Polyethylene and biodegradable plastic mulches improve growth, yield, and weed management in floricane red raspberry

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Processed Red Raspberry

~ 78 Million Pounds in Washington State

Whatcom County: over 97% of State Production
Tissue Culture

Number of Plants
Aseptic Techniques
Establishment Difficulty
Weak Competitor with Weeds
Biodegradable Plastic Mulch (BDM)

- Manufactured with **different feedstocks and additives** compared to polyethylene (PE) mulches
- Engineered to **biodegrade in soils** by microbial activities (ASTM D5988)
- Potential to **reduce plastic waste generation**
Why Consider a BDM?

- Few studies, but promising results
- May reduce labor and costs associated with PE mulch removal and disposal
- May promote on-farm efficiencies

Gerbrant, 2015; Król-Dyre and Siwek, 2015; Tecco et al., 2016; https://www.mlive.com/
Root Lesion Nematode
Major Plant Parasite Activity
No Previous Studies
Spring-Planted Trial Established May 2017
## Treatments

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Code</th>
<th>Thickness</th>
<th>Extruder/converter</th>
</tr>
</thead>
<tbody>
<tr>
<td>BASF 0.5</td>
<td>A</td>
<td>0.5 mil</td>
<td>PolyExpert Inc.; Laval, Quebec, Canada</td>
</tr>
<tr>
<td>BASF 0.6</td>
<td>B</td>
<td>0.6 mil</td>
<td>PolyExpert Inc.; Laval, Quebec, Canada</td>
</tr>
<tr>
<td>Novamont 0.5</td>
<td>C</td>
<td>0.5 mil</td>
<td>Dubois Agrinovation; Saint Remi, Quebec, Canada</td>
</tr>
<tr>
<td>Novamont 0.6</td>
<td>D</td>
<td>0.6 mil</td>
<td>Dubois Agrinovation; Saint Remi, Quebec, Canada</td>
</tr>
<tr>
<td>Polyethylene</td>
<td>E</td>
<td>1.0 mil</td>
<td>FilmTech, LLC., Stanley, WI</td>
</tr>
<tr>
<td>Bare Ground</td>
<td>F</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>
### Experimental Design

#### Plot Map

<table>
<thead>
<tr>
<th>Row</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Block 1</td>
<td>26-D</td>
<td>25-C</td>
<td>16-A</td>
<td>15-F</td>
<td>6-E</td>
<td>5-B</td>
</tr>
<tr>
<td>Block 2</td>
<td>27-F</td>
<td>24-A</td>
<td>17-D</td>
<td>14-E</td>
<td>7-B</td>
<td>4-C</td>
</tr>
<tr>
<td>Block 3</td>
<td>28-A</td>
<td>23-B</td>
<td>18-C</td>
<td>13-D</td>
<td>8-E</td>
<td>3-F</td>
</tr>
<tr>
<td>Block 4</td>
<td>29-B</td>
<td>22-D</td>
<td>19-E</td>
<td>12-F</td>
<td>9-C</td>
<td>2-A</td>
</tr>
<tr>
<td>Block 5</td>
<td>30-C</td>
<td>21-E</td>
<td>20-B</td>
<td>11-A</td>
<td>10-F</td>
<td>1-D</td>
</tr>
</tbody>
</table>

#### Design Details

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Size</strong></td>
<td>2 acres</td>
</tr>
<tr>
<td><strong>Design</strong></td>
<td>Randomized Complete Block</td>
</tr>
<tr>
<td><strong>Treatments</strong></td>
<td>6</td>
</tr>
<tr>
<td><strong>Replications</strong></td>
<td>5</td>
</tr>
<tr>
<td><strong>Plot Length</strong></td>
<td>120 ft</td>
</tr>
<tr>
<td><strong>Block</strong></td>
<td>Across Row</td>
</tr>
<tr>
<td><strong>Fumigation</strong></td>
<td>Broadcast; Sept. 2016</td>
</tr>
<tr>
<td><strong>Cultivar</strong></td>
<td>Wake™ Field</td>
</tr>
</tbody>
</table>
Objectives

1. Plant growth
2. Fruit yield
3. Weed incidence
4. Root lesion nematode populations
5. Soil temperature and moisture
6. Mulch surface and in-soil degradation
Data Collection

- **Plant**
  - Primocane height, number, and emergence
  - Yield

- **Pests**
  - Weed number
  - Weed shoot fresh and dry weight
  - RLN root and soil densities

- **Soils**
  - Soil temperature
  - Soil moisture
  - Soil nutrient status

- **Mulch**
  - Percent soil exposure (PSE)
  - In-soil degradation
    - Apr. 2018 to Oct. 2019
2017 Primocane Height

Primocane height (in.)

25-May
30-Jun
28-Jul
30-Aug
29-Sep
27-Oct

NS: nonsignificant
** : P ≤ 0.01
*** : P ≤ 0.0001

14 in. difference

BASF 0.5
BASF 0.6
Novamont 0.5
Novamont 0.6
PE
Bare Ground
2017 Primocane Number

- **BASF 0.5**
- **BASF 0.6**
- **Novamont 0.5**
- **Novamont 0.6**
- **PE**
- **Bare Ground**

**NS**: nonsignificant

*******: $P \leq 0.0001$

5 canes (71%) difference
Plant Growth Comparison (2018 April)

BASF 0.5  BASF 0.6  Novamont 0.5  Novamont 0.6  PE  BG

Mulched  Non-mulched
## 2018 Plant Growth

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Primocane emergence/30 ft</th>
<th>Primocanes/plant</th>
<th>Primocane height (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BASF 0.5</td>
<td>35 ab&lt;sup&gt;2&lt;/sup&gt;</td>
<td>5</td>
<td>125</td>
</tr>
<tr>
<td>BASF 0.6</td>
<td>37 ab</td>
<td>6</td>
<td>125</td>
</tr>
<tr>
<td>Novamont 0.5</td>
<td>30 b</td>
<td>6</td>
<td>128</td>
</tr>
<tr>
<td>Novamont 0.6</td>
<td>41 ab</td>
<td>6</td>
<td>125</td>
</tr>
<tr>
<td>PE</td>
<td>23 b</td>
<td>5</td>
<td>129</td>
</tr>
<tr>
<td>BG</td>
<td>45 a</td>
<td>6</td>
<td>124</td>
</tr>
</tbody>
</table>

*Means followed by the same letter are not significantly different at $P < 0.05$, using a means comparison with a Tukey's Honestly Significant Difference test except total yield, which was analyzed with LSD Student's t test.*

| $P$ - value | 0.05 | 0.28 | 0.71 |
Harvest 2018

Yield (lbs/30ft)

BASF 0.5
BASF 0.6
Novamont 0.5
Novamont 0.6
PE
BG

Peaks

6/29 7/4 7/7 7/11 7/14 7/17 7/20 7/23 7/26 8/1 8/4 8/8 8/10
1 harvest 2 harvest 3 harvest 4 harvest 5 harvest 6 harvest 7 harvest 8 harvest 9 harvest 10 harvest 11 harvest 12 harvest 13 harvest
### Average Fruit Yield lbs/acre

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Total Yield lbs/acre</th>
<th>Total Yield lbs/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>BASF 0.5</td>
<td>8198</td>
<td>57.1 a</td>
</tr>
<tr>
<td>BASF 0.6</td>
<td>9555</td>
<td>66.5 a</td>
</tr>
<tr>
<td>Novamont 0.5</td>
<td>9052</td>
<td>63.0 a</td>
</tr>
<tr>
<td>Novamont 0.6</td>
<td>8882</td>
<td>61.8 a</td>
</tr>
<tr>
<td>PE</td>
<td>9191</td>
<td>64.0 a</td>
</tr>
<tr>
<td>BG</td>
<td>6233</td>
<td>43.4 b</td>
</tr>
</tbody>
</table>

Significant differences are indicated by different letters. Averages followed by the same letter are not significantly different at $P < 0.05$, using a means comparison with a Tukey's Honestly Significant Difference test except total yield, which was analyzed with LSD Student's t test.

Average Fruit Yield (lbs/30 ft): 8976 lbs/acre

Average Fruit Yield (lbs/acre): 6233 lbs/acre

Total Yield (lbs/acre): 2743 lbs/acre
Data Collection

- **Plant**
  - Primocane height, number, and emergence
  - Yield

- **Pests**
  - Weed number
  - Weed shoot fresh and dry weight
  - RLN root and soil densities

- **Soils**
  - Soil temperature
  - Soil moisture
  - Soil nutrient status

- **Mulch**
  - Percent soil exposure (PSE)
  - In-soil degradation
    - Apr. 2018 to Oct. 2019
Weeds count (number/11 ft²)

Hand weeded BG plots 3 times during growing season

2017 Cumulative Weed Number

NS: nonsignificant
*: P ≤ 0.05
## Root Lesion Nematode Nematode (RLN)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>May 2017&lt;sup&gt;z&lt;/sup&gt;</th>
<th>October 2017</th>
<th>May 2018</th>
<th>September 2018</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RLN/ 100g soil</td>
<td>RLN/ 100g soil</td>
<td>RLN/ g root</td>
<td>RLN/ 100g soil</td>
</tr>
<tr>
<td>BASF 0.5</td>
<td>0</td>
<td>51 ab&lt;sup&gt;y&lt;/sup&gt;</td>
<td>105 ab</td>
<td>52 a</td>
</tr>
<tr>
<td>BASF 0.6</td>
<td>1</td>
<td>49 ab</td>
<td>134 ab</td>
<td>50 ab</td>
</tr>
<tr>
<td>Novamont 0.5</td>
<td>0</td>
<td>66 ab</td>
<td>165 a</td>
<td>40 ab</td>
</tr>
<tr>
<td>Novamont 0.6</td>
<td>0</td>
<td>100 a</td>
<td>164 ab</td>
<td>38 ab</td>
</tr>
<tr>
<td>PE</td>
<td>1</td>
<td>72 a</td>
<td>45 b</td>
<td>40 ab</td>
</tr>
<tr>
<td>BG</td>
<td>0</td>
<td>5 b</td>
<td>44 b</td>
<td>10 b</td>
</tr>
</tbody>
</table>

<sup>z</sup>Pre-plant densities.
<sup>y</sup>Averages followed by the same letter are not significantly different at \( P < 0.05 \), using a means comparison with a Tukey's Honestly Significant Difference test for the May 2017 data and a non-parametric multiple comparisons Wilcoxon test for the October 2017, and May and September 2018 data.
Data Collection

- **Plant**
  - Primocane height, number, and emergence
  - Yield

- **Pests**
  - Weed number
  - Weed shoot fresh and dry weight
  - RLN root and soil densities

- **Soils**
  - Soil temperature
  - Soil moisture
  - Soil nutrient status

- **Mulch**
  - Percent soil exposure (PSE)
  - In-soil degradation
    - *Apr. 2018 to Oct. 2019*
Percent Soil Exposure (PSE; %)

Before cane tying: PE: 2.6%; BDMs: 67 to 81%
After cane tying: PE: removed; BDMs: 90 to 95%

7 wind events with a speed over 10 mph in Oct. and Nov. – WSU AgWeatherNet

Raspberry cane tying

NS: nonsignificant
*: P ≤ 0.05
Conclusions to Date

• Plants grown with BDMs and PE mulch exhibited greater primocane height and number relative to the BG control
• Yield was higher in all mulched treatments than the BG control
• There is no difference in average berry weight
• Mulched treatments successfully controlled weeds so no hand weeding was needed
• RLN soil and root populations were greater when soil and plants treated with PE mulch
• Soil temperature was higher with mulched treatments
• PE removal activity could remove 1010 pounds soil per acre
• Overall, BDMs and PE mulch are viable tools to use in commercial red raspberry production with plants established as TC transplants
Team

Lisa DeVetter
Carol Miles
Chris Benedict
Me
Inga Zasada
Shuress Ghimire
Additional Team Members and Thanks

Left to right, top to bottom: Ed Scheenstra, Matt Arrington, Clara TeVelde, Naida Bostan, Qianwen Lu, Weixin Gan, Sean Watkinson, and Washington raspberry growers.
Funding and Material Support

Washington Red Raspberries

Commission on Pesticide Registration

BASF

Novamont

Rader Farms

Washington State Department of Agriculture
Literature Cited


• Biodegradable mulch website: https://ag.tennessee.edu/biodegradablenmulch/Pages/default.aspx.


• Washington State University Small Fruit Horticulture website: https://smallfruits.wsu.edu/.
Thank You!

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Washington State University Small Fruit Horticulture website: https://smallfruits.wsu.edu/