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# *Use of Reflective PAR Mulches to Enhance Winter-time Greenhouse Strawberry Production*

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Mention of specific products and trade names is for reference only and not to the exclusion of others that may be suitable.

## *USDA/CSREES NE1035: Commercial Greenhouse Production: Component and System Development.*

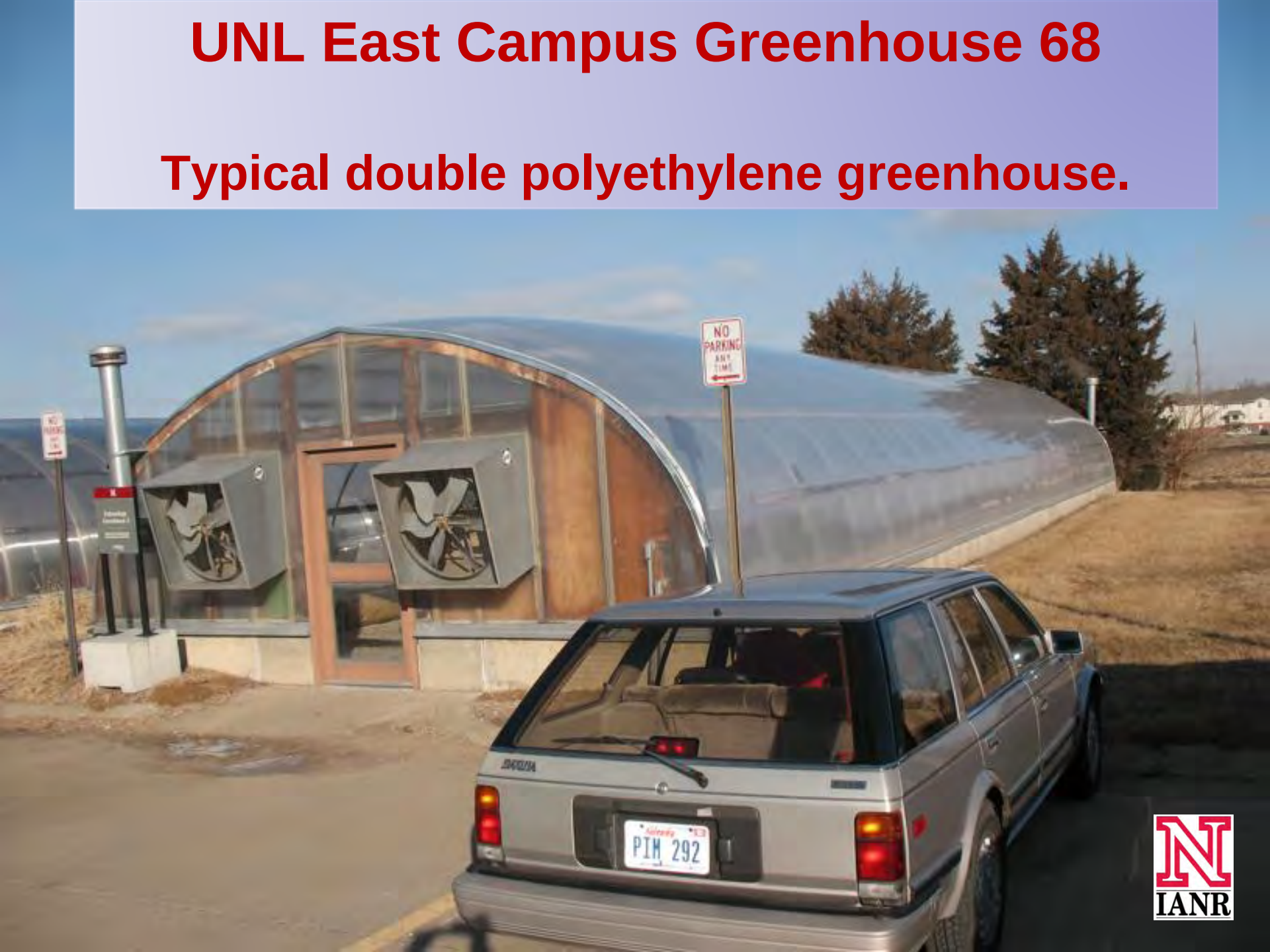
**Pepsi Cola Bottling Company (UCARE).**

Nebraska Department of Agriculture

- **Small Commercial Cooperator Greenhouses: (quonsets, high tunnels, sale houses used as a growing house.**
- **Small town Nebraska: e.g. Beatrice, Grand Island, O'Neil and others.**
- **Compete very successfully with large retail centers – quality and availability (farmer's market, retail on-site).**
- **Over 50 Nebraska rural high schools sport a modern teaching Greenhouse as part of biology and environmental curricula.**

# UNL East Campus Greenhouse 68

## Typical double polyethylene greenhouse.



# Winter Time Greenhouse Strawberry Objectives

a. To create and test a cost effective and energy efficient prototype system for CEA winter fruit and vegetable production.
b. To determine the photo reflective properties of plastic mulches and how these might affect the production of greenhouse strawberries.
c. To actually grow a strawberry crop using a selected plastic mulch with a CapMAT system.
d. To evaluate product quality and marketability.

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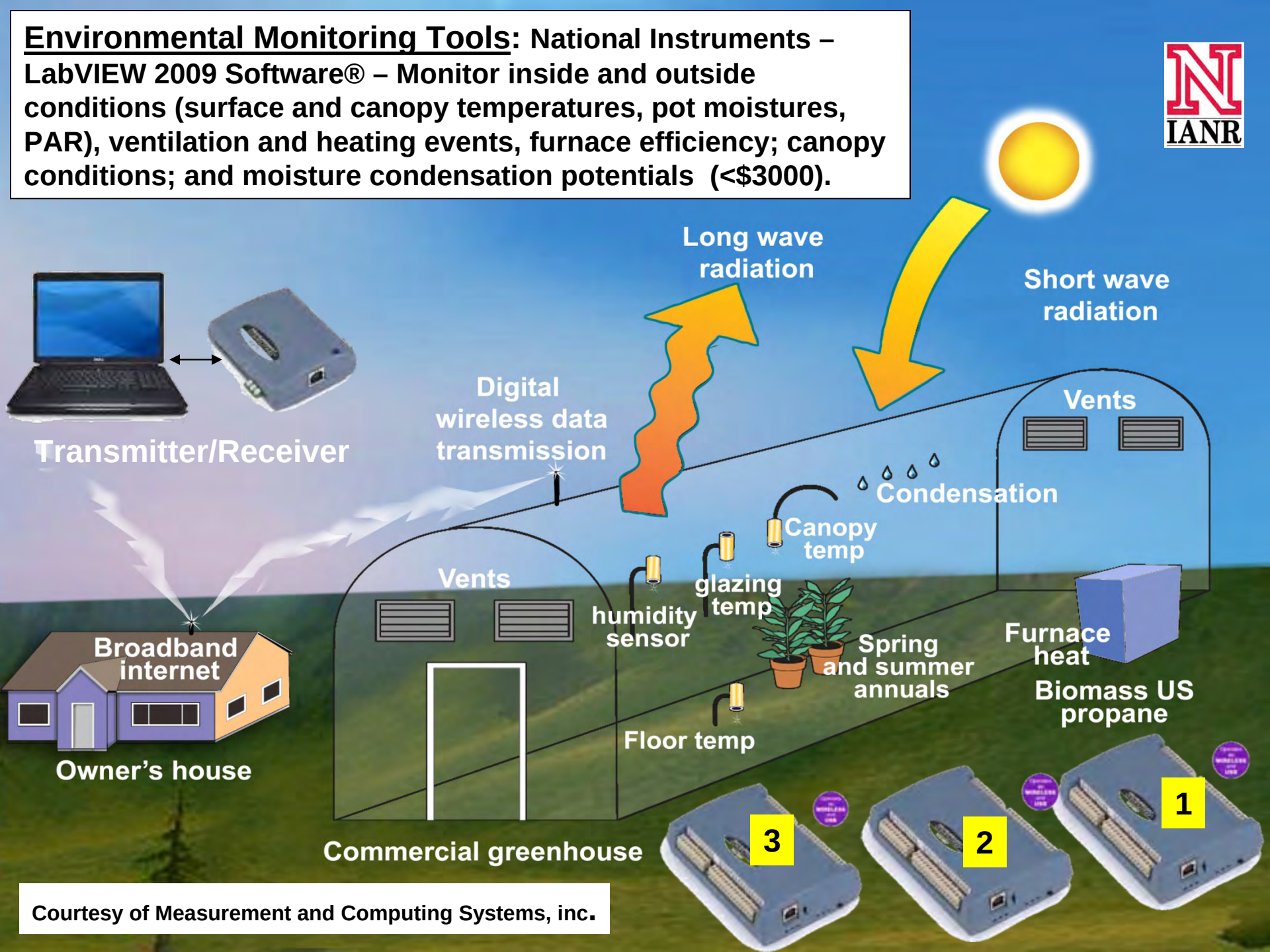
**Environmental Monitoring Tools**: National Instruments – LabVIEW 2009 Software® – Monitor inside and outside conditions (surface and canopy temperatures, pot moistures, PAR), ventilation and heating events, furnace efficiency; canopy conditions; and moisture condensation potentials (<$3000).




Courtesy of Measurement and Computing Systems, inc.


**Courtesy: LabJack, inc**.

**Courtesy: Licor, inc**.

**Courtesy: Mikron Systems, inc**.

**GC Pyranometer**


**Courtesy: Measurement and Computing, inc**.

**Courtesy: Omega, inc**.

# Non-Intrusive monitoring of the operational events for fertigation (Cap-Mat™), heating, and cooling systems (split-core sensors).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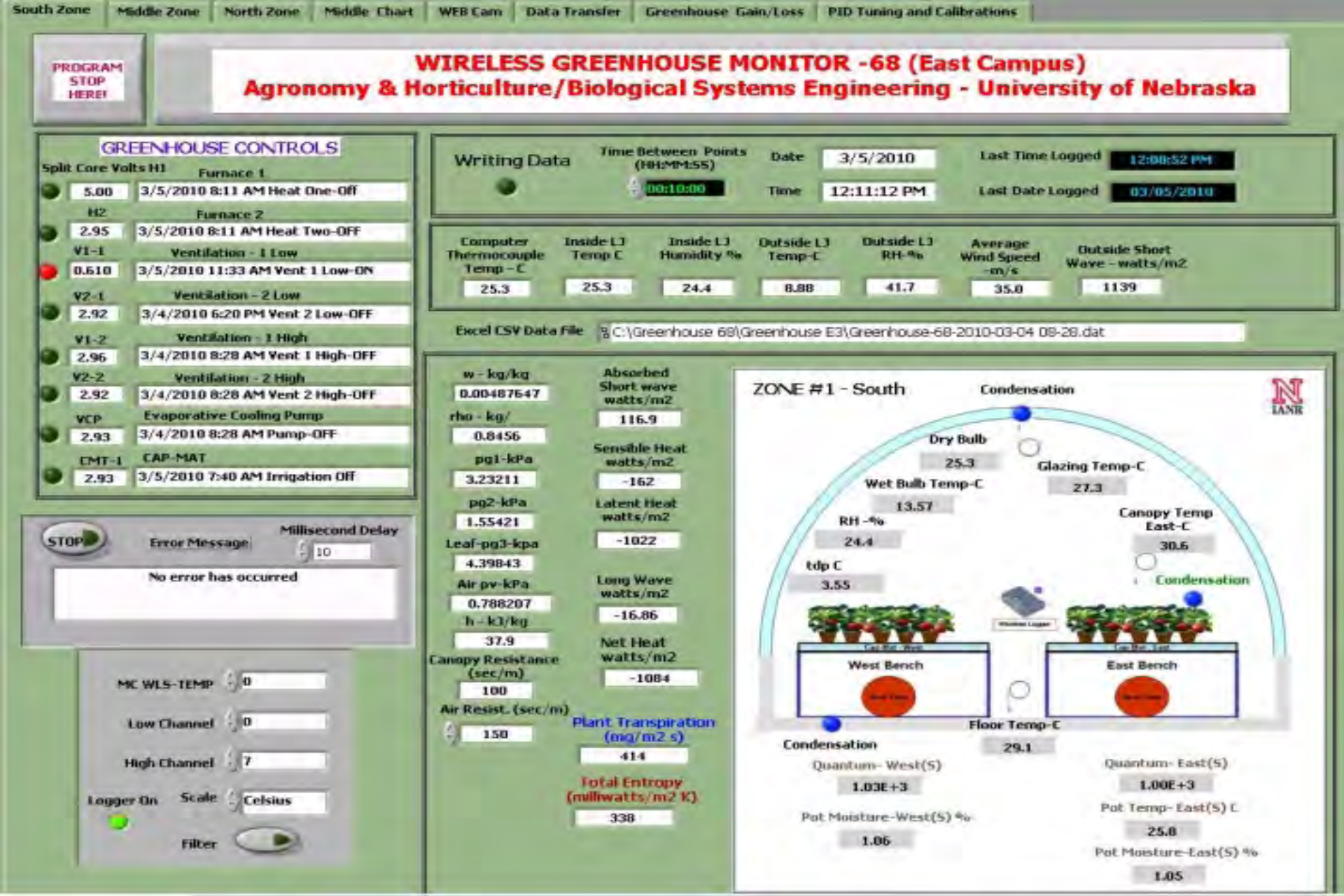


Non-intrusive “split-core” sensing of environmental control events are logged as time and events as they occur. Tells us about energy usage.

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Favorites Center (Alt+C)
View favorites, feeds, and history

Go to -- Select one --

Pan speed 0

Tilt speed 0

Pan Stop Patrol

Digital Output

ON OFF

Snapshot

Client Settings

## Greenhouse-IPCAM

(HTTP-V) 2010/03/05 12:26:03 PM

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- Csizinszky , A.A., D.J. Schuster, and J.B. Kring, 1995. Color Mulches Influence Yield and Insect Pest Populations in Tomatoes. J. Amer. Soc. Hort. Sci. 120(5):778-784.

- Decoteau, D.R., M.J. Kasperbauer, and P.G. Hunt, 1989. Mulch Surface Color Affects Yield of Fresh-market Tomatoes. J. Amer. Soc. Hort. Sci. 114(2):216-219.


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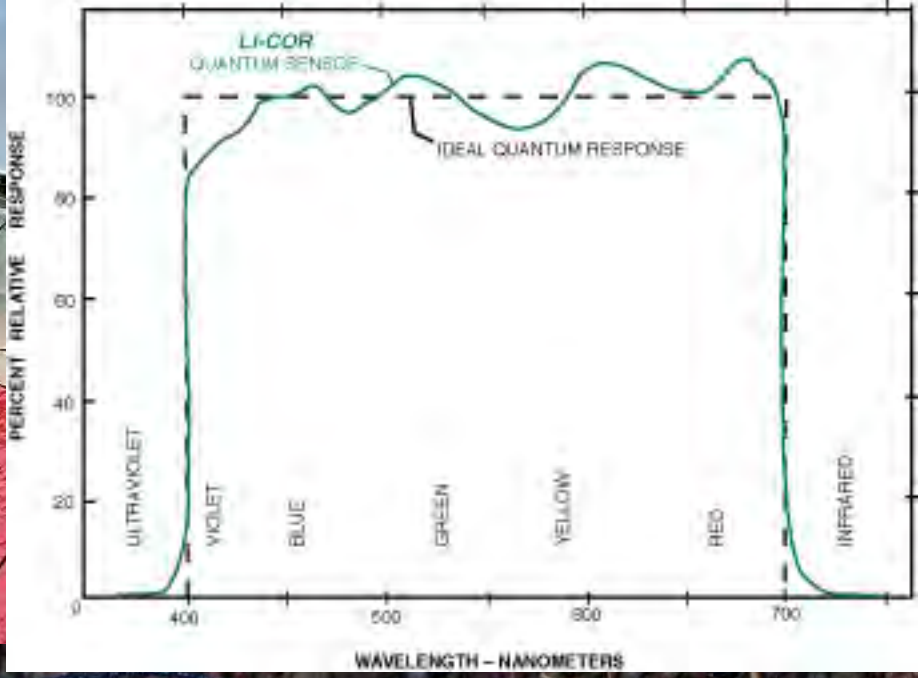
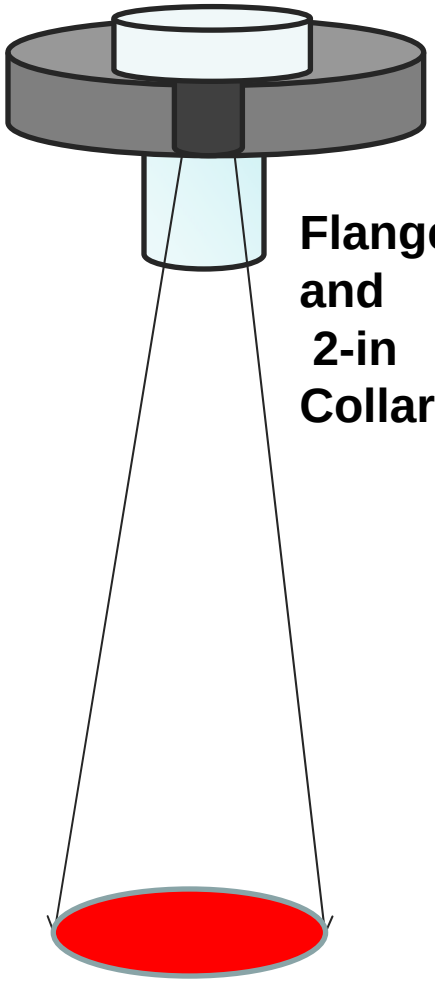




LiCor Biosciences.Technical Note #126. 2009. Comparison of Quantum Sensors with Different Spectral  Sensitivities.

## LiCor PAR Cell (Pointing Down)




Spot Area ( 1 $m^2$)

**Cell normally views hemispherically. So, we want only what is reflected by the plastic back up to the canopy.**

**Some is transmitted and retained as soil heat.**

South Zone | Middle Zone | North Zone | South Chart | Mulch Plots | WEB Cam | Data Transfer | Greenhouse Gain/Loss | PID Tuning | Crop Scales Data

# REFECTIVE MULCH PLOTS

NORTH END

Turn Mulch Logger On

PAR-5 MEAN: 503.522
PAR-5 STD: 0.906815
PAR-7 MEAN: 597.696
PAR-7 STD: 0.498467

MC WLS-TEMP: 4
Low Channel: 0
High Channel: 7
Scale: Celsius
Filter

Error Message: No error has occurred

Sample Size: 20

| | Soil Temp (1)-C | Soil Temp (2)-C | Soil Temp (3)-C | Soil Temp (4)-C | Soil Temp (5)-C | Soil Temp (6)-C |
|---|---|---|---|---|---|---|
| | 25.7 | 21.2 | 18.4 | 18.7 | 23.4 | 18.3 |
| | PAR4 Mean: 6.358 | PAR-0 Mean: 57.1 | PAR-2 Mean: 13.30 | PAR-3 Mean: 56.175 | PAR-6 Mean: 16.0455 | PAR-1 Mean: 55.8264 |
| | PAR4 STD: 2.23 | PAR-0 STD: 0.5614 | PAR-2 STD: 0.6198 | PAR-3 STD: 0.5657 | PAR-6 STD: 5.358 | PAR-1 STD: 1.294 |
| | Reflection Coeff.-1: 0.01155 | Reflection Coeff.-2: 0.104 | Reflection Coeff.- 3: 0.0242 | Reflection Coeff.4: 0.102 | Reflection Coeff.-5: 0.0291 | Reflection Coeff.-6: 0.101 |

| | | | |
|---|---|---|---|
| SL-0 | 330 | PAR-0: 56.8935 | Q37746 |
| SL-1 | 330 | PAR-1: 56.1559 | Q41462 |
| SL-2 | 330 | PAR-2: 12.5391 | Q41461 |
| SL-3 | 330 | PAR-3: 56.1554 | Q41460 |
| SA-4 | 460 | PAR4: 8.77384 | Q40644 |
| SA-5 | 460 | PAR-5: 505.867 | Q40643 |
| SA-6 | 390 | PAR-6: 9.64707 | Q40642 |
| SL-7 | 340 | PAR-7: 597.788 | Q37747 |

| | |
|---|---|
| Plot 0 | 57.14 |
| Plot 1 | 55.83 |
| Plot 2 | 13.30 |
| Plot 3 | 56.18 |
| Plot 4 | 6.36 |
| Plot 5 | 503.52 |
| Plot 6 | 16.05 |
| Plot 7 | 597.70 |


| | |
|---|---|
| Plot 0 | 18.27 |
| Plot 1 | 23.36 |
| Plot 2 | 18.66 |
| Plot 3 | 18.42 |
| Plot 4 | 21.25 |
| Plot 5 | 25.66 |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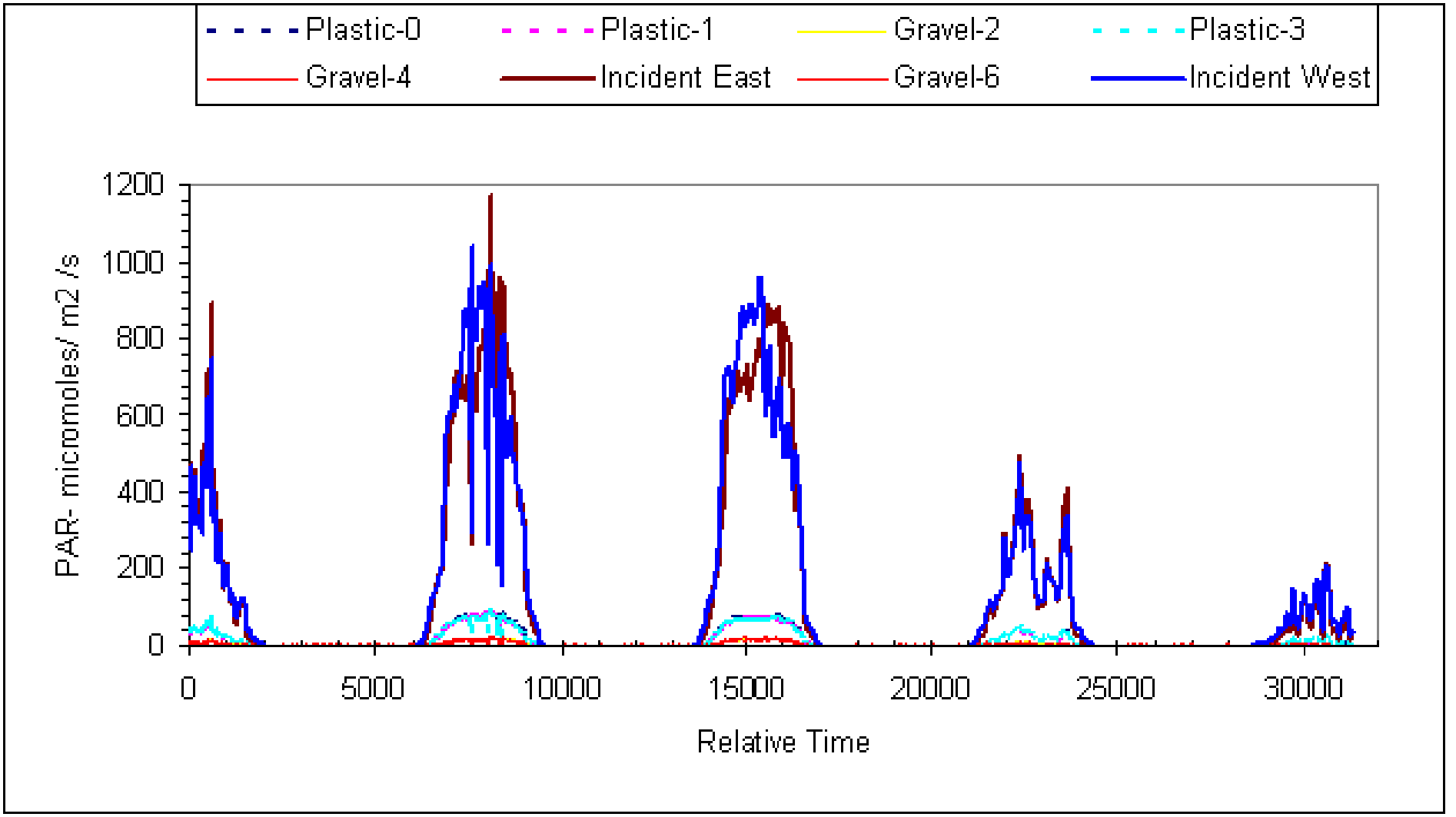


6-mil white plastic mulch

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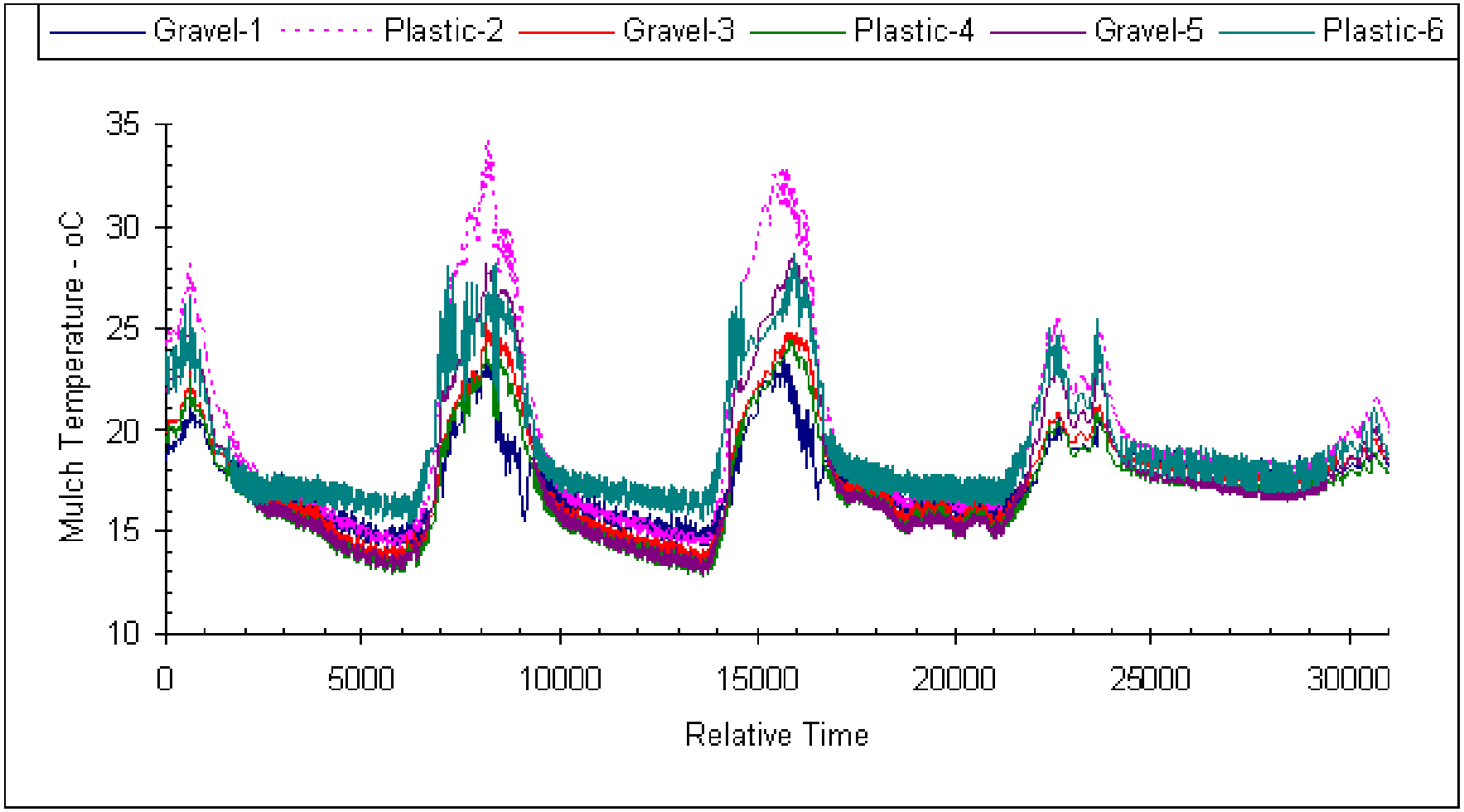


6-mil white plastic mulch

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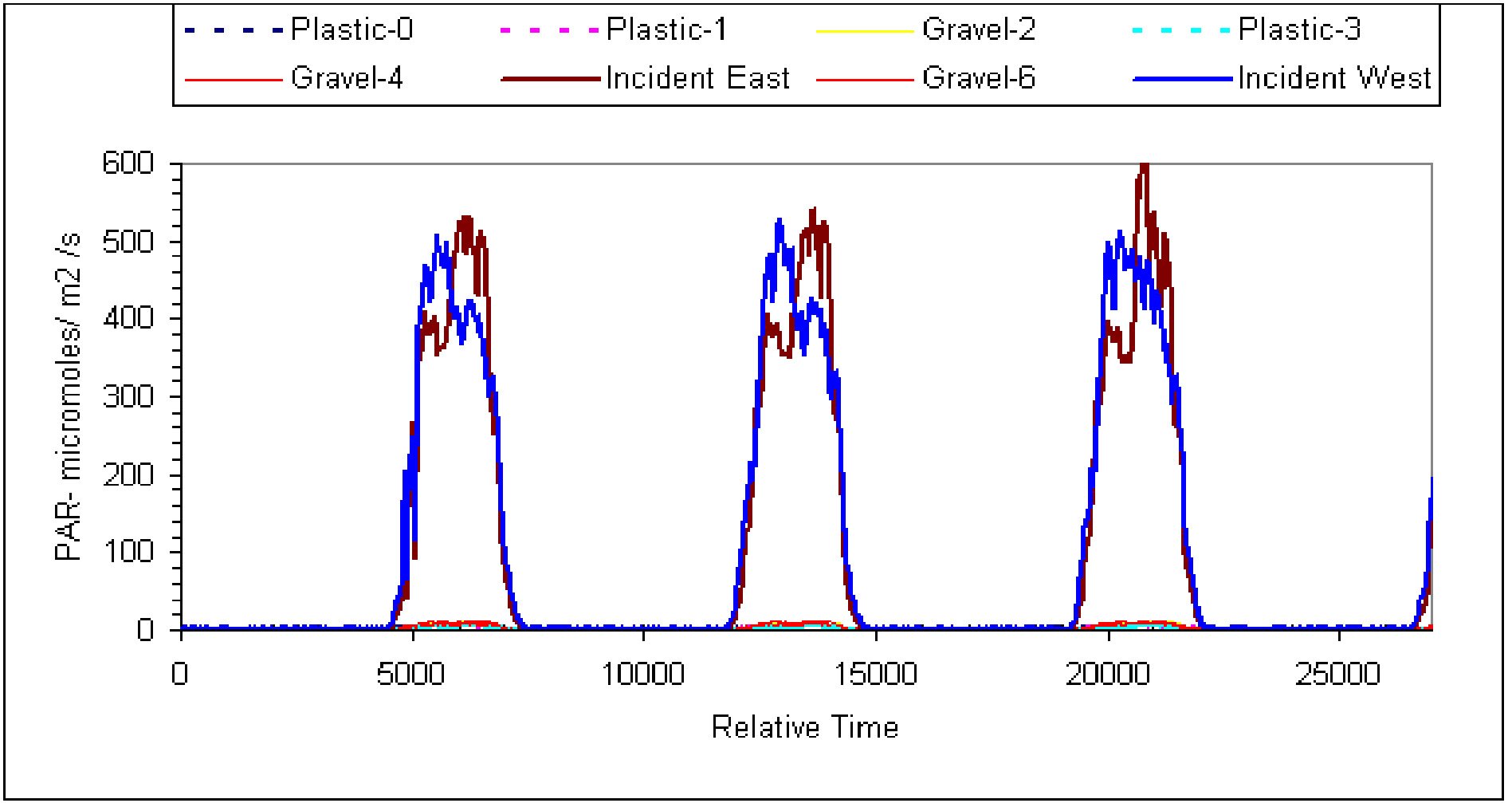


6-mil red plastic mulch

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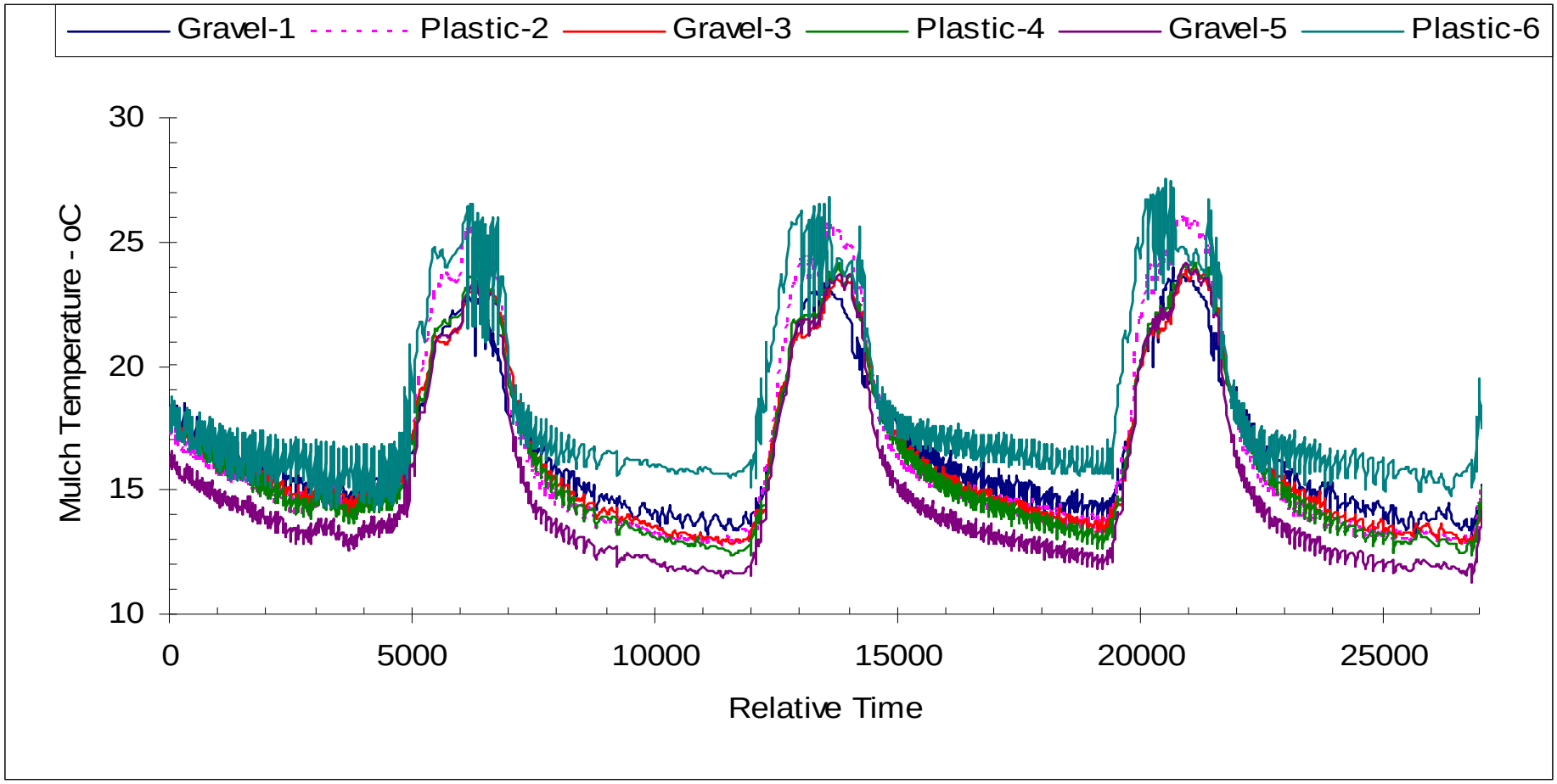
Gravel-1
Plastic-2
Gravel-3
Plastic-4
Gravel-5
Plastic-6
Mulch Temperature - oC
30
25
20
15
10
0
5000
10000
15000
20000
25000
Relative Time

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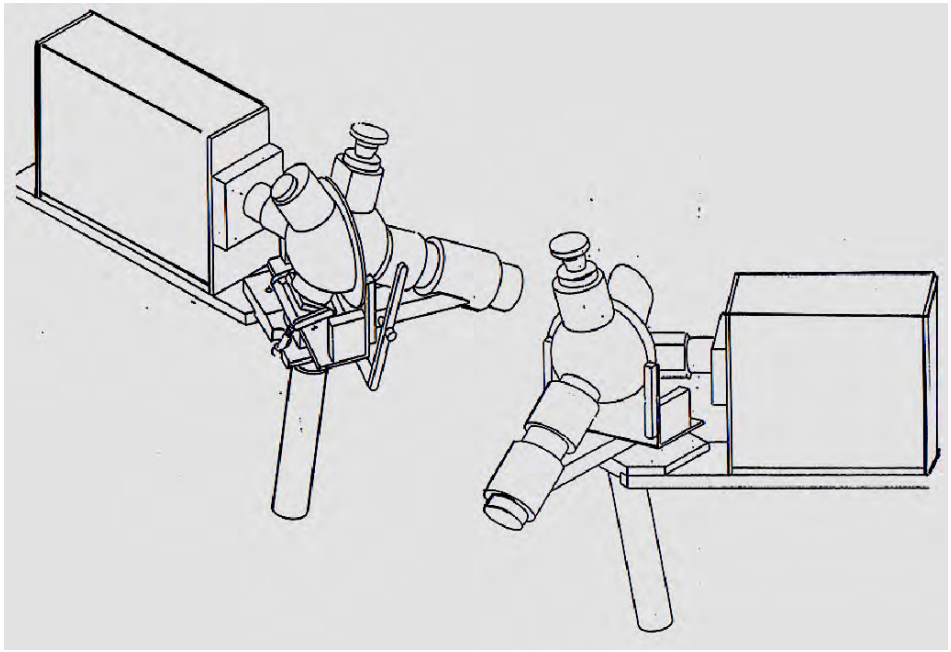

Spectron SE 590 Diffraction Grating Spectoradiometer and LiCor Integrating Sphere (courtesy: Elizabeth Walter-Shea, School of Natural Resources).

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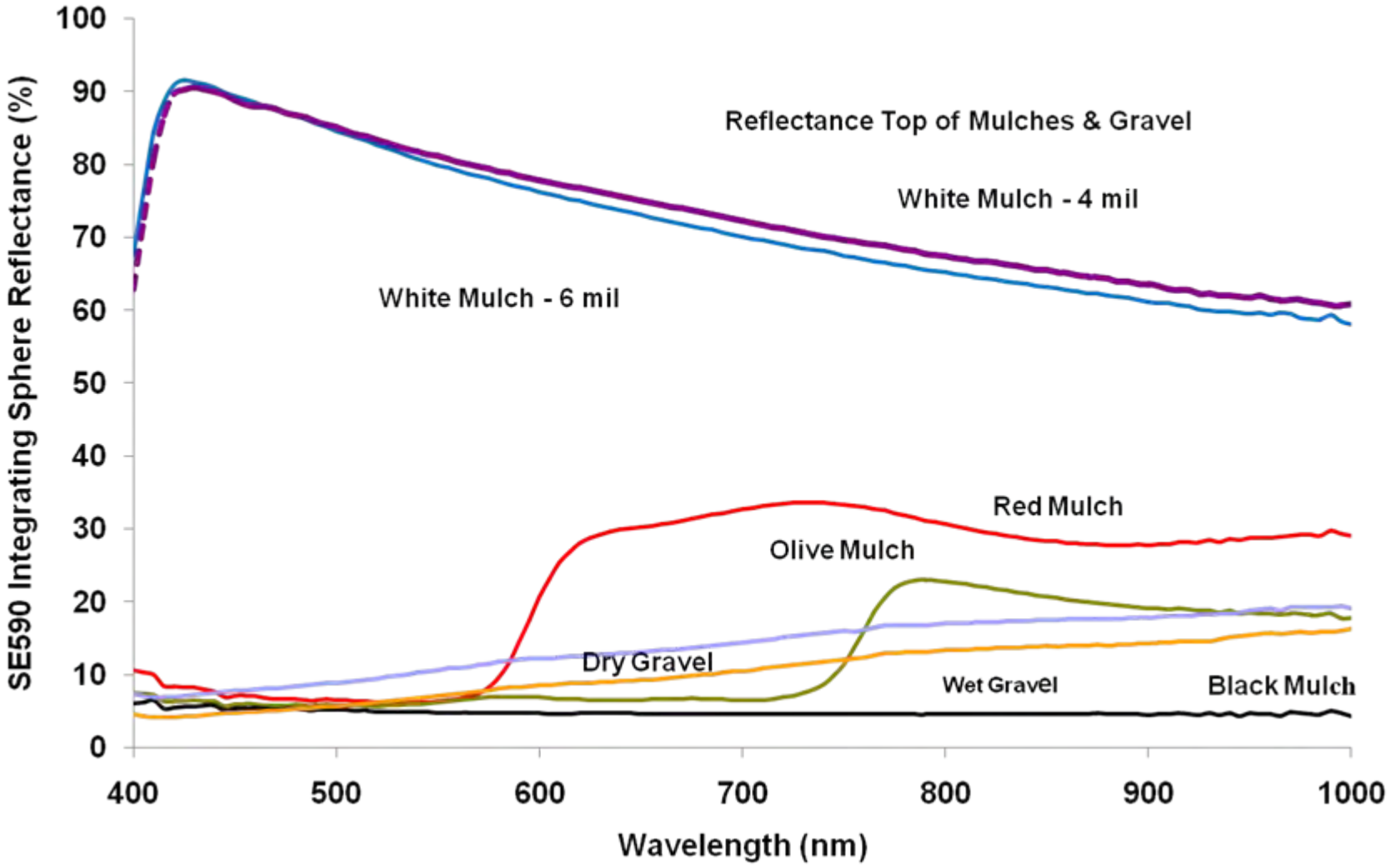
Reflectance Top of Mulches & Gravel
White Mulch - 4 mil
White Mulch - 6 mil
Red Mulch
Olive Mulch
Dry Gravel
Wet Gravel
Black Mulch
SE590 Integrating Sphere Reflectance (%)
Wavelength (nm)
100
90
80
70
60
50
40
30
20
10
0
400
500
600
700
800
900
1000

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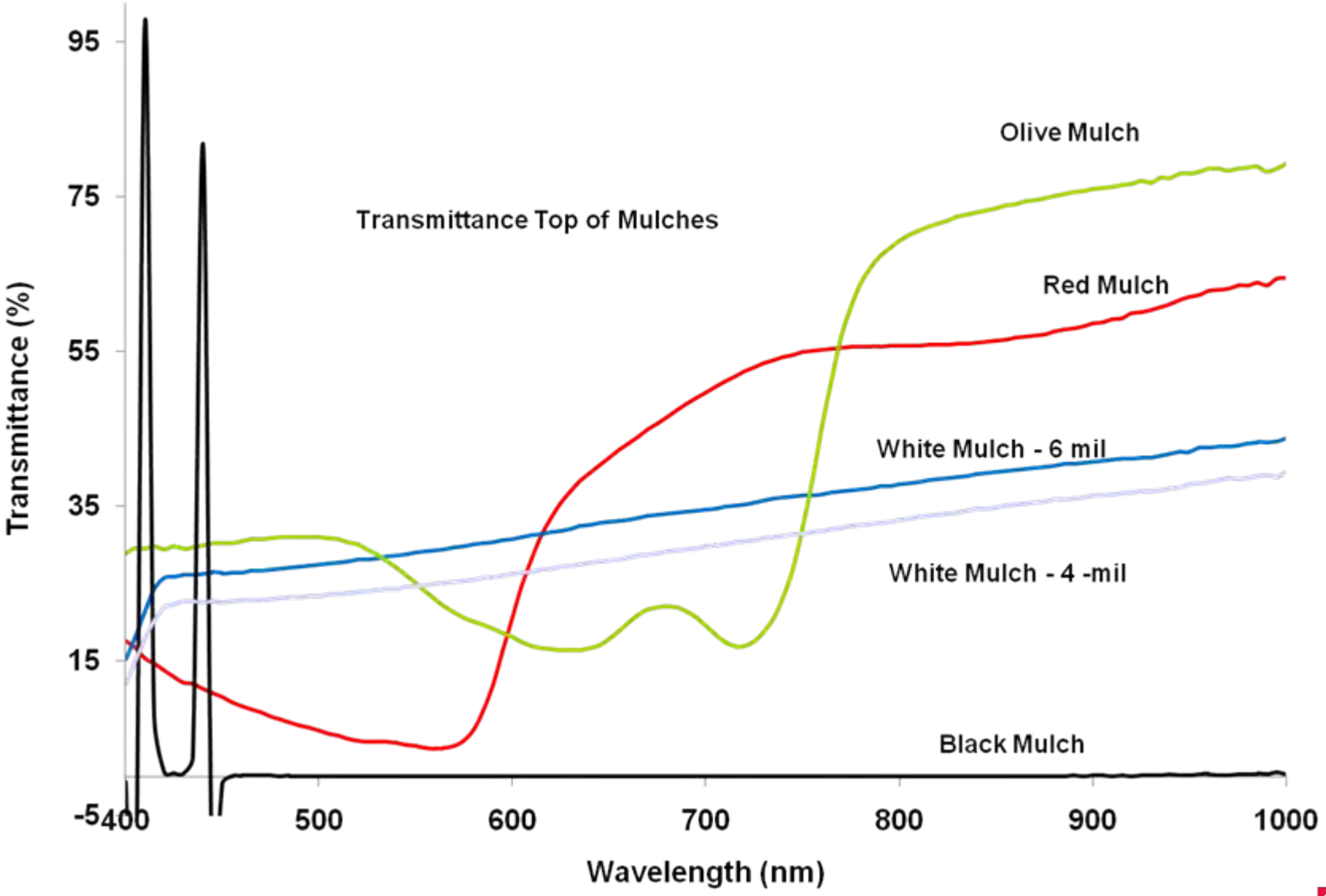
Transmittance Top of Mulches
Olive Mulch
Red Mulch
White Mulch - 6 mil
White Mulch - 4 -mil
Black Mulch
Transmittance (%)
95
75
55
35
15
-5
400
500
600
700
800
900
1000
Wavelength (nm)

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Using white reflective mulch in a greenhouse strawberry cultivar trial Winter 2009-2010. Start with CapMAT™.
CapMat's feed plants through capillary action at the bottom of the pot
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Plastic mulch hole cutter for 6-inch pot insertion

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**Decagon EC-5 Capacitance Sensor**

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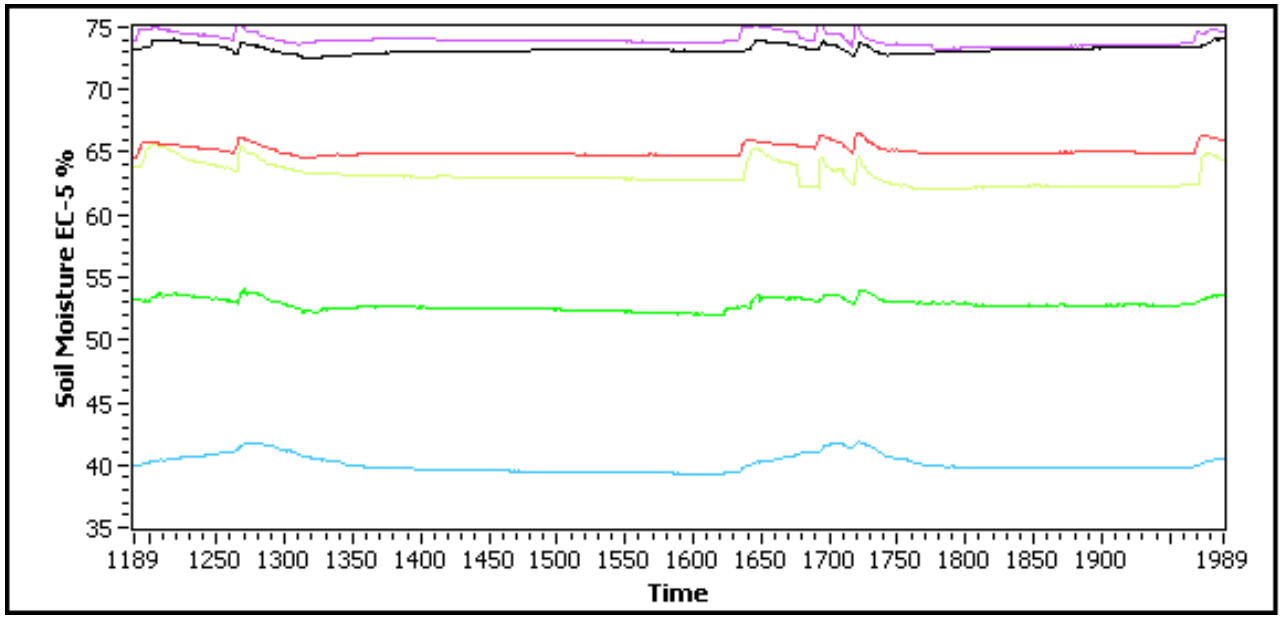


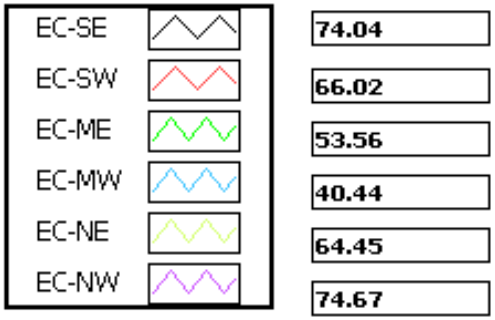


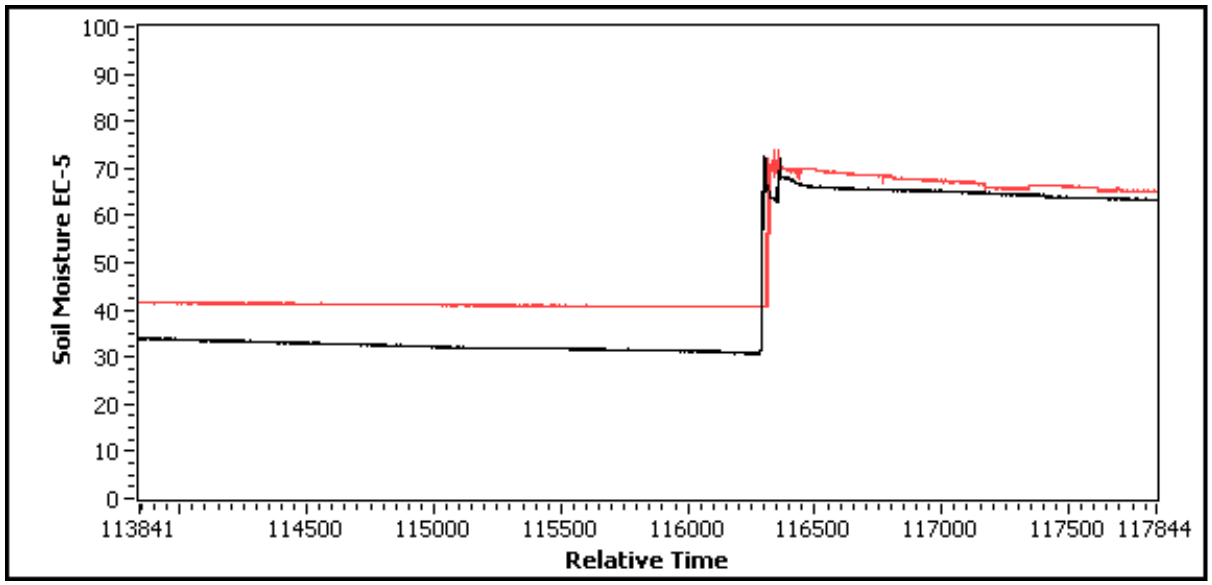


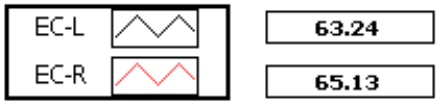


Sensors are very responsive

60-65% Volumetric
Full Moisture Capacity

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Hive

Greenhouse bee

# Pollination


250 Plants, 14 Cultivars, over 4000 berries
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Spider mite and thrip issues.
Algae grows between the layers.

# Observation Summary

**The white poly (4 mil) had the best PAR reflectance performance and was selected as the film and covering for the follow-up CapMAT strawberry variety trial.**

**This second phase included growing strawberry plants on the capillary mats. During this phase, the strawberry plants performed well by producing numerous flowers and fruit. This latter study showed that pots could be kept moist and that the mulch reduced evaporative loses from the fabric.**

**The only problem noted was that some light penetrated the while polyethylene mulch and allowed algal growth on the CapMAT fabric. This greenhouse study was successful and will continue.**

**The neutraceutical value study of the strawberries is currently under way (from frozen strawberries)**

**The study will continue for a second year starting this fall with fresh plants.**

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Paparozzi, E.T., S. Adams, G.E. Meyer, M. E. Conley, V. Schlegel, E. Blankenship and
P.E. Read, 2010. Selecting Strawberry Cultivars for Winter Greenhouse Production. American Society for Horticultural Science Annual Meeting. Palm Desert, CA, HortScience, in press.