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Economic analysis of row cover insect exclusion for cucurbit crops

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ABSTRACT. Cucurbit crops are vulnerable to fungal infections spread by insects which act as a disease vector. Excluding insects by covering rows of cucurbit crops in a low tunnel structure offers an alternative to insecticide application. Differences in costs for using spunbond polypropylene (e.g. Agribon) or polyethylene mesh (e.g. Proteknet) as row covers were compared with a conventional chemical application strategy. Costs of materials, machinery, and insecticide were calculated for ten years of operation on 0.2, 0.4, 0.8, 2, or 4 ha (0.5, 1, 2, 5, or 10 acres).

The total costs of the spunbond polypropylene system were $1620/ha to $5290/ha ($650/acre to $2140/acre) greater than the conventional system depending on operational size. Smaller production areas were more costly due to machinery costs. The polyethylene mesh system was $1500/ha ($600/acre) more costly than using spunbond polypropylene due to material costs. A truck-mounted sprayer became more cost effective than a backpack sprayer as operational size increased beyond 0.8 ha (2 acre). The increased costs of the row cover strategy will need to be off-set by increased yield or value of the cucurbit crop (i.e. organic sales).

Keywords. *Cucurbit, disease, horticulture, insects, supports, tunnels.*

Introduction

The Cucurbitaceae is a family of frost-sensitive, predominantly trendily-bearing vines which are found in subtropical and tropical regions around the globe. Cucurbits is a generalized term coined for the species of the family Cucurbitaceae. Members of the cucurbit family include cucumbers, muskmelons, pumpkins, watermelons, squashes (which consist of summer and winter varieties), and gourds. Cucurbits have many diverse uses, but the most common is food and drink. The fresh fruits are sold shortly after harvest. Processing these fruits for long-term storage often involves canning, freezing or pickling (Robison and Decker-Walters, 1997).

Cucurbits display differences among production practices and yields. One issue which is common for all cucurbit crops is the incidence of bacterial wilt, which is caused by cucumber beetle infestation. No matter the cucurbit type, bacterial wilt will negatively affect yield and crop quality. This will result in financial losses to the grower.

The purpose of this study was to develop a cost comparison for different versions of pest control for cucurbit crops. A conventional chemical method and mechanical exclusion method were compared.

General Economic Analysis

Equipment was used on production land sizes of 0.2, 0.4, 0.8, 2.0, and 4.0 ha (0.5, 1.0, 2.0, 5.0, and 10.0 acres). Annual costs on a per hectare (acre) basis were calculated assuming operation over a 10 year period. For all operations and land sizes, a standard field row was assumed to be 61.0 m long by 2.1 m wide (200 ft by 7 ft). A diesel cost of $1.06/l ($4.00/gal) was assumed for all operations.

Machinery costs were divided into fixed and variable costs. Fixed costs included depreciation, interest, taxes, insurance and housing. Variable costs included repairs and maintenance, fuel and labor costs. To determine the salvage value of the tractor and implements, remaining value factor was multiplied by the new cost of the implement (ASABE Standards 496.3 and 497.7). A capitalization rate of 8 percent (interest plus inflation) was assumed with guidance from Edwards, 2015. An hourly wage of $10 was assumed. Labor costs were determined to be $11 per hour and were calculated by multiplying the hourly wage by a multiplier of 1.1 (Edwards, 2015), and considered the average field efficiency of a worker.

Tractor

Hourly cost was calculated for tractor operation. Hourly tractor cost was then associated with implement operations of the tunnel layer or bed shaper and mulch layer depending on their hours of use. It was assumed that a 45 kW (60 hp) tractor would be purchased used after 5 years and kept with the operation for 10 years. The cost of the tractor was determined through research of tractors for sale on tractorhouse.com. The average purchase cost for a 5 year old, 45 kW (60 hp) tractor was determined to be $22,000. The purchase price of a new 45 kW (60 hp) tractor was found to be $33,327.00 (Bobcat of Ames, IA).

Implements

Implements included the tunnel layer, bed shaper and mulch layer, and the option of using two types of sprayers, a truck mounted sprayer and backpack sprayer. All implements were assumed to be purchased new. The purchase price for the tunnel layer and bed shaper and mulch layer were received from the company, Mechanical Transplanter, Holland, MI. Costs for the two sprayers were determined based on average market data from online sellers. Table 1 indicates the purchasing cost, assumed total repair costs, and economic life of each implement.

Table 1: Economic Life, Purchasing Costs, and Repair Costs for implements

Implement	Economic Life (Years)	Purchase Price	Repair Costs[a]
Tunnel Layer	10	$6467	$500
Bed Sprayer & Mulch Layer	10	$3154	$540
Sprayer			
Truck	10	$330	$60
Backpack	10	$80	$60

[a]Assumed total repair costs over 10-year period

The number of annual hours required to use each implement on varying production areas was determined through calculations using travel speed and field efficiency of each implement. Table 2 indicates the annual hours each implement was used as well as assumed travel speed and field efficiency.

Table 2: Annual hours used for implements, travel speed, and field efficiency.

System &		Tunnel layer	Bed shaper & mulch layer	Sprayer	
Hectares	Acres			Truck	Backpack
Agribon & Proteknet					
0.2	0.5	1.17	0.49	0.37	0.65
0.4	1.0	2.29	0.96	0.72	1.27
0.8	2.0	4.70	1.96	1.47	2.61
2.0	5.0	11.67	4.86	3.65	6.48
4.0	10.0	23.50	9.79	7.34	13.06
Conventional					
0.2	0.5		0.49	1.48	2.65
0.4	1.0		0.96	2.88	5.08
0.8	2.0		1.96	5.88	10.44
2.0	5.0		4.86	14.60	25.92
4.0	10.0		9.79	29.36	52.24
Travel speed, km/h		1.6	4.8	6.4	3.2
mi/h		1.0	3.0	4.0	2.0
Field efficiency		50%	60%	60%	55%

Truck

The portable sprayer was mounted to a truck for spraying operations. The cost of the truck was determined by rental rates of Iowa State University Transportation Services. It was assumed a half-ton truck would be rented. The full day, eight hour, cost of a half-ton truck is a $40.6/h, while the half a day, four hour, cost is $20.3/h. Most calculations involving the rental truck assumed a full half day rental cost during each spraying, although longer rental times were used if required based on the number of hours the truck mounted sprayer was used for the varying field areas.

Material

The two cover materials for the exclusion method analyzed were Proteknet and Agribon. Proteknet and wire hoops were assumed to last the entire 10 year life of the analysis without replacement whereas Agribon was assumed to be replaced two additional times (3.3 year life).

The costs of the materials were based on the purchase price of each material used in Iowa State University field tests. Proteknet cost $2,133.34 per roll, 100 m (328 feet) by 8 m (26.2 feet). Cost included splicing of two 4-meter rolls sewn together. A cost of $2.67/m^2 ($.25/ft^2) of Proteknet calculated from this price was used to determine costs. Agribon cost $115.00 per roll 152 m long by 2.1 m wide (500 ft long by 7 ft wide). Cost of the wire hoops to support the row cover material was $.48 per hoop (Mechanical Transplanter, Holland, MI). Hoops are spaced at 1.5 m (5 ft). Black plastic mulch cost $109.95 per roll (Mechanical Transplanter, Holland, MI) 610 m by 0.9 m (2000 ft by 3 ft).

Insecticides

Imidacloprid (Admire), the most commonly used insecticide in Iowa State University cucurbit crops was used for economic analysis. Staff at the Iowa State University Horticulture Farm found that crops usually need to be sprayed one time for the mechanical exclusion method and 4 times for the conventional chemical method. For this analysis, one spray was assumed for the exclusion method and four sprays for the conventional method. Imidacloprid costs were $20.28/ha ($8.21/acre) for the exclusion method, and $81.11/ha ($32.85/acre) for the conventional method.

Results

Implement (machinery) costs for each system and acreage were determined using calculations of fixed and variable costs for each individual implement. Hourly tractor costs were also included based on number of hours each implement was used on the various production area sizes. The conventional system did not require the use of the tunnel layer implement. All three systems utilized the bed shaper and mulch layer as well as the sprayers. Table 3 lists the machinery costs for the system and production area.

Table 3: Annual machinery costs per hectare or acre for system and production area

System &		Tunnel Layer	Bed Shaper & Mulch Layer	Sprayer	
Hectare	Acres			Truck sprayer	Backpack sprayer
Agribon Proteknet					
0.2		$4173.16	$1959.69	$307.45	$107.69
	0.5	$1688.82	$793.06	$124.42	$43.58
0.4		$2186.63	$1008.36	$152.49	$70.30
	1.0	$884.90	$408.07	$61.71	$28.45
0.8		$1201.23	$536.17	$76.75	$53.57
	2.0	$486.12	$216.98	$31.06	$21.68
2.0		$605.33	$250.79	$30.91	$42.45
	5.0	$244.97	$101.49	$12.51	$17.18
4.0		$453.36	$161.61	$20.46	$39.22
	10.0	$183.47	$65.40	$8.28	$15.87
Conventional					
0.2			$1959.69	$608.42	$213.70
	0.5		$793.06	$246.22	$86.48
0.4			$1008.36	$302.98	$173.86
	1.0		$408.07	$122.61	$70.36
0.8			$536.17	$151.99	$159.98
	2.0		$216.98	$61.51	$64.74
2.0			$250.79	$61.01	$148.14
	5.0		$101.49	$24.69	$59.95
4.0			$161.61	$50.56	$145.72
	10.0		$65.40	$20.46	$58.97

The bed shaper and mulch layer costs were identical for the Agribon, Proteknet, and conventional systems. For the conventional system, the truck mounted sprayer was $395/ha ($160/acre) more than the backpack sprayer at 0.2 ha (0.5 acre), and $129/ha ($52.25/acre) more than the backpack sprayer at 0.4 ha (1 acre). As production areas increased to 0.8, 2, and 4 ha (2, 5, and 10 acre), the cost increased by a range of $7 to $94 per hectare ($3 to $38 per acre) more for the backpack sprayer. In all three systems, the truck sprayer was more cost effective for fields with larger production areas and the backpack sprayer was more cost effective for fields of smaller areas.

Upon performing calculations, a materials, machinery, and insecticide cost were determined for each system and production area. Table 4 indicates the materials cost, machinery cost using either the truck mounted or backpack sprayer, insecticide cost, and total costs for Agribon, Proteknet, or conventional systems on varying production areas.

Table 4: Total annual machinery and material costs per hectare or acre for conventional chemical and mechanical exclusion methods (10 year operation assumed).

System & Hectare	Acres	Materials	Machinery		Insecticide	Total Cost	
			Truck sprayer	Backpack sprayer		Truck sprayer	Backpack sprayer
Agribon							
0.2		$2365.78	$6439.80	$6240.04	$20.29	$8825.87	$8626.11
	0.5	$957.40	$2606.10	$2525.26	$8.21	$3571.71	$3490.87
0.4		$465.24	$3347.48	$3265.29	$20.29	$5833.01	$5750.83
	1.0	$997.65	$1354.68	$1321.42	$8.21	$2360.54	$2327.28
0.8		$2282.04	$1814.12	$1790.94	$20.29	$4116.45	$4093.27
	2.0	$923.51	$734.15	$724.77	$8.21	$1665.87	$1656.49
2.0		$2191.06	$887.03	$898.57	$20.29	$3098.38	$3109.94
	5.0	$886.69	$358.97	$363.64	$8.21	$1253.87	$1258.55
4.0		$2201.01	$635.43	$654.16	$20.29	$2856.73	$2875.46
	10.0	$890.72	$257.15	$264.73	$8.21	$1156.08	$1163.66
Proteknet							
0.2		$3885.33	$6439.80	$6240.04	$20.29	$10,345.42	$10,145.66
	0.5	$1572.34	$2606.10	$2525.26	$8.21	$4186.65	$4105.81
0.4		$3900.55	$3346.17	$3265.29	$20.29	$7267.01	$7186.13
	1.0	$1578.50	$1354.15	$1321.42	$8.21	$2940.86	$2908.13
0.8		$3764.69	$1814.12	$1790.94	$20.29	$5599.10	$5575.92
	2.0	$1523.52	$734.15	$724.77	$8.21	$2265.88	$2256.50
2.0		$3683.20	$887.03	$898.57	$20.29	$4590.49	$4602.06
	5.0	$1490.54	$358.97	$363.64	$8.21	$1857.71	$1862.39
4.0		$3683.67	$635.43	$654.16	$20.29	$4339.39	$4358.12
	10.0	$1490.73	$257.15	$264.73	$8.21	$1756.09	$1763.67
Conventional							
0.2		$1086.77	$2568.11	$2173.39	$81.17	$3736.05	$3341.33
	0.5	$439.80	$1039.28	$879.54	$32.85	$1511.93	$1352.19
0.4		$1086.77	$1311.34	$1182.22	$81.17	$2479.28	$2350.17
	1.0	$439.80	$530.68	$478.43	$32.85	$1003.33	$951.08
0.8		$950.93	$688.14	$696.14	$81.17	$1720.25	$1728.23
	2.0	$384.83	$278.48	$281.72	$32.85	$696.16	$699.39
2.0		$869.41	$311.80	$398.93	$81.17	$1262.39	$1349.51
	5.0	$351.84	$126.18	$161.44	$32.85	$510.87	$546.13
4.0		$869.41	$212.16	$307.32	$81.17	$1162.75	$1257.91
	10.0	$351.84	$85.86	$124.37	$32.85	$470.55	$509.06

The total material costs for the Agribon and Proteknet systems ranged from $1280 to $2810 more per hectare ($520 to $1,140 more per acre) than the conventional system. Adding machine (and insecticide) for total costs, the Agribon system cost $1620/ha ($650/acre) more over 4 ha (10 acres) or $5290/ha ($2140/acre) more over a smaller 0.2 ha (0.5 acre) system. Price difference decreased as the acreage size increased. The Proteknet system added an additional $1500/ha ($600/acre) annual cost to these values (due to materials costs). Total costs of the Proteknet system, using the truck sprayer and the backpack sprayer, ranged from $3100 to $6800 per hectare ($1,250 to $2750 per acre) more than the conventional system.

Using the mounted truck sprayer on 0.2, 0.4, and 0.8 ha (0.5, 1, and 2 acre) Agribon and Proteknet systems, machinery costs ranged from $25 to $200 per hectare ($10 to $80 per acre) more than when using the backpack sprayer. As the production area size increased to 2 and 4 ha (5 and 10 acres), the truck sprayer cost $12 to $19 per hectare ($5 to $8 per acre) less than the backpack sprayer.

Conclusion

The exclusion technique added an annual cost of about $1620 to $5290 per hectare ($650 to $2140 per acre) when Agribon was used, and $3100 to $6800 per hectare ($1250 to $2750 per acre) when the Proteknet was used. The greatest increase in price for the exclusion method was due to the addition of the tunnel layer implement for smaller acreages up to about 0.4 ha (one acre). Systems larger than 0.4 ha (one acre) were more effectively able to amortize initial

cost of the tunnel layer but materials costs per area remained similar. Although Proteknet was assumed to last three times as long (10 years) as Agribon before replacement, an extra $1500/ha ($600/acre) annual cost was incurred using assumed current prices. The annual price of the Agribon and Proteknet systems decreased as the production area size increased.

Determining the most cost effective sprayer option depends on production area size and system. For production areas 0.4 ha (2 acres) or less, the backpack sprayer was the most cost effective while for larger areas the truck mounted sprayer was the most cost effective.

Additional annual costs for the mechanical exclusion methods of $1620 to $5290 per hectare ($650 to $2140 per acre) may be able to be recouped by the grower if fruit can be marketed with a premium due to lower pesticide use and/or greater amounts of fruit are produced.

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