Climate Action Initiative
BC AGRICULTURE & FOOD

Effects of various plastic mulches on soil temperature and the surface energy balance

Research Factsheet

Farm Adaptation Innovator Program

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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

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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 supress 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.

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 (5TM, 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)

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

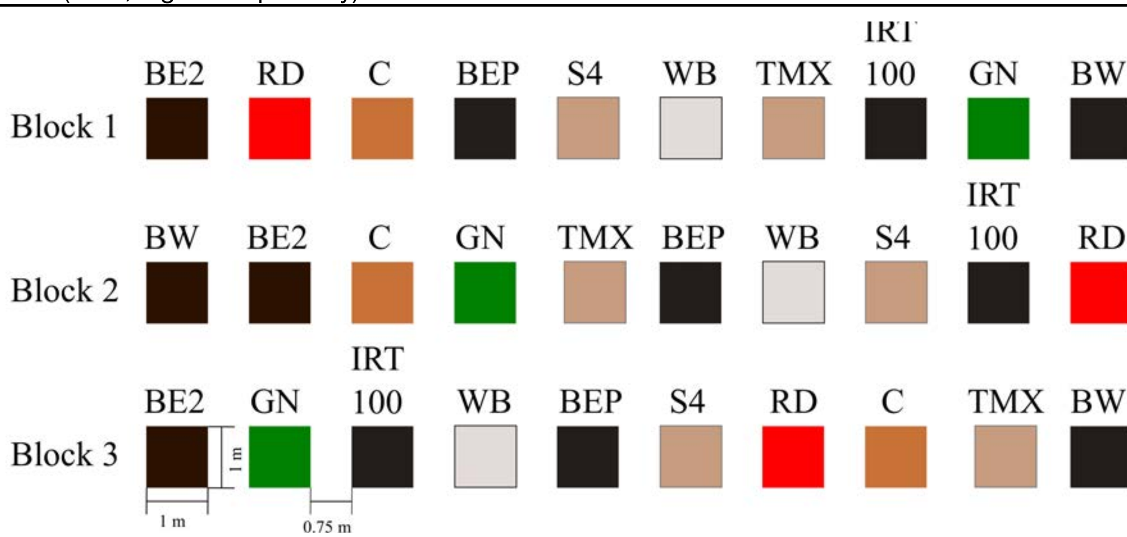

Figure 1. Overhead view of the experimental layout for comparing mulches

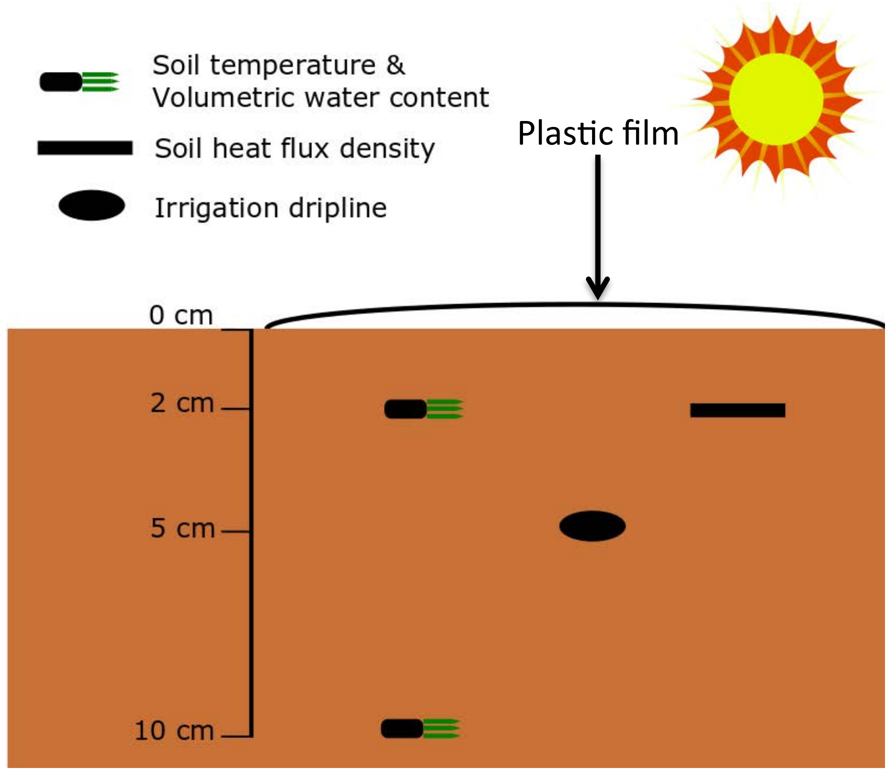

Figure 2. Diagram of soil temperature, volumetric water content and heat flux density sensor placement within the soil profile

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).

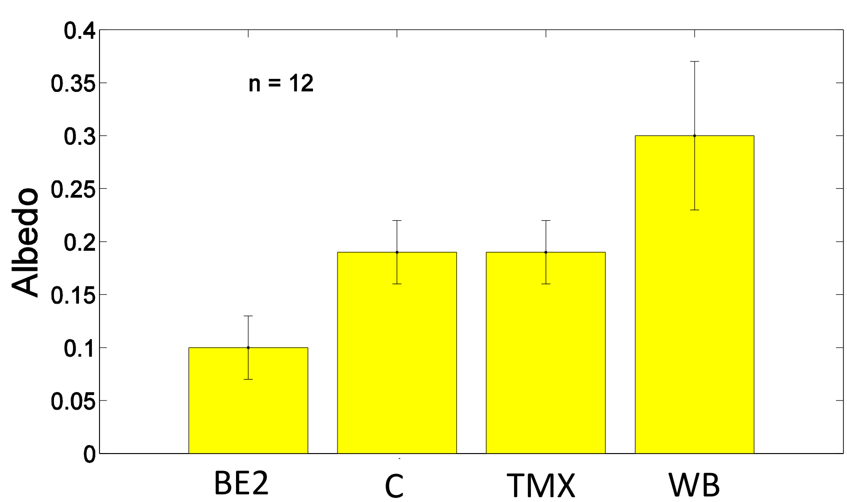

Figure 3. Measured albedos (i.e., reflectivity) of various plastic films at UBC Farm during a sunny day in August 2015 at mid-day. For abbreviations see Table 1. C no mulch (Control)

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.

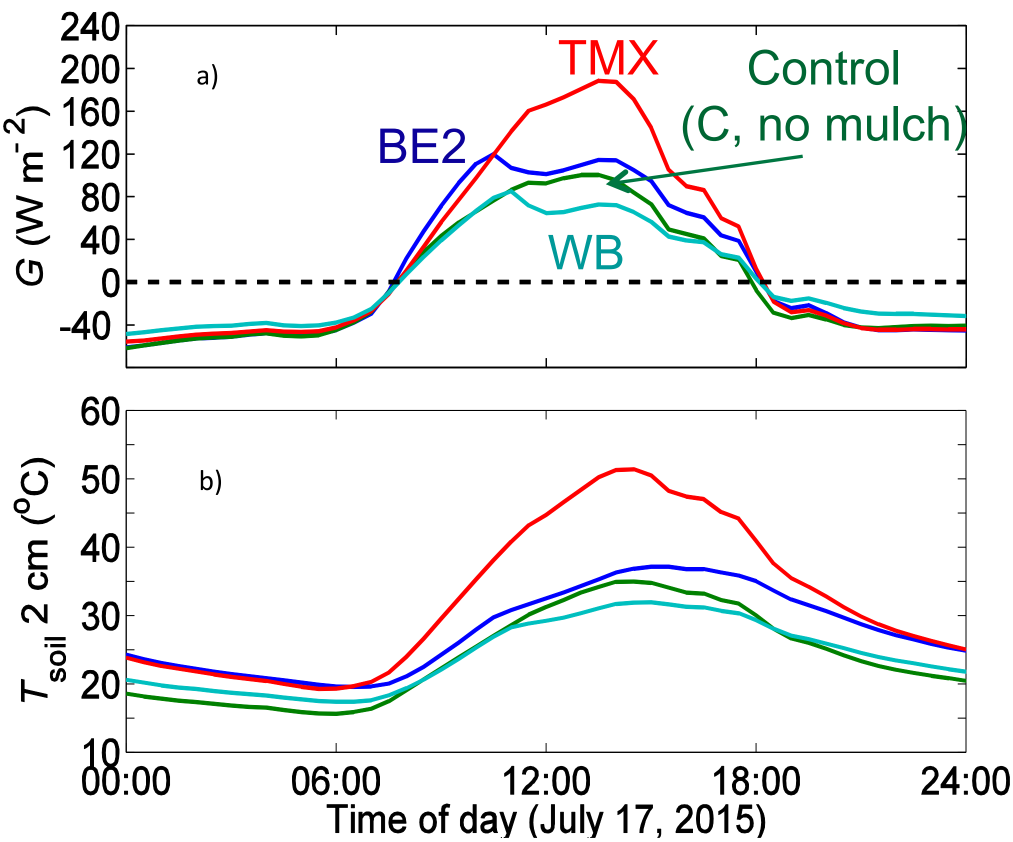

Figure 4.The daytime and nighttime effects of BE2, S4 and TMX plastic films on soil heat flux density (panel a) and soil temperature (T_s) (panel b) in relation to the control (i.e., no mulch)

For more information:
For more details on this project visit the Climate Action Initiative website:
https://www.bcagclimateaction.ca/faip-project/fi07/

For Soil Physics and Biometeorology Lab website:
http://lfs-biomet.sites.olt.ubc.ca/

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.

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