Evaluation of Biodegradable Mulches in Pepper Production

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# Evaluation of Biodegradable Mulches in Pepper Production

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## 1.0 Executive Summary
Pepper producers use dark plastic mulches to warm the soil and advance crop maturity when planted early in the season. Dark plastic mulches also provide weed suppression. Disposal of the plastic at the end of the season in municipal landfills is presently not a problem in Ontario, but it has become an issue in other vegetable production regions of North America. It has been estimated that in excess of 500 tons of agricultural plastic is disposed of yearly in Ontario; plastic mulches are a significant contributor to this total. Recently, biodegradable mulch films have become available, which break down through microbial activity in the soil. These materials would provide labour costs savings of 75-100/acre since they do not have to be removed from the field. Data is required on the length of time the biodegradable mulch will last in the field, its soil warming potential, and its effects on crop growth, yield and quality.

Infra-red transmitting (IRT) mulches allow a high proportion of near infrared solar radiation to pass through them, while blocking most photosynthetically active radiation; the result is soil warming and weed suppression; however, under cool conditions weed development may occur.

Trials were established at Ridgetown College, University of Guelph, Ridgetown ON., and at Agriculture & Agri-Food Canada, Greenhouse & Processing Crops Research Center, Harrow ON., in order to evaluate the effectiveness of biodegradable mulch films and infra-red transmitting mulches (Harrow location only) on bell pepper production.

Biodegradable mulches evaluated to date in pepper production have provided production benefits similar to black plastic mulch. Yields at Ridgetown did not differ across any mulch treatments, but all mulches provided earlier and greater yields than bare soil. At the Harrow site, only black plastic mulch resulted in greater early pepper yields when compared to degradable and IRT mulches and bare soils, while during the main season all mulches (standard as well as degradable and IRT mulches) produced greater yields than bare soil. Standard and IRT mulches provided the largest marketable yields; while degradable mulches provided greater marketable yields than bare soil at the Harrow site, the differences were not statistically significant. Fruit weights, length and diameters did not differ across treatments at the Ridgetown site, while peppers grown on the Recoltech mulch at the Harrow site produced larger fruit by weight. The degradation rate of Recoltech mulch appears slow enough to ensure that a large amount of the soil is still covered at the end of the growing season. Conversely, the Polar Gruppen mulch is largely degraded by late summer and it is questioned if this is acceptable. It appears that the Recoltech mulch completely degrades over the winter.

The dark Polar Gruppen mulch was very expensive because of the small quantity we ordered, and would be more affordable if large quantities were purchased. The Vandenbussche (Recoltech) mulches are produced in France, and had been very expensive due to the value of the Euro; however their current prices are not known. Producers should contact the suppliers to determine actual costs.

2.0 Research Results and Conclusions.
2.1 PERFORMANCE OF BELL PEPPER ON BIODEGRADABLE MULCHES.

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BACKGROUND:

Fresh market pepper growers use dark plastic mulch to warm the soil and advance maturity when planted early in the season. These plastics also help retain soil moisture and suppress weed growth. Disposal of the plastic at the end of the season is presently not a problem in Ontario, but it has become an issue in other vegetable production regions of North America. It has been estimated that in excess of 500 tons of agricultural plastic is disposed of yearly in Ontario; plastic mulches are a significant contributor to this total. Recently, biodegradable mulch films have become available, which break down through microbial activity in the soil. Data is required on the length of time the biodegradable mulch will last in the field, and its effects on crop growth, yield and quality.

The objectives of this trial were to compare the performance of bell pepper on standard black plastic mulch and 2 biodegradable dark mulches, and to document the degradation of the mulch.

METHODS: The trial was established on a Brookston clay loam sand spot phase soil on the Ridgetown College research farm. Mulches were laid on 10 June; embossed black plastic was used as a standard comparison. Bell peppers (cv = Boynton Bell) were hand transplanted on 16 June on a double row (45 cm x 45 cm diamond pattern) for a plant population of 29,630 plants/ha (12,000 plants/acre). Weeds were controlled with a preplant incorporated treatment of Edge. Weed escapes were controlled with hoeing.

Nitrogen fertilizer was applied preplant at rate of 60 kg/ha actual N. Phosphorous and potassium applications were based on soil analysis.

European corn borers were controlled with sprays of Decis and Pounce. There were a total of 4 insecticides sprays applied.

DATA COLLECTION: Peppers were harvested according to Ontario processing standards: mature green peppers were a minimum 2 3/4" diameter with a 5% tolerance on color. At the first harvest, samples were taken and the following assessment made:

a. fruit length: average length of 10 fruit per plot
b. fruit diameter: average diameter of 10 fruit per plot
c. wall thickness: average thickness of 10 fruit per plot

EXPERIMENTAL DESIGN AND DATA ANALYSIS: The trial was established in a randomized complete block design with four replications. A single plot consisted of 1 bed containing a double row with plants spaced 45cm x 45 cm. Bed length was 8.0 m with 1.0 m
between the beds.

The data was statistically analysed using analysis of variance for a randomized complete block design. A protected LSD was used to separate the treatments with significant differences. Means followed by the same letter do not differ significantly (P=0.05, Duncan’s New MRT)

RESULTS AND DISCUSSION:

The two degradable mulches which were evaluated in 2002 were evaluated again in 2003; these were the Polar Gruppen and Recoltech mulches. Their characteristics are outlined below:

Table 1: Mulch types and characteristics

<table>
<thead>
<tr>
<th>Mulch Type</th>
<th>Supplier</th>
<th>Color</th>
<th>Thickness (mil)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>Plastitech 811 James St Delhi ON N4B 2C9</td>
<td>Black</td>
<td>1</td>
</tr>
<tr>
<td>Polar Gruppen</td>
<td>Polar Gruppen North America Vancouver BC.</td>
<td>Black; slightly translucent</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td>Supplied locally by: Trade Match International 27 Cricklewood Crescent Thornhill ON L3&amp; 4T8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recoltech</td>
<td>Recoltech St. Remi, Quebec Vandenbussche Irrigation 970 James St. Delhi ON N4B 2X1</td>
<td>Black</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Fruit characteristics of bell pepper grown on the biodegradable mulch did not differ from peppers grown on standard plastic or bare soil in 2003 (Table 2). Fruit length, diameter, wall thickness and average weight did not differ across any treatments. Early and total yields of pepper were improved by using mulches when compared to bare soil, but early and total yields were similar across mulch types (Table 3). Fruit numbers per plant did not differ across any treatments.

The Polar Gruppen degradable mulch started to degrade after several weeks in the field, and was about essentially gone by late August. The Recoltech mulch was more durable, and was still covering 55-60% of the soil surface by early October. Regardless of the degradation of the Polar Gruppen mulch, yields were still improved when compared to bare soil. Early degradation of the mulch may reduce weed control, but this was not noted in this trial.

CONCLUSIONS:
Biodegradable mulches evaluated to date have provided production benefits similar to black plastic mulch. The degradation rate of Recoltech mulch appears slow enough to ensure that a large amount of the soil is still covered at the end of the growing season. Conversely, the Polar Gruppen mulch is largely degraded by late summer and it is questioned if this is acceptable. It appears that the Recoltech mulch completely degrades over the winter, as no trace can be found in our plots the following spring.

At the present time the cost of these mulches is not known. The Polar Gruppen mulch was very expensive because of the small quantity we ordered, and would be more affordable if large quantities were purchased. Earlier in 2004 the Recoltech mulch was not readily available, and it is not known if this has changed.

Table 2. Fruit characteristics of Boynton Bell pepper grown on standard and biodegradable mulch. Ridgetown College, 2003

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Fruit length (cm)</th>
<th>Fruit Diameter (cm)</th>
<th>Wall Thickness (mm)</th>
<th>Average fruit weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>8.9</td>
<td>9.1</td>
<td>6.9</td>
<td>247</td>
</tr>
<tr>
<td>Polar Gruppen</td>
<td>8.8</td>
<td>9.1</td>
<td>6.7</td>
<td>242</td>
</tr>
<tr>
<td>Recoltech</td>
<td>8.9</td>
<td>9.1</td>
<td>6.3</td>
<td>236</td>
</tr>
<tr>
<td>Bare soil</td>
<td>9.0</td>
<td>8.8</td>
<td>6.5</td>
<td>244</td>
</tr>
</tbody>
</table>

LSD (.05) - - - -
CV 4.44 3.22 6.65 5.04
P-value N.S. N.S. N.S. N.S.

Table 3. Green and mature fruit yields of Boynton Bell pepper grown on standard plastic, bare soil and degradable mulches. Ridgetown College, 2003.
<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Early Yield (t/acre)</th>
<th>Fruit/plant</th>
<th>Total Yield (t/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>6.9 a</td>
<td>8</td>
<td>17.3 a</td>
</tr>
<tr>
<td>Polar Gruppen</td>
<td>6.0 a</td>
<td>8</td>
<td>17.6 a</td>
</tr>
<tr>
<td>Recoltech</td>
<td>6.5 a</td>
<td>8</td>
<td>18.0 a</td>
</tr>
<tr>
<td>Bare Soil</td>
<td>3.6 b</td>
<td>7</td>
<td>12.2 b</td>
</tr>
<tr>
<td>LSD (0.05)</td>
<td>1.3</td>
<td>-</td>
<td>3.9</td>
</tr>
<tr>
<td>C.V.</td>
<td>14.24</td>
<td>11.1</td>
<td>15.01</td>
</tr>
<tr>
<td>P-value</td>
<td>0.0012</td>
<td>N.S.</td>
<td>0.0254</td>
</tr>
</tbody>
</table>

**2.2 EVALUATION OF BIODEGRADABLE AND SOLAR MULCH FILMS IN PEPPER PRODUCTION**
John Warner and John Zandstra

Black plastic mulch is commonly used in pepper production to advance maturity and to improve the yield of peppers. Plastic mulches warm the soil and conserve soil moisture. In addition, black mulches provide weed control. Solar mulch film (a product of Plastitech) is an infrared transmitting plastic mulch. A high proportion of near infrared solar radiation (solar heat energy) is transmitted through the mulch to warm the soil. Most photosynthetically active radiation (visible light) is blocked, thus suppressing weed growth under the mulch. A major disadvantage of the use of plastic is the disposal of the plastic at the end of the season. Biodegradable mulch films (starch based) break down through microbial activity in the soil. 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 effect of black plastic, solar mulch film, and biodegradable black mulch films on pepper maturity, yield and quality and to compare the soil warming effects and longevity of plastic and biodegradable mulches.

Experimental Details:

Experimental design: Randomized complete block design
Replications: 4
Treatments: 1. Standard black plastic, embossed, 54” wide, 1 mil thick
  3. Biodegradable (R): a black biodegradable mulch, 56” wide, 0.8 mil thick, (Recoltech, St.-Remi, Quebec)
  4. Solar mulch film, 48” wide, 1 mil thick (Plastitech)
  5. Bare ground
Plot size: 1.5 x 7.0 m (twin row)
Cultivar: Boynton Bell

Crop Management:

Soil type: Fox sandy loam
Fertilizer: 15-8-0 at 500 kg product/ha applied ppi before mulch film was laid
Stand establishment: Seeded into 72 cell plug trays on March 27. Mulch films laid May 26. Field planted through the mulch film on May 26 using a single row Mechanical mulch transplanter.
Row spacing: Twin row with 45 cm between rows and 40 cm between plants within the row with 1.5 m centres (33,333 plants /ha or 13,300 plants/ac). 36 plants/plot

1 University of Guelph, Ridgetown College
Weed control: Treflan 0.6 kg ai/ha applied ppi on May 22
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 25 (8 hr), July 3 (4 hr), July 15 (6 hr), July 28 (7 hr) and July 30 (4 hr).
Pest control: Bravo + Kocide applied at 1 to 2 week intervals for disease control

**Harvest and Evaluations:**

Harvest: Fruit harvested at mature green stage at approx. 12 to 14 day intervals. First harvest, July 31. Last harvest, Sept. 8
Yield and quality: Total yield, marketable yield and cull (weight and number of peppers)
Fruit size: Average weight of all marketable fruit
Fruit length, diameter, wall thickness: Average of 10 fruit per plot on Sept. 8
Soil temperature: Data collected from 1 replicate at 5 cm depth from May 29 to July 5
Mulch cover: 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

**Results:**

During the period from May 29 to July 5 (first 5.5 weeks of growing season), average soil temperature at the 5 cm depth was increased by the soil covers except for the biodegradable (PG) mulch, compared to bare ground (Table 1). Solar mulch increased average soil temperature by 1.5 °C, whereas black plastic increased soil temperature by 0.6 °C, compared to bare ground. All the mulch films reduced radiation heat loss from the soil at night and thus increased the mean minimum soil temperature by 2.0 to 3.3 °C compared to bare ground (Table 1). Daytime maximum soil temperatures were reduced under the mulch films compared to bare ground. With black or dark mulch films, good soil surface contact with the film is required to maximize heat transfer to the soil.

The black plastic, solar mulch and biodegradable (R) mulch lasted through the season with virtually no breakdown (Table 2). The biodegradable (PG) mulch lasted until mid-July before any appreciable breakdown of the mulch occurred. By the end of Aug., the biodegradable (PG) mulch was largely deteriorated with 50% or more of the soil exposed.

Total and marketable yields were increased with the black plastic and solar mulch compared to bare ground (Table 3). Yields from the biodegradable films were not significantly \( P < 0.05 \) increased compared to bare ground. Early yield (July 31) was greater for black plastic compared to
the other mulch films and bare ground. Marketable yield from the first two picks (July 31 and Aug. 12) was greater for all mulch films compared to bare ground. Fruit size was largest from the biodegradable (R) mulch compared to the other treatments except solar mulch. No difference in fruit length, diameter or wall thickness occurred between the soil covers in 2003 (data not shown).

Table 1: Effect of Soil Cover on Maximum, Minimum and Average Soil Temperature (°C) at the 5 cm Depth from May 29 to July 5, 2003

<table>
<thead>
<tr>
<th>Soil cover</th>
<th>Mean maximum</th>
<th>Mean minimum</th>
<th>Average temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black plastic</td>
<td>28.0</td>
<td>18.5</td>
<td>23.2</td>
</tr>
<tr>
<td>Biodegradable (PG)</td>
<td>27.3</td>
<td>17.9</td>
<td>22.6</td>
</tr>
<tr>
<td>Biodegradable (R)</td>
<td>28.8</td>
<td>18.2</td>
<td>23.5</td>
</tr>
<tr>
<td>Solar mulch</td>
<td>29.0</td>
<td>19.2</td>
<td>24.1</td>
</tr>
<tr>
<td>Bare ground</td>
<td>29.3</td>
<td>15.9</td>
<td>22.6</td>
</tr>
</tbody>
</table>

y Black, biodegradable film supplied by Polar Gruppen North American, Vancouver, BC.
z Black, biodegradable film supplied by Recoltech, St.-Remi, Quebec.
Table 2: Effect of Type of Mulch on Soil Cover Rating for Various Dates

<table>
<thead>
<tr>
<th>Type of mulch</th>
<th>June 9</th>
<th>June 23</th>
<th>July 11</th>
<th>July 24</th>
<th>Aug. 7</th>
<th>Aug. 21</th>
<th>Sept. 4</th>
<th>Sept. 18</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black plastic</td>
<td>0</td>
<td>0 b x</td>
<td>0 b</td>
<td>0 b</td>
<td>0 c</td>
<td>0 c</td>
<td>0 c</td>
<td>0 c</td>
</tr>
<tr>
<td>Biodegradable (PG) y</td>
<td>0.5</td>
<td>1.0 a</td>
<td>1.8 a</td>
<td>3.5 a</td>
<td>4.3 a</td>
<td>4.8 a</td>
<td>4.8 a</td>
<td>5.0 a</td>
</tr>
<tr>
<td>Biodegradable (R) z</td>
<td>0</td>
<td>0 b</td>
<td>0.5 b</td>
<td>0.5 b</td>
<td>0.8 b</td>
<td>1.0 b</td>
<td>1.0 b</td>
<td></td>
</tr>
<tr>
<td>Solar mulch</td>
<td>0</td>
<td>0 b</td>
<td>0 b</td>
<td>0 b</td>
<td>0 c</td>
<td>0 c</td>
<td>0 c</td>
<td>0 c</td>
</tr>
</tbody>
</table>

* 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 26, 2003.

x Means followed by the same letter within each column not significantly different using LSD (P < 0.05). Absence of letters indicates no significant difference.

y Black, biodegradable mulch supplied by Polar Gruppen North American, Vancouver, BC.

z Black, biodegradable mulch supplied by Recoltech, St.-Remi, Quebec.
Table 3: Effect of Soil Cover on Pepper Yield (Tons per Acre at Mature Green Stage) and Fruit Size

<table>
<thead>
<tr>
<th>Soil cover</th>
<th>Total yield</th>
<th>Marketable fruit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total season</td>
<td>Early July 31</td>
</tr>
<tr>
<td>Black plastic</td>
<td>19.6 ab</td>
<td>17.7 ab</td>
</tr>
<tr>
<td>Biodegradable (PG)‡</td>
<td>17.6 bc</td>
<td>15.4 bc</td>
</tr>
<tr>
<td>Biodegradable (R)‡</td>
<td>17.3 bc</td>
<td>15.5 bc</td>
</tr>
<tr>
<td>Solar mulch</td>
<td>22.1 a</td>
<td>19.6 a</td>
</tr>
<tr>
<td>Bare ground</td>
<td>15.5 c</td>
<td>13.4 c</td>
</tr>
</tbody>
</table>

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

‡Black, biodegradable mulch supplied by Polar Gruppen North American, Vancouver, BC.

‡Black, biodegradable mulch supplied by Recoltech, St. Remi, Quebec.