AUTOMATED HOOP HOUSE ARCH REMOVAL

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Introduction

Hoop houses have been proven to protect strawberries from extreme weather conditions. Currently, hoop houses' implementation and removal process is done by hand, resulting in high labor costs for the growers and a mildly unsafe work environment. A solution to this problem is to design an agricultural implement that can safely and efficiently remove hoop houses from the ground to ensure optimal harvest timing, reduced labor costs, and a safe work environment. Three iterations were tested in grower and research fields.

Materials | Assumptions

- John Deer 6125 Tractor
- 3 Hydraulic Circuits
- Access to Fabrication Means
- Installed Hoop House Arches

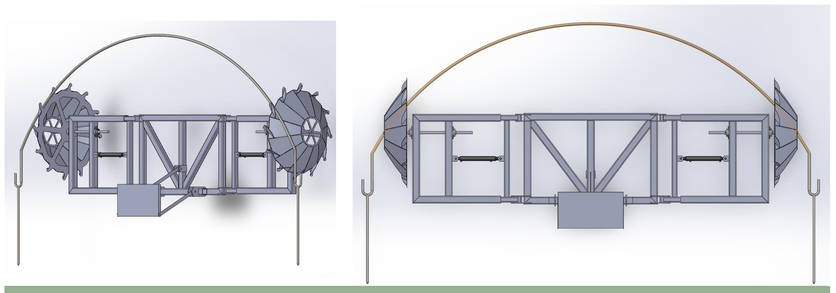
- All growers have access to a tractor with a category two three-point hitch.
- The tractor used to run this implement will provide a hydraulic flow rate of at least eight gallons per minute.
- The operator has the knowledge to run the removal implement.
- The strawberry harvest has already taken place.

Critical Design Aspects

- Adjustability
  - Hoop Arch Height 12.5 FT ± 1 FT
  - Hoop Arch Width 18 FT ± 1 FT
- Arch Removal
  - Malleability of the aluminum arches
  - Constant rate of removal
- Hydraulic Control
  - Implement adjustment
  - Implement Rotary Motion

Iteration 1

Design for iteration 1 started with some preliminary components produced to accomplish the critical aspects of the hoop arch removal process. These components were combined to create the first iteration of the hoop house removal implement seen below.



Side View | Front View

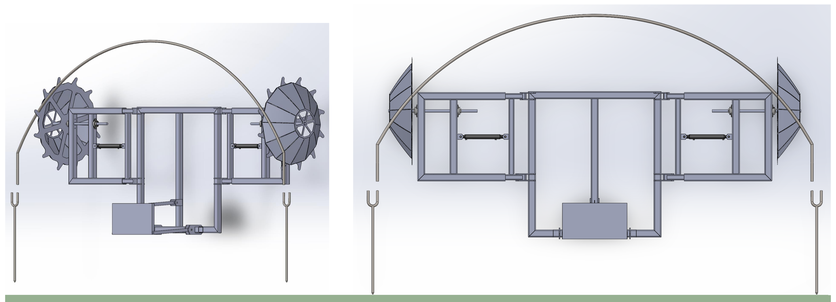
Fabrication process began with the center frame, moved outwards to the extension wings and removal wheels, and finalized with the hydraulic motors, valves, and hose routing.

Rear view of the first iteration final product

Testing the first iteration occurred at Eat Sweet Ranch in Santa Maria, California. Testing of iteration 1 was completed on March 8th at 10 am. The implement had some success, especially with the wheel removal concept, however, a substantial redesign was needed after testing as there were 3 problems with this iteration. During testing bolts sheered on the torque couplers. This was quickly fixed in the field by using a stronger grade bolt. The strawberry bed height was higher than anticipated and the removal wheel did not lift the hoops all the way off their stake. This problem required an in-shop redesign to extend the frame and account for a larger height. The third and final problem was encountered with the removal wheels. The hooks and fins on the removal wheel did a great job grabbing ahold of the hoops; however, as the wheel rotated backward, it did a poor job releasing the hoop. A minor in-shop redesign was necessary to modify the shape of the hooks and remove the fins to encourage the release of the hoop at the proper time.

Iteration 2

Design for iteration 2 began with the most significant redesign aspect, the center frame modification to allow for on-the-spot adjustments between hoops; the frame was extended by 24 inches. The secondary aspect of the redesign was to allow the removal wheel to release the hoop arch after removing it; fins were removed from the outside of the wheel, and the wheel hooks were modified to be less severe. The final modification of iteration two; rotary flow control was removed from the cylinder circuit allowing the cylinders to adjust individually when only a single stake is offset.



Side View | Front View

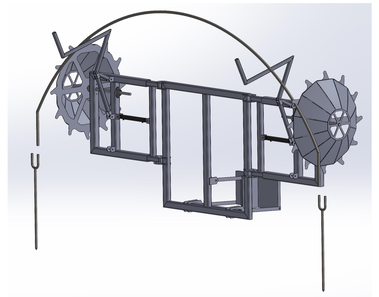
Fabrication modifications began by disassembling the implement, removing the wings, including the hydraulic valves and hose routes, and modifying the center frame.

Rear view of the second iteration final product

Testing for the second iteration occurred at SoCal Strawberries in Nipomo, California. Testing of iteration 2 was completed on March 30th at 10 am. The implement had much success during testing, especially when it came to grabbing the arch, removing it from the stakes, and then releasing it off the back of the wheel. However, there were still some problems. These hoops were installed differently than the field in the previous testing. The stakes were installed at the edge of the beds, which shifts the entire hoop about 30 inches to one side. The extension wings on the implement could not account for this variation. The left wing when fully retracted, was unable to fit down the left side of the row. In order to still salvage this testing session, the left-wing was folded in, and the right-wing was running at full extension to test the height capabilities and the releasing of the hoop. The rightwing was able to remove and release 95% of the hoops from the right stake. As for the offset hoops, a massive redesign would be needed to allow the entire implement to shift 30 inches and center itself under the hoop.

Iteration 3

Design for iteration 3 was an addition to the implement; a hoop arch collecting system. The main challenge of the hoop collector is that the natural hoop width is wider than the stake placement in the field. The secondary challenge was height restriction of the overall implementation. In order to ship this implement on a trailer, the height restriction is roughly 10 feet, but stake clearance requires the hoops to be carried at 12 feet. Due to this height restriction, the collection height needed to be adjustable for transportation.



Side view

Fabrication of the hoop collecting system began with the collector arms and then moved to the mounting brackets.

Side view, arms in working position

Testing for the third iteration occurred at Cal Poly Crops Unit, Field 25. Testing of iteration three was completed on May 31st at 10 am. The hoop arch removal wheels successfully removed 96% of the hoops. The hoop collector arms also showed great promise in collecting the hoop arches after being removed from the stake. A redesign to create quicker contact with the hoop after it is removed from the stake would eliminate some of the variations in hoop movement. In addition, by lowering the collector arms and bringing them farther forward, they would contact the hoop almost immediately after its removal, providing more support to eliminate any extra hoop movement. After the hoop arches were removed from the stake and the tension was released, the hoops had less arch, and some caught on the front point of the collector arms.

Conclusion

During final testing, the implement produced a 98 percent success rate in removing the hoop from the stake and a 68 percent success rate in racking the hoops after removal. The economic analysis revealed that the payback period of the implement, assuming a 40 percent market value increase, would be roughly 100 acres of hoops. Hence, saving the grower almost $50,000 in their first season.