Effects of Various Plastic Mulches on Soil Temperature and the Surface Energy Balance

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Research Factsheet

Farm Adaptation Innovator Program

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Background
Mulches are protective covers placed on the soil surface. Like mineral and organic mulches, plastic films used as soil mulches have the potential to suppress weeds, reduce erosion and soil evaporation ($E_s$), and alter soil ($T_s$) and air ($T_a$) temperature. Unlike mineral (e.g., sand, gravel and stones) and organic (e.g., crop residue, sawdust, wood chips, and bark) mulches, which typically slow soil warming (unless mineral mulch is applied to high organic matter soils), plastic film mulches permit faster or slower soil warming depending on their radiative properties (i.e., the reflectivity, transmissivity and absorptivity of the plastic), while also reducing $E_s$. The data presented in this document aim to enhance farmers’ understanding of the changes caused when using various plastic film mulches. This will strengthen farmer awareness and decision making confidence, enabling them to use plastic films (or plastic-like films) to adapt to weather variability and climate change.

Objective
To test commercially available state-of-the-art modern plastic films for their ability to alter soil temperature and the radiation balance of the soil surface when used as mulches.

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Geographic Applicability
This study was conducted at UBC Farm and findings may be applied to other soils in BC and globally, if the soil thermal properties are known.

Commodity relevance
This study was conducted on a sandy loam soil and with drip irrigation. While the relative effects should hold, the magnitude of the effects will differ for different soils and wetness conditions.

Timeline
July 2015 – April 2016
Methods

In June of 2015, 10 treatments (9 plastic mulches, 1 control, i.e., no plastic) were implemented on 1 m x 1 m plots on a tilled Podzolic soil at UBC Farm in a simple randomized complete block design (n = 3) with 0.75-m buffers between each treatment (Table 1, Fig 1). A weather transmitter (not shown) (WXT520, Vaisala Oy, Helsinki, Finland) provided half-hourly mean $T_a$, precipitation, wind velocity and direction, barometric pressure and relative humidity at a height of 2 m. For each treatment, previous to installing the plastic films, 1 soil heat flux plate was installed at a depth of 3 cm (Peltier coolers) and 2 $T_s$ and volumetric water content sensors (STM, Decagon Devices Inc., Pullman, WA, USA) were installed at the 2-cm and 10-cm depths (Fig 2).

Table 1. Plastic mulch names, abbreviations and % effect on soil temperature ($T_s$)

<table>
<thead>
<tr>
<th>Plastic mulch name</th>
<th>Plastic mulch abbreviation</th>
<th>Approximate % effect $T_s$ (2 cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black embossed #2</td>
<td>BE2</td>
<td>+ 20%</td>
</tr>
<tr>
<td>Black embossed PABPNARB</td>
<td>BEP</td>
<td>+ 30%</td>
</tr>
<tr>
<td>Black on white</td>
<td>BW</td>
<td>+ 30%</td>
</tr>
<tr>
<td>White on black</td>
<td>WB</td>
<td>- 20%</td>
</tr>
<tr>
<td>Infrared transmitting</td>
<td>IRT100</td>
<td>+ 20%</td>
</tr>
<tr>
<td>Green</td>
<td>GN</td>
<td>+ 30%</td>
</tr>
<tr>
<td>Red</td>
<td>RD</td>
<td>+ 30%</td>
</tr>
<tr>
<td>Thermax (clear, high transparency)</td>
<td>TMX</td>
<td>+ 55%</td>
</tr>
<tr>
<td>Super 4 (clear, high transparency)</td>
<td>S4</td>
<td>+ 30%</td>
</tr>
</tbody>
</table>

Figure 1. Overhead view of the experimental layout for comparing mulches
Results

When placed on the soil surface, plastic films can change the reflectivity of sunlight (albedo) and strongly control $T_s$. Black plastic films reflect very little sunlight (i.e. low albedo) and increase $T_s$ (Table 1, Figs. 3 and 4). In contrast, white plastic films reflect more sunlight (i.e. high albedo), and typically decrease $T_s$ (Table 1, Figs. 3 and 4).

![Figure 2. Diagram of soil temperature, volumetric water content and heat flux density sensor placement within the soil profile](image)

![Figure 3. Measured albedos (i.e., reflectivity) of various plastic films at UBC Farm during a sunny day in August 2015 at mid-day. For abbreviations see Table 1. C no mulch (Control)](image)
Perhaps not surprisingly, transparent plastic films reflect a similar amount of sunlight as the soil surface they cover, yet they cause the largest increase in measured $T_s$ (Table 1, Fig. 4). This is because sunlight that passes through the transparent film is absorbed by the soil surface and the resulting heat becomes trapped by the plastic film. The degree of contact between the soil and the plastic will alter soil heating. The highest achievable $T_s$ occurs with high and low degrees of contact for black and transparent plastic films, respectively.

![Figure 4](image_url)

**Figure 4.** The daytime and nighttime effects of BE2, S4 and TMX plastic films on soil heat flux density (panel a) and soil temperature ($T_s$) (panel b) in relation to the control (i.e., no mulch).

### Conclusions

- Modern plastic films used as soil mulches provide a wide range of soil cooling and warming potential (-20% to 55%).
- Transparent plastic films resulted in the highest increases in $T_s$.
- Black plastic films also significantly increase $T_s$ while preventing weed growth.