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Mechanization of Row Cover Application and Removal

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Abstract
Row covers are a moderately new innovation in vegetable crop production. Their uses vary extensively from protection against wind, frost, insects, fungal diseases, as well as control timing of harvest. Row covers are typically deployed immediately after transplant and then removed at anthesis. Until recently, row covers have been deployed and retrieved manually. Due to the labor-intensive needs of row covers, their use has been limited to small fields on small-scale farms.

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Mechanization of Row Cover Application and Removal

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Introduction

Row covers are a moderately new innovation in vegetable crop production. Their uses vary extensively from protection against wind, frost, insects, fungal diseases, as well as control timing of harvest. Row covers are typically deployed immediately after transplant and then removed at anthesis. Until recently, row covers have been deployed and retrieved manually. Due to the labor-intensive needs of row covers, their use has been limited to small fields on small-scale farms.

In order to use row covers on large-scale farms, well-designed, affordable machinery to mechanize the handling of row covers at deployment and retrieval is needed. The possibility of mechanizing row cover handling is now within reach due to machinery designed by Mechanical Transplanter, Inc. and its Model 95 tunnel layer, as well as Frösö Trädgård AB and its Hi-Wer system. Although these machines are capable of deploying and retrieving row covers on large scales, there still is more development needed to make these machines more practical and to make row covers reusable as desired by growers.

Here we report the results of the machinery evaluation in the second year of a multi-state, two-year cooperative project with the University of Kentucky. We report on the effectiveness of each machine, focus on design complications with the tunnel-laying machine, and describe ideas for improving the tunnel-laying machine.

Materials and Methods

Plots were located on three separate farms, with contrasting soil types. On the first two farms (Agricultural Engineering and Agronomy Research Farm, Boone, Iowa, and the Applied Sciences Research testing area, Ames, Iowa), we deployed two rows each 750-1,000 ft of raised beds with plastic to test the tunnel-laying machine. On the third farm (the ISU Horticulture Research Station, Ames, Iowa) two 100-ft-long plots with several rows of muskmelons were used to evaluate the tunnel layer and Hi-Wer system.

Multiple tests were conducted on the first two farms over a range of soil moisture levels (Figure 1). Tests consisted of using the tunnel layer to place 75 wire hoops continuously without row cover material being applied, then three 50-ft-long sections of row cover were subsequently deployed over the wire hoops. Once tests were complete, data were taken on the angle of hoop insertion, insertion depth on sides, hoop height, hoop width, hoop spacing, and number of failures (incomplete insertions) per trial. Once the insertion tests were completed, data were taken on the tunnel layer.

Modifications were made to the tunnel layer to make it more practical for the application of row covers. Before these tests were completed, the tunnel-laying machine was used solely to set the wires and not place the row cover over the wires. Upon completion of these tests, there is now work underway on redesigning the wire placing mechanism, removing the need to have an operator to manually place the hoops in the machine, and redesigning the rear half of the machine to allow easier application of the row cover.

Results and Discussion

Throughout all testing, the distance between hoops and the width of the hoops held constant, at 55 in. and 48.5 in., respectively. The angle of the hoops changed slightly; the most important change was insertion depth, hoop height, and number of failures (Table 1, Figure 1). The number of failures decreased as we continued to do more trials because the operator's skill increased on when to set hoops in the laying machine in relation to changing driving conditions. It was found that the optimal speed to operate the machine was between 0.5-1.5 mph, which was constrained by the operator's ability to feed the wires into the tunnel-layer machine fast enough.

Major differences that occurred were between laying row covers and just setting hoops without laying row covers. There was a difference in insertion depth depending on the soil moisture content; typically, the insertion depth decreased as soil moisture content increased. When the machine was laying the row cover, there was a difference in insertion depth of 0.25 in. deeper, hoop height of 2.64 in. less, and the angle of the hoop with respect to the ground was 8.91 degrees angled closer to the ground. When testing was done to compare the advantages of mechanically deploying and retrieving row covers, the row cover material was initially placed by hand because we had not yet determined the technique used in later tests. The tunnel layer decreased the amount of time to set wires by ~ 1 minute (Table 2) compared with manual deployment. But as the tunnel layer progressed along the row, it created a trench to bury the edges and provided supplemental dirt for burying. Use of the machine also allowed for easier wire storage, by eliminating entanglement and space constraints.

The Hi-Wer system was not as extensively tested as the tunnel layer, due to the fact that the machine runs as expected and is utilized to its fullest potential. While using the Hi-Wer retrieval mechanism, the time to remove row covers was cut down by 10.75 seconds/100 ft (Table 1) compared with manual retrieval.

Using both of these machines, a minimum of 14.5 hours/acre would be saved. However, there are further modifications needed. Possible modifications could improve hoop placement mechanism, automate the wire placement process, and a way to utilize spooled-up row covers from Hi-Wer machine with tunnel layer for re-use. Neither of the machines created damage to the Agribon 30-row covers, so their potential to aid re-use of row covers is good.

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Table 1. Number of people and labor minutes required for each 100 ft of row cover deployment and removal using manual vs. mechanical means.

		Manual		Mechanical	
Task	Duty	People	Labor (min:sec)	People	Labor (min:sec)
Deployment	Erect hoops[a]	2	03:30	2	02:10
	Position fabric &	2	06:24	2	05:36
	Secure edges	2		2	
Subtotal			09:54		07:46
Removal	Pull edges[b]	1	02:26	1	03:07
	Roll fabric	2	04:00	1	01:38
	Store fabric	2	06:00	1	00:15
	Remove hoops[c]	1	02:00	1	01:45
	Store hoops	1	04:00	1	01:00
Subtotal			18:26		07:05
Total			28:20		14.51

[a]Mechanical layer uses tensile, recoiling wire, and manual methods use preformed hoops.
[b]Ditch made along edge of plastic by tunnel layer made securing easier and pulling edges more difficult.
[c]~25 hoops per 100 ft.

Table 2. Row cover insertion depth, hoop height and angle, and failure rates for testing at two sites.

					Insertion depth (in.)		Hoop		# of failures				
Month	Site	Row cover[a]	Soil moisture (%)	# of hoops	Left	Right	Height (in.)	Angle (deg)	Left	Right	Both	Total	%
June	AEA[b]	NRC	14.5	405	5.2	4.4	15.8	91.90	14	23	68	105	25.9
June	AS[c]	NRC	10.4	411	5.6	4.5	15.4	88.20	15	35	47	97	23.6
July	AEA	NRC	12.1	330	5.6	4.6	14.5	90.32	14	21	65	100	30.3
July	AS	NRC	9.8	336	6. 1	4.7	14.8	90.32	15	33	45	93	27.7
Aug	AEA	NRC	16.8	75	3.5	3.7	17.1	93.52	0	2	3	5	6.7
Aug	AS	NRC	11.0	75	3.5	3.7	16.1	86.02	0	2	2	4	5.37
	All	NRC	12.5	816	5.4	4.4	15.6	90.02	29	58	115	202	24.8
June	AEA	RC	14.7	350	4.9	4.1	12.8	81.12	0	0	0	0	0
June	AS	RC	10.4	356	6.3	5.4	13.2	81.20	0	0	0	0	0
July	AEA	RC	12.6	330	5.9	4.4	13.9	88.12	0	0	0	0	0
July	AS	RC	9.9	336	6.0	4.5	13. 9	87.30	0	0	0	0	0
Aug	AEA	RC	16.9	20	4.0	3.8	11.6	74.10	0	0	0	0	0
Aug	AS	RC	11.0	20	6.7	6.2	12.5	75.00	0	0	0	0	0
	All	RC	12.6	706	5.6	4.7	13.0	81.10	0	0	0	0	0

[a]NRC was testing done without row covers, RC was testing done with 50-ft sections of row covers.
[b]Agricultural Engineering and Agronomy Research Farm, Boone, IA.
[c]Applied Sciences Research testing area, Ames, IA.

Figure 1. (left to right) Measuring hoop height. Looking backward from the row cover layer. Looking forward from behind the row cover layer.