Biodegradable Polymer Mulches in Bell Pepper Production

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Plastic mulches (polyethylene) are used in pepper production to warm the soil, to advance harvest maturity, and to improve pepper yield and quality. However, plastic mulches have a negative impact on the environment. They are produced from non-renewable resources and are often disposed of after a single season. Disposal usually involves taking the plastic to a municipal landfill which is expensive and plastics persist for many years after disposal. Incineration is no longer allowed in most municipalities and recycling is limited due to contamination with plant material, soil, moisture and possible chemical residues associated with mulches after their use in the field.

Biodegradable mulch films are now becoming available, may be made from renewable resources, and are converted through microbial activity in the soil to CO_2, water and natural substances, eliminating the need for pick up and disposal at the end of the season. Experimentation is required to determine the length of time the biodegradable mulch will last in the field, its soil warming potential, and effects on crop growth, yield and quality.

The objectives of this experiment were to compare the effects of black plastic mulch and biodegradable dark polymer mulch films in pepper production on soil warming, plant growth, crop maturity, yield and quality; and to document the degradation of the biodegradable polymers under field use.

Experimental Details:

Experimental design:	Randomized complete block design
Replications:	4
Treatments:	1) Bare soil
	2) Black plastic mulch (polyethylene), 1 mil thick, 54” wide
	3) Mater-Bi (black), 0.6 mil thick, 48” wide
	4) Eco-one (black), 0.88 mil thick, 48” wide
	5) Biolene (grey, green, translucent), 0.7 mil thick, 47” wide
	6) EcoWorks (silvery, grey, translucent), 1.0 mil thick, 48” wide
	7) EcoFilm (grey, translucent), 0.75mil thick, 48” wide
	8) Green plastic (black, photodegradable), 0.8 mil thick, 36” wide.
Plot size:	1.5 x 7.0 m (twin row using raised beds), 29 plants/plot
Cultivar:	Aristotle

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Crop Management:

Soil type:	Fox sandy loam.
Fertilizer:	20-20-10 at 550 kg/ha + 34-0-0 at 120 kg/ha applied ppi before the mulch was laid.
Drip irrigation:	Drip irrigated using Netafilm drip tape with emitters spaced at 12" (30 cm). Output = 16 US gal/hr/100 ft (199 L/hr/100 m). Irrigated June 22 - 30 (1 hr/day), July 1 - August 16 (2 hr/day), August 16 - August 28 and September 13 - September 20 (2 hr/2 days). Water was shut off after heavy rains.
Plot establishment:	Seeded into 72 cell plug trays on March 30. Mulch films were laid May 30. Transplants were placed through the mulch or into bare soil on June 1 using a twin row water wheel mulch planter. After planting, 75 ml of a plant starter solution (2.5 g/l of 10-50-10) was injected into the root zone beside each plant.
Row/plant spacing:	Each plot consisted of a twin row of peppers with 45 cm between the rows and 50 cm between the plants within the row using a diamond pattern (26,667 plants/ha or 10,624 plants/ac).
Weed control:	Applied Treflan 1.25 L/ha (trifluralin 0.6 kg ai/ha) ppi over whole experimental area before mulch films were laid May28.
Pest control:	Kocide and Mancozeb June 14 Kocide and Dithane June 25 and July 2 Kocide July 17 and 23 Kocide and Furadan July 30 Pounce August 6.

Harvest and Evaluation:

Harvest:	Fruit harvested at mature green stage on August 3, 11, 25, September 8 and 30.
Yield:	Total yield, marketable yield and cull.
Fruit Size:	Average weight of all marketable fruit.
Fruit characteristic:	Fruit length, diameter and wall thickness averaged on ten fruit per plot on August 25.
Soil temperature:	Soil temperatures (at 5 cm depth) were collected from 2 reps under each mulch film and in bare soil treatment.
Mulch degradation:	0 to 5 rating (rated every 2 weeks): 0 = no breakdown of mulch, 100% soil cover. 1 = small holes forming in mulch, nearly 100% soil cover. 2 = one or more small tears over 30 cm long, > 90% soil cover. 3 = multiple tears and holes in mulch, 75 to 90% soil cover. 4 = multiple tears and holes, 50 to 75% soil cover. 5 = mulch largely deteriorated, < 50% soil cover.

Results:

During the period from June 4 to July 10 (first 5.5 weeks of growing season), average soil temperature at the 5 cm depth was increased by the soil covers compared to bare soil (Table 1). EcoFilm increased average soil temperature the most by 3.9 ˚C, whereas Green plastic increased soil temperature the least by 0.7 ˚C, compared to bare soil.

All the mulch films reduced radiation heat loss from the soil at night and thus increases in the mean minimum soil temperature ranged from 1.2 ˚C under Green plastic to 3.1 ˚C under EcoFilm compared to bare soil.

Daytime maximum soil temperatures were increased ranging from 0.2 ˚C under Green plastic and Mater-Bi to 5.9 ˚C under EcoFilm compared to bare soil.

In early June, after 3 hot, sunny days, stem injury was observed on about 20% of the plants growing through the EcoFilm. Soil temperature on June 8th and 9th was 47 ˚C under the EcoFilm compared to 37 ˚C under the next warmest film (EcoWorks). The injury appears to be due to sun burning or scorch from the hot temperatures encountered on the EcoFilm. Only a couple plants were affected on the other films.

Black plastic, and Eco-one lasted through the season with virtually no breakdown (Table 2). Mater-Bi survived the season with nearly full soil cover. EcoWorks lasted until late August and Biolene until mid-September before any appreciable breakdown of the mulch occurred. EcoFilm was over 50% deteriorated by late July and Green Plastic deteriorated the most rapidly and was largely deteriorated by mid-June.

Seasonal total and marketable yields were not significantly ($P \leq 0.05$) affected by soil cover (Table 3). Early marketable yield (August 3) was reduced for Biolene, black plastic, Ecofilm and Mater-Bi compared to EcoWorks and Green plastic. Cumulative marketable yield of the first two picks (August 3 and August 12) was lower for all mulch films compared to bare soil except for EcoWorks and Green plastic. Culls were highest in the black plastic and lowest in bare soil. The fruit size from the bare soil and Green plastic plots was significantly larger than from the Biolene plots. No significant difference in fruit length, diameter or wall thickness occurred between the soil covers in 2004 (data not shown).

Conclusions:

Differences between mulches were observed in soil temperature and film breakdown. However, these differences did not affect total or marketable yield over the season. None of the mulches increased early yield compared to bare soil. The performance of biodegradable mulches was similar to black polyethylene except that field removal of the biodegradable films was not required at the end of the season.

Table 1: Effect of Soil Cover on Maximum, Minimum and Average Soil Temperature (˚C) at 5 cm Depth from June 4 to July 10, 2004

Soil cover [z]	Mean maximum	Mean minimum	Average temperature
Bare soil	27.8	16.8	21.8
Biolene	29.2	19.3	23.8
Black plastic	29.5	19.2	23.9
EcoFilm	33.7	19.9	25.7
Eco-one	30.4	19.8	24.6
EcoWorks	31.4	19.7	24.9
Green plastic	28.0	18.0	22.5
Mater-Bi	28.0	19.2	23.2

[z] Mulches laid May 30.

Table 2: Effect of Type of Mulch on Soil Cover Rating for Various Dates

	Soil cover rating [y]															
Type of mulch	Jun 11		Jun 23		Jul 08		Jul 22		Jul 30		Aug 14		Aug 30		Sep 13		Oct 01	
Biolene	1.0	b [z] c	1.0	b	1.0	c	1.0	d	1.3	c	2.3	c	2.3	c	3.0	c	4.5	a
Black plastic	0.0		0.0	c	0.0	d	0.0	e	0.0	d	0.0	e	0.0	e	0.0	e	0.3	c
EcoFilm	0.0	c	0.3	c	2.5	b	4.0	b	5.0	a	5.0	a	5.0	a	5.0	a	5.0	a
Eco-one	0.0	c	0.0	c	0.0	d	0.0	e	0.0	d	0.0	e	0.0	e	0.0	e	0.3	c
EcoWorks	1.0	b	1.0	b	1.0	c	2.0	c	2.0	b	2.8	b	3.5	b	4.0	b	4.8	a
Green plastic	1.5	a	5.0	a	5.0	a	5.0	a	5.0	a	5.0	a	5.0	a	5.0	a	5.0	a
Mater-Bi	1.0	b	1.0	b	1.0	c	1.0	d	1.0	c	1.0	d	1.0	d	1.3	d	3.0	b
LSD	0.32		0.28		0.32		0.00		0.28		0.39		0.42		0.70		0.74	

[y] 0 to 5 rating: 0 = no breakdown of mulch, 100% soil cover; 1 = small holes forming, nearly 100% soil cover; 2 = one or more small tears over 30 cm long, > 90% soil cover; 3 = multiple tears and holes, 75 to 90% soil cover; 4 = multiple tears and holes, 50 to 75% soil cover; 5 = mulch largely deteriorated, < 50% soil cover. Mulch laid May 30, 2004.

[z] Means followed by the same letter within each column not significantly different using LSD ($P \leq 0.05$).

Table 3: Effect of Soil Cover on Pepper Yield (Tonnes per Hectare at Mature Green Stage) and Fruit Size

Soil cover	Early marketable yield to Aug 03		Early marketable yield to Aug 12		Culls to Aug 12		Seasonal total yield	Seasonal marketable yield	Seasonal marketable Fruit size(g)	
Bare soil	17.6	ab [z]	23.3	a	1.3	c	52.9	49.3	163	a
Biolene	15.5	bc	20.0	bc	1.7	bc	46.5	43.0	147	b
Black plastic	15.5	bc	20.4	bc	3.2	a	49.5	44.6	155	ab
EcoFilm	14.4	c	19.2	c	1.9	bc	46.3	42.6	157	ab
Eco-one	16.1	abc	20.0	bc	1.8	bc	48.3	44.8	155	ab
EcoWorks	17.8	a	22.1	ab	2.7	ab	50.0	45.0	158	ab
Green plastic	17.9	a	21.6	abc	1.7	bc	50.6	46.5	163	a
Mater-Bi	15.4	bc	19.7	bc	1.6	bc	45.8	42.3	152	ab
LSD	2.3		2.6		1.1		9.7	9.8	14	

[z] Means followed by the same letter within each column are not significantly different using LSD ($P \leq 0.05$). Absence of letters indicates no significant difference.