Performance Evaluation of an End-Effector Designed Based on Harvesting Multiple Cotton Bolls at a Time

Shekhar Thapa1,*, Glen Rains2, Wesley Porter3, Simerjeet Virk3
1College of Engineering, University of Georgia, Tifton, GA, USA
2Department of Entomology, University of Georgia, Tifton, GA, USA
3Department of Crop and Soil Sciences, University of Georgia, Tifton, GA, USA
*Corresponding author: shekhar.thapa@uga.edu

Introduction
- Cotton bolls at the bottom third to half of the plant have the highest value and yield.
- Harvesting cotton bolls as soon as they open can maintain the fiber quality and reduce yield loss.
- Currently, cotton is harvested by a widely used, heavy, and expensive mechanical harvester.
- A handful of studies have been performed on robotic cotton harvesting, which all have end-effectors that are designed based on detecting individual cotton bolls and harvesting single boll at a time, resulting in slow harvesting time per boll.
- Harvesting speed can be improved from a new approach: harvesting multiple cotton bolls at a time.

Objective
- To evaluate the harvesting performance of an end-effector design based on harvesting multiple cotton bolls at a time and compare with other robotic cotton harvesting systems.

Materials and Methods
End-effector
- CAD modeled in Autodesk Inventor 2022
- 3D printed using Ultimaker S5
- Roller (height =125mm, 60 mm dia., 28 tines)
Robotic platform
- Small Red Rover
- Cartesian type of robotic arm
Vacuum system
- CRAFTSMAN, 120V AC, 850watt, 85 CFM
- Hose 2-1/2“ diameter & 6 ft long

Results

<table>
<thead>
<tr>
<th>Picking Ratio</th>
<th>Lab tests, 5 ft row, 2 seed/foot</th>
<th>Field tests, 5 ft row, 2 seed/foot</th>
<th>Field tests, 10 ft row, 2 seed/foot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Row 1L</td>
<td>64.28</td>
<td>55.42</td>
<td>34.23</td>
</tr>
<tr>
<td>Row 2L</td>
<td>70.72</td>
<td>44.48</td>
<td>43.3</td>
</tr>
<tr>
<td>Row 3L</td>
<td>42.8</td>
<td>38.94</td>
<td></td>
</tr>
<tr>
<td>Row 1F</td>
<td>44.48</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Row 2F</td>
<td>34.23</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Row 3F</td>
<td>34.23</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Row 4F</td>
<td>43.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Row 5F</td>
<td>43.3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Average picking ratio, average picking time per boll and average rover speed for the lab and field tests.

Conclusions
- The end-effector showed statistically higher performance in lab tests than in field tests, primarily due to the presence of rigid plants in the simulated environment, resulting in a greater success rate of encounters with cotton bolls.
- The end-effector has a significantly faster harvesting time per boll than the other robotic cotton harvesting systems.
- The end-effector has significant room for improvement in the picking ratio.

Future Research
- Improve picking ratio; upcoming studies will investigate the potential benefits of using larger and wider end-effectors.
- Investigate the quality of cotton fiber harvested from a mechanical harvester and the robotic cotton harvester.
- Implement a vision system with a cotton detection model to optimize picking ratio.

Acknowledgement