterally and also be pushed straight back about ¾″ with very little force. These points reduce the impact shock of the initial contact with the spears and start them back along the sides of the dividers.

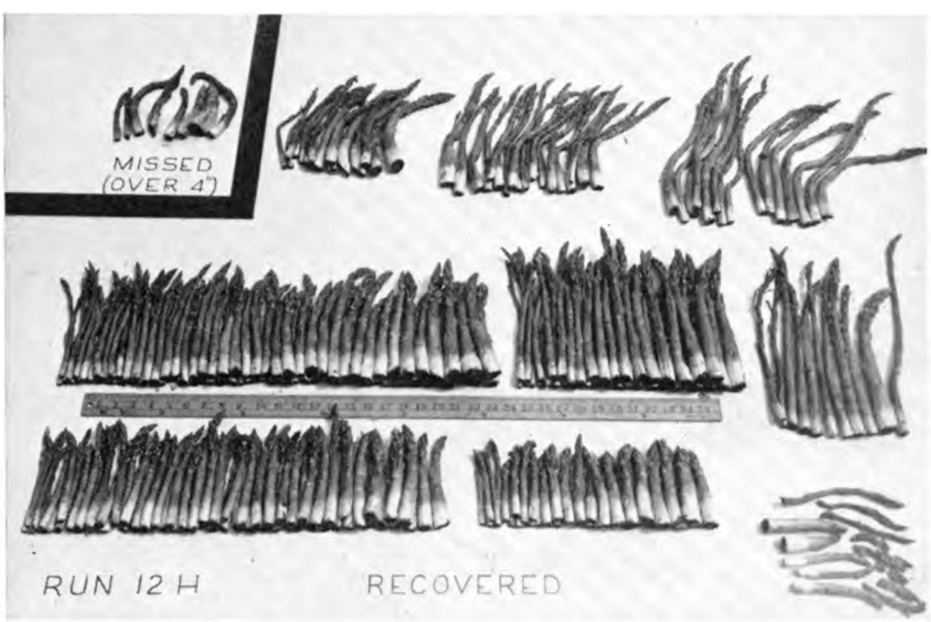
Scope of Tests

A total of 36 test runs—each covering about ¼ mile of row—were made with various combinations of adjustments, modifications and operating conditions. The normal operating speed was 2½ miles per hour. Most of the runs were made in a one-half acre, direct-seeded field at Davis which had been flat-planted in 1949. Beds about 4″ high and 15″ wide at the top were formed and maintained during the season with a crowder. Nine cuttings were made at intervals of five to seven and one-half days, beginning on March 28 and ending on May 19.

After a few cuttings had been made in the direct-seeded field, 11 rows—160 feet long—of a 12-year-old bed planting in an adjacent field were ridged up and shaped to accommodate the harvester. Normal sized beds were thrown up and then narrower ridges 15″ wide and 4″ high were formed on top of the regular beds. Since the spears in these old beds covered a band width of 30″ to 36″ and the machine was limited to 15″, all the side spears were cut by hand before each run so machine losses could be checked accurately. Four cuttings were made in this field between April 30 and May 19.

After the runs at Davis, two test cuttings were made on a 1½-acre portion of a 5-year-old bed planting in peat soil—the kind of soil in which most of the California asparagus is grown—on Staten Island in the Sacramento River delta. The first cutting was on May 27–28, and the second one was six days later. These beds were relatively young so the spears covered a band only about 2′ wide. A moderate amount of hand cutting narrowed the band down to the 15″ width of the harvester. The spears in the Staten Island planting were the largest encountered—about 15% were over ¾″ in diameter, and a number exceeded 1″.

Photograph showing spears over 4″ long missed, and those recovered, during best run in delta planting. Identification of the groups of recovered spears is as follows: *bottom row, left to right*—5–6″ length, 4–5″ length, pieces of broken spears recovered; *middle row*—6–8″ straight spears, 8–10″ straight spears, 10–16″ straight spears; *top row*—6–8″ crooked spears, 8–10″ crooked spears, 10–16″ crooked spears. Range of spear diameters at cut end was 3/8″ to 1 3/16″.



The efficiency measure of the harvester in regard to spear damage and losses is based on the total number of spears longer than 4″—broken spears plus missed whole spears plus recovered whole spears. The 4″ length is about the minimum which the test machine could be expected to recover, since the gripping level was about 3¾″ above the blade level. Also, it is about the minimum length from which No. 1 grade canning or freezing asparagus could be obtained.

Analysis of Runs

In analyzing the runs, the damaged spears were divided into the following classifications:

1. Whole spears with damaged tips. This damage was generally confined to the inside center portion of the extreme tip end of the spear. Many of the spears included in this group probably would be acceptable in the No. 1 grade of canning or freezing asparagus.

2. Whole spears with side damage. This type of damage always occurred in the area between 3″ and 4″ from the cut ends of the spears, because of excessive pressure exerted by the divider points or by the lower portion of the divider in bending off-center spears over to the grippers.

3. Broken spears. The total percentage of broken spears—missed plus those recovered—was determined by counting the number of cut ends with tops missing and the number of broken tops, and then taking which ever was larger. Usually the totals matched pretty well.

The bar graph on page 9 represents the results of typical test runs with the harvester. Although the machine was designed for each pick-up unit to cover a 2½″ width of row, a number of runs were made at Davis with the pick-ups modified to give a 3″ spacing. The performance with the 2½″ spacing was considerably better and the results indicated by the left-hand bar may be considered as typical for the direct-seeded field with its small-diameter—usually under ½″—spears.

During two of the three runs included for the bed-planted field at Davis the pick-up units were at the 3″ spacing, and other adjustments were not at the best settings. The results do not represent the best obtainable performance.

In the delta runs the best-known combination of adjustments and modifications was used. Two runs were at a cutting depth of 1″ and two at 1½″—all made during the second machine cutting of these beds.

The percentage of missed spears in the delta runs was less than in the direct-seeded field, but the damage was greater. Probably these differences are related to the larger diameters of the spears in the delta planting. A minor redesign of the dividers may eliminate most of the spear side damage.

About 15% of the spears over 4″ long in the delta runs were extremely crooked which undoubtedly contributed to the breakage loss, as at least ⅔ of the broken spears were found in the hopper.

Breakage of crooked spears was somewhat greater when the harvester was traveling against the general direction in which the spears leaned. Two runs for each direction of travel are included in the group of four delta runs represented by the fourth bar in the graph on this page.

In general, ⅓ to ½ of all the missed spears longer than 4″ were between 4″ and 4½″ in length. Very few spears shorter than 4″ were recovered. If the cutting blade were moved up about ½″ closer to the pick-up wheels, the minimum recovered length could be reduced somewhat, and the percentage recovery of 4″–4½″ spears could be increased considerably. This change might cause a little more damage unless the depth of cutting were also reduced by ½″. It could increase the over-all recovery of spears longer than 4″, by 1% to 2%, in addition to recovering some spears under 4″.

To meet the 1951–52 California Marketing Order requirements for No. 1 grade 3½″ green asparagus for canning or freezing the depth of cutting would have to be limited to about ½″ if the 4″ spears were to be acceptable.

Considering the results of the delta runs as shown in the bar graph it is reasonable to assume that spear side damage could be reduced to about 1½% by improving the divider design; breakage—in a field without an excessive number of bad crooks—could be reduced to 3% or 4%; and half of the damaged tips would be acceptable. This would leave about 90% of all spears over 4″ long as recovered, No. 1 canning or freezing asparagus.

Band-saw blades which had scallops ¾″ apart, cut 3/16″ deep with a 7/16″ diameter punch, did an excellent job of cutting in all three plantings at a blade speed of 5,000 feet per minute. This type of cutting device is not bothered by weeds and light trash and does not introduce unbalanced forces as does a reciprocating knife.

The principal problem when using the band saw in abrasive soils is the rapid wear. In the sandy loam soil at Davis which is very abrasive, the blade described above would be reduced in width about 1/32″ per mile of forward travel. In the peat soil, blade wear was negligible—less than 0.001″ per mile. Blades should be replaced or recut after about ⅛″ of wear if the scallops were initially 3/16″ deep.

Until further tests indicate that higher forward speeds are satisfactory, an operating speed of about 2½ miles per hour should be assumed. The maximum length of spears which can be handled readily by the 30″ diameter pick-up units is 17″ to 18″. The minimum spear length which will be recovered is 3½″ to 4″, depending on the distance between the blade and the gripper rings.

Occasional spears with branches not more than an inch or so long will go through the machine without causing any trouble but longer branches or more fern may not unload. The presence of extremely crooked spears will increase breakage and losses.

To minimize the length of white on short spears, cutting should be at the minimum depth—perhaps ½″—that can be used without causing abnormal plant growth or otherwise affecting yields.

For a harvester—of the type tested in the 1952 season—to be most satisfactory, the tops of the beds must be flat and wide enough to include all of the growing spears. A crowder type of bed shaper is suggested, because it will disturb a minimum amount of soil. The beds probably will not need re-shaping after every cutting so the shaper should be easily detachable from the rear of the harvester.

An important consideration in set-level harvesting is the distribution of spear lengths. It is desirable to have most of the spears within the range of lengths from which No. 1 grade asparagus can be obtained. The minimum length in this range would be perhaps ¼″ or ½″ longer than the final trimmed length, and the maximum is the length of the longest spears of good quality.

Spears cut shorter than 4″ represent loss of potential yield. These shorter spears were picked up by hand and counted for all runs at Davis. At the beginning of the season, 70% of all spears from the 3-year-old direct-seeded field were longer than 4″. By mid-season this proportion had increased to 80%, but it then decreased to a low of 60% at the end of the season. These results are probably not representative of a normal bed planting, but they do indicate some tendency toward cycling during the first part of the season. It will be necessary to compare the yields from hand cutting and machine cutting for an entire season in the same field, before the relative yields can be established.

Estimated Labor and Costs

It is estimated that one full-size machine—taking one row of a regular 7-foot planting and operated 10 hours per day at 2½ miles per hour—could take care of at least 80 acres on a 5-day cutting schedule. The machine would require a driver and at least one man to box the asparagus. It would replace 10 to 12 hand cutters, plus the two men and tractor now used to haul out hand-cut asparagus.

Based on a rough estimate of costs for a self-propelled harvester, the total machine charge—fixed, plus operating costs—would not be over $15 per acre per year. Assuming an average yield of 2,500 pounds per acre and a hand-cutting cost of 3¼¢ per pound, the annual saving in labor would be $80 per acre. If other economic differences are neglected, this would leave a $65 difference in favor of mechanical harvesting, to offset the reduction in yield resulting from the use of the set-level harvesting system.

At a price of 10¢ per pound paid to the grower, the two systems would then yield the same net return if the mechanical harvesting yield were 75% of the hand-cutting yield.

Robert A. Kepner is Associate Professor of Agricultural Engineering, University of California College of Agriculture, Davis.

The above progress report is based on Research Project No. 947.

Performance efficiencies in 1952 asparagus harvesting tests.