A Strawberry Harvest Mechanization System[1]

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Abstract. **The development of a narrow bed cultivation technique, concentrated ripening varieties, and a novel machine for harvesting is presented as a potential solution to problems of strawberry production for processing.**

Results of tests in the 1969 season and the steps in the development of this system are described. The harvester itself can readily be mounted on certain conventionally designed garden tractors.

The cost of equipment required and results obtained are sufficiently encouraging to suggest that an economical minimum labor production system might again be possible in areas which have been forced to abandon strawberry production by rising costs.

Possibly no crop represents more of a challenge for mechanical harvesting than strawberries. Pioneering work on this problem was begun at Iowa State University (1) where Denisen (Horticulture) has been developing cultivars suitable for machine harvesting since 1959 and was joined by Buchele (Agr. Engineering) on a cooperative project in 1964. Because the high cost and nonavailability of hand labor had caused a decline in production in some states, as in Iowa, the objective of this project was to develop a harvest mechanization system, with maximum recovery and minimum damage. While picking fruit for the fresh market is the ultimate goal, the economical machine gathering of fruit suitable for processing is the acceptable goal.

The first machine developed by Buchele and Denisen (2) had a series of scoops mounted on a continuously moving pair of chains which traveled in the row and scooped, elevated and deposited the fruit. The disadvantages of this principle were (a) individual forks or scoops were not continuously in contact with the plants, (b) maintenance of an even picking height was difficult, (c) the locus of motion of the tips of the teeth is such that it tended to uproot plants and collect fruits, plants and debris, (d) unloading fruit from the teeth was difficult and involved dropping the fruit through some distance, and (e) the machine was complicated and rather cumbersome.

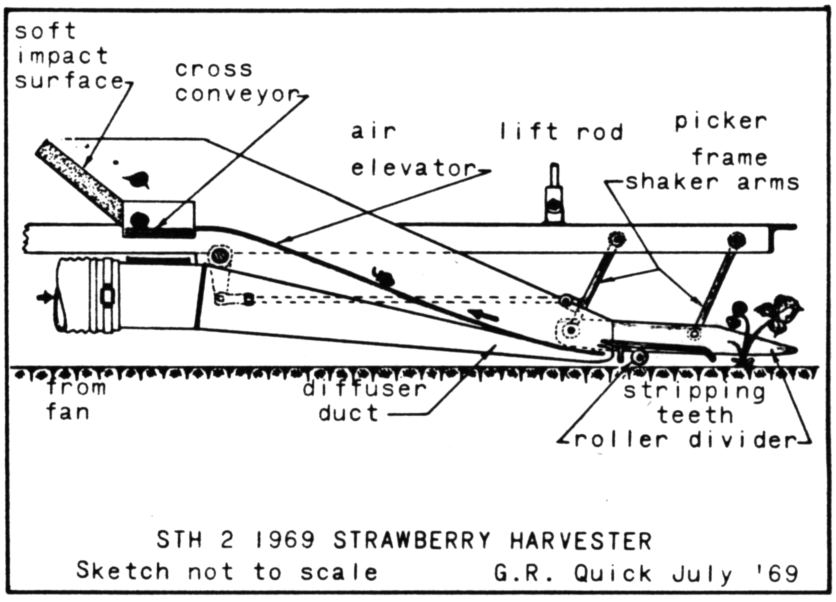

Fig. 1. Diagrammatic side view of strawberry harvester showing construction details.

In 1968 the vibrating teeth principle was devised which avoided the above limitations, and became the subject of a patent disclosure (4).

The 1968 trials indicated several other advantages might be obtained, e.g. (a) the extremely compact mechanism could readily be suspended under a garden tractor, (b) it would be inexpensive and thus within reach of the small grower, yet have the production capacity for the larger grower, (c) picking potential is 100% recovery, and (d) damage level could be held to reasonable levels, and machine picking for the fresh market is even a definite possibility.

1969 model strawberry harvester - STH:2 Fig. 1 illustrates the operating principles of the machine, built to fit under a "CUB LO BOY" tractor as in Fig. 2. It utilizes an air elevator to pneumatically convey the fruit from the vibrating teeth to the cross conveyor, both these functions being driven from the rear power take-off. The air used to convey the berries is directed through a 5/16 inch nozzle at around 80 mph nozzle velocity. This requires 540 cfm of air and a static head of 3.5 inch water, from a size 31 type V, 8 inch wheel, Buffalo fan with 4-1/2 inch diam outlet. According to the manufacturer 0.73 hp is required to drive the fan and require a minimum of headroom, so that it can fit behind and beneath the picker teeth, a distance of no more than 1-1/4 inch. The air elevator does a very effective cleaning job. Leaves, trash and

Fig. 2. 1969 STH2 Picker mounted under Cub tractor.

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mulch proceed over the foam rubber impact surface with the air stream. The impact surface was too shallow because of clearance limitations and there was some loss of lighter fruit in the 1969 model. The cross conveyor (Fig. 3) is a 3-1/2 inch wide cross ribbed strip of industrial conveyor belting, running at about 1.15 mph.

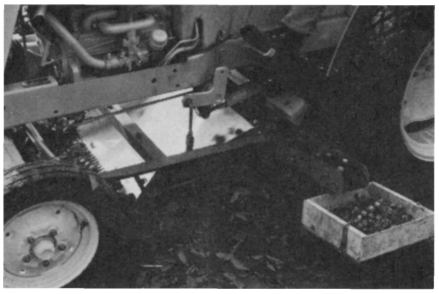

Fig. 3. STH:2 picker in action, showing fruit being stripped, elevated, cross-conveyed and collected.

Picker specifications and performance. The first set of vibrating picker teeth were 5/16 inch diameter steel rods with an 0.4 inch clearance. Picking width between dividers was 22-3/8 inches, suitable for rows about 20 inches wide.

Unfortunately, the machine-harvestable selection plantings were seriously damaged by water erosion, so the machine was only tested in cv. 'Surecrop', 'Blakemore', 'Sparkle' and 'Dixieland'. Beds for these varieties were on 6 ft 6 inch centers and had spread up to 40 inches in a ragged fashion. As a consequence, we had to hand-trim these rows down to our 20 inch width, smooth the wheel tracks, and carefully level a deep mulch of ground corncobs before picking.

Ground corncob mulch is very suitable for machine harvesting in this type of level bed preparation since the mulch presents a homogeneous light material with particles small enough to be sifted through the picker fingers or readily cleaned from the fruit by the air stream. The picker teeth were shaken at 600 to 740 cpm with 1/2 inch double amplitude and have a jog-conveyor action due to the forwardly inclined legs, which aids the motion of the fruit toward the rear. The free-rotating roller under the teeth pulls the stems through, and much of the separation occurs due to this action. Performance data are shown in Tables 1-4.

General system considerations. of paramount importance to the success of any mechanical picking assembly is the need to stay below the fruit for maximum recovery. Anytime fruit was left behind with this machine, it was generally because the machine had been angled or raised so that the teeth ran above some fruit, or pierced some berries, with subsequent damage. It was observed then that the beds need to be machine-prepared at all stages prior to harvest, with the harvest-operation in mind. The machine needs to have an automatic hydraulic height controller built onto it so the picking teeth height can be maintained just above the mulch with precision. It appears most of the damage to the fruit occurred at the tips of the picking teeth suggesting a soft or blunt picking tooth would reduce the damage. To test this premise, a set of 1/2 inch diam. teeth with 0.4 inch spacing was built and coated with approximately 1/16 inch of silicone rubber. This approach could not be accurately assessed in 1969.

The following procedure will be followed in future Iowa machine picking strawberry systems:

1. Concentrated ripening fruit plantings are being established on beds with minimum of ridging, plants being closely spaced to support the fruit trusses.
   The necessary mulch for overwintering will be removed and collected by side-delivery rake in the spring.
2. A fine corn cob mulch applied to retain soil moisture will prevent splash and keep the berries off the soil.
   The mulch will be carefully leveled over the beds and wheel rows.
3. Beds will be narrowed several weeks before harvest and wheel rows mowed and leveled. For a 30 inch picker head, 28 inch beds on 40 inch centers allows vehicles not wider than 52 inch access down the rows.
4. Within the week prior to machine stripping, the primary berries will be handpicked for fresh market.
5. Just before machine harvest upper leaves on the rows will be mowed. The mower might be mounted on the picker itself.
6. Machine picking follows.

Table 1. Average performance of 6 trials on June 19 and 23, 1969, in 'Surecrop' with 5/16 inch tooth spacing, average forward speed 0.43 mph.

Average picking rate	12.4 lb./min	
Fruit recovered in box	24.2 lb.	(66.9%)
Fruit remaining on plants*	5.55 lb.	(15.3%)
Fruit picked and dropped or ejected	6.4 lb.	(17.7%)
Total fruit	36.15 lbs	(100.0)
Potential picking recovery	30.6 lbs	(84.8% of total row yield)
Trash collected in box	1.6 (+) lbs	(6.4% of material collected in box)

*Includes all fruit on plant or ground, irrespective of size.

Table 2. Fruit damage assessment, analysis of 11.45 lb. of berries from 3 rows, machine-picked on June 23, 1969.

Undamaged + overripe + green fruit	9.95 lb.	(86.9%)
Severe damage	1.5 lb.	(13.1%)

Table 3. Fruit maturity, analysis of 4.75 lb. of berries machine-picked on June 23, 1969.

Commercially usable	2.7 lb.	(57%)
Damaged	0.7 lb.	(15%)
Green	0.9 lb.	(19%)
Color inception	0.3 lb.	(6%)
Overripe (undamaged)	0.15 lb.	(3%)

Table 4. Capping and stemming tendency, analysis of 3.95 lb. of cv. 'Surecrop' on June 19, 1969.

Without stem or calyx	nil	(0%)
Without stem, with calyx	2.8 lb.	(70%)
With stempiece, with calyx	1.0 lb.	(25%)
In clusters	0.15 lb.	(4%)
Leaves, separated or attached	nil	(0%)

Literature Cited

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