DEVELOPMENTS IN PICKUP EQUIPMENT FOR ORANGES TO REDUCE WINDROWING

D. B. CHURCHILL AND H. R. SUMNER
USDA-Agricultural Research Service
Lake Alfred

Abstract. During the 1974 and 1975 seasons, two citrus pickup systems were investigated for the purpose of increasing fruit recovery and decreasing fruit movement prior to the pickup operation. A low-profile unit picked up oranges directly from the ground from a single layer. Raking was required to remove the fruit from the tree trunk line and in front of the propelling unit. A second system was an offset machine that picked the oranges up from a windrow at the tree drip line.

Fruit pickup efficiencies for both systems varied from 65 to 99%, depending on grove conditions. The low-profile pickup system in two tests had an average pickup rate of 557 lb/min when it traveled at one-half mile per hour. The offset pickup system averaged 675 lb/min at a travel speed of one-half mile per hour in one test.

Development work on citrus pickup equipment to recover fruit dropped on the ground by mass removal devices was started in 1967 (1). Sumner and Hedden (1972) reported on an experimental citrus rake attached to the front of a tractor (2). This machine required two passes to gather the fruit to the center between two tree rows for pickup, and fruit was damaged when the drawbar drags on top of the windrow. A citrus rake and pickup machine that gathered and picked up fruit in one operation was reported by Sumner and Hedden (3). This unit combined the two operations to minimize fruit damage caused by the additional movement of fruit when forming a windrow in the center of the rows. However, fruit was damaged in high-yielding groves when a large volume was raked from the tree trunk line to the center between two rows.

Two rake and pickup methods that minimize the distance fruit must be raked have been developed at the Agricultural Research and Education Center at Lake Alfred. The purpose of this study was to evaluate two rake and pickup systems designed to decrease the distance fruit must be raked prior to the pickup operation and to increase fruit recovery.

Materials and Methods

System I Low-profile Pickup Machine and Oblique Rake

A low-profile pickup machine was designed to operate underneath the tree canopy and close to the tree trunk line. It consisted of a pickup cylinder and an oblique rake. The rake was 3-1/2 ft long x 14 inches high and had three bars of molded rubber teeth (Fig. 1). The rake attached to a 15-ft-long tube that pivoted at the front of the machine, allowing the rake to move in and out of the tree trunk line. The rake moved the fruit from the tree trunk line and placed it in a location accessible to the pickup cylinder. The pickup machine used a 20 inch O.D. cylinder, 81 inches long. It consisted of eight flaps of 3/16-inch thick belting material, 5 inches wide, bolted to 1/8 inch x 1-1/2 inch flat metal strips.
Fig. 1. Low-profile pickup machine and oblique rake.

Fig. 2 shows the assembly of the pickup head and position of the cross conveyor. The pickup cylinder rotated in the opposite direction from machine travel. Oranges were picked up between the cylinder and cover shroud and then dropped behind the cylinder onto a cross conveyor. The front of the pickup head had a belt bolted to the shroud, which formed a seal once the fruit was between the cylinder and shroud. The discharge angle on the pickup shroud was 5° above the horizontal, and the cylinder rotated at 125 rpm. The pickup assembly and cross conveyor were mounted to a self-propelled machine that made the unit a complete pickup handling system.

In June 1974 a field test was conducted with the low-profile pickup machine and oblique rake in a grove of 'Valencia' orange trees that were spaced at 15 x 30 ft and had a yield of about three boxes per tree. One side of the tree row was flat and the other side had a ridge at the tree trunk and a disk furrow 4 ft from the tree trunk line.

Another test was conducted in January 1975 in a grove of 'Pineapple' orange trees that were spaced at 25 x 25 ft and had a yield of about six and one half boxes/tree. The oblique rake was omitted in this test because the propelling unit had insufficient horsepower. The oranges were hand raked from the tree trunk line. A comparison test was conducted to determine if additional ground preparation would increase the pickup efficiency. One half the trees in a row of 'Pineapple' oranges were disked and leveled before the harvesting. Leveling was accomplished by dragging a 4 x 4 wood beam behind the disk and running as close as possible to the tree trunk line. A ground profile was determined for six trees; three had been disked and leveled, and three had not. The fruit on the ground was counted before and after the pickup operation.

System II Windrow Rake and Offset Pickup Machine

The windrow raking component of the system had three oblique rake assemblies that were attached to a tractor. One was an 8-ft-long, four-bar rake that moved the fruit from the row middle to the drip line of the tree. Another was 3-1/2-ft-long, three-bar rake with rubber teeth that recovered the oranges from the tree trunk line and discharged them in front of a 4-ft-long, four-bar rake that moved the oranges to the tree drip line. Fig. 3 shows the raking arrangement in field operation. The 3-1/2-ft and 4-ft rakes were mounted on long tubes that pivoted near the tractor frame, and the amount of rake overlap could be adjusted. The rakes formed a 40-inch wide windrow at the drip line on each side of the tree. Two passes were required to form the two windrows.

An offset pickup machine picked up fruit in the windrow at the tree drip line. Fig. 4 shows the machine in field operation. This machine combined several proven principles considered desirable from previous machines. It was tractor drawn and had a steered rear axle and a 30-box storage hopper. The pickup assembly had two
Fig. 4. Offset pickup machine.

3/8 inch x 21 inch x 2 inch pitch rod draper chain sections side by side to form a 45 inch wide pickup frame. A 44-inch long x 14-inch O. D. flapper cylinder similar to the one on the low-profile pickup machine was mounted in front of the pickup chain to assist movement of the oranges onto the pickup chain. The overall height was 2 ft, and gauge wheels controlled the depth of the pickup frame by following the ground contour.

From the pickup chain, the fruit was discharged onto a 3/8 inch x 21 inch x 2 inch pitch rod draper chain cross conveyor. The fruit was then discharged onto a 24 inch-wide x 30 inch-long trash eliminator belt that separated the trash from the fruit and dropped the fruit onto the side elevator. The fruit was conveyed up the side elevator and discharged into the 30-box storage hopper before it was loaded into hi-lift groove trucks.

Two hydraulic pumps were driven directly from the power take-off on the tractor and provided all of the hydraulics for the complete pickup machine.

Three field tests were conducted with System II and data were collected to determine raking and pickup performance. The first test was conducted on May 27, 1975 in a 'Valencia' grove that had a tree spacing of 16-1/2 x 26 ft and a yield of about five boxes/tree. The second test on June 3, 1975 was in a young 'Valencia' grove that had a tree spacing of 20 x 30 ft and a yield of about three and one-half boxes/tree. The third test on June 11, 1975 was also in a 'Valencia' grove. This grove had a tree spacing of 25 x 25 ft and a yield of about two and one-half boxes/tree. Preharvest raking was done for the third test only. This raking was necessary to remove the large amount of wood from the previous year's hedging operation.

Results and Discussion

System I Low-Profile Pickup Machine and Oblique Rake

The test conducted in June 1974 with System I showed that, when the operation was on the flat side of the row, and with a forward travel speed of one-half mile per hour, the pickup rate was 590 lb/min, with an efficiency of 95%. When the operation was on the opposite side, which

Table 1. Field performance of System I--low-profile pickup machine and oblique rake, January 1975.

<table>
<thead>
<tr>
<th>Tree No.</th>
<th>Fruit on ground No.</th>
<th>Fruit left after pickup No.</th>
<th>Pickup efficiency %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1140</td>
<td>13</td>
<td>99</td>
</tr>
<tr>
<td>2</td>
<td>1312</td>
<td>63</td>
<td>95</td>
</tr>
<tr>
<td>3</td>
<td>1165</td>
<td>31</td>
<td>97</td>
</tr>
<tr>
<td>4</td>
<td>1240</td>
<td>38</td>
<td>97</td>
</tr>
<tr>
<td>5</td>
<td>1669</td>
<td>92</td>
<td>94</td>
</tr>
<tr>
<td>6</td>
<td>1398</td>
<td>77</td>
<td>94</td>
</tr>
</tbody>
</table>

*Average ground speed was one-half mile per hour.*
Table 2. Results from the windrow rake and offset pickup tests.

<table>
<thead>
<tr>
<th>Test No.</th>
<th>Avg ground speed (rake) mph</th>
<th>Avg ground speed (pickup machine) mph</th>
<th>Yield boxes/tree</th>
<th>Pickup rate boxes/min</th>
<th>Tree spacing ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.5</td>
<td>0.50</td>
<td>5.0</td>
<td>7.50</td>
<td>16 1/2 x 26</td>
</tr>
<tr>
<td>2</td>
<td>0.5</td>
<td>0.75</td>
<td>3.5</td>
<td>5.25</td>
<td>20 x 30</td>
</tr>
<tr>
<td>3</td>
<td>0.5</td>
<td>0.75</td>
<td>2.5</td>
<td>3.30</td>
<td>25 x 25</td>
</tr>
</tbody>
</table>

*Does not include downtime or turnaround time. Pickup efficiency was above 99%.*

had the disked furrow and ridge, the pickup efficiency was approximately 65%. The furrow was below the middle of the pickup head, and the flapper cylinder could not pick up the oranges from the furrow, even after the head was adjusted to a lower height.

Table 1 shows the results from the test conducted in January 1975. With a forward travel speed of one-half mile per hour, the average pickup rate was 524 lb/min, and the efficiency varied from 94 to 99%. No significant difference occurred between the pickup efficiency of the machine on the disked ground and that on the nondisked ground.

**System II Windrow Rake and Offset Pickup Machine**

Results of the three pickup tests are shown in Table 2. The system with three oblique rakes did an adequate job of gathering and forming a windrow at the tree drip line. The average ground speed of the windrow rake was about one-half mile per hour. Compared with present raking systems, the formation of a windrow at the tree drip line decreased the size of the windrow and minimized the distance the fruit was moved to form the windrow. The pickup operation directly followed the raking and did not require both sides to be windrowed before fruit were picked up. The average pickup ground speed was .67 mile per hour in the three tests. Small trash that was picked up usually dropped through the rod draper chain conveyors, and a high percentage of the larger trash was removed by the trash eliminator belt. The flapper pickup assist cylinder assembly in front of the pickup chain recovered 100% of the oranges as the machine came to the end of each pickup row. Recovering all the oranges at the end of each windrow has been a problem with the commercial pickup machines.

The results from System II, the windrow rake and offset pickup machine, indicated that this type of operation can be used in a complete harvest operation. The following three accomplishments are gained with this type of rake and pickup system over the present commercial units: (a) The fruit is moved a shorter distance to form the windrow, (b) The size of the windrow is decreased, and (c) the tractor drawbar clearance problems caused by a high, compact windrow are eliminated.

**Literature Cited**