Reflective Mulches Influence Plant Survival, Production, and Insect Control in Fall Tomatoes

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Abstract. Aluminum mulches lowered soil temperatures and reduced heat stress for young tomato transplants, increasing their survival and height. Yields were improved in all mulch treatments. Greatest yields of large and extra-large fruits were obtained from plants grown on aluminum alone, on aluminum in combination with black plastic, and on black plastic alone. Aphids were repelled by the aluminum mulches, while fruit injury increased due to tomato pinworm and tomato fruitworm feeding in these plots.

In South Carolina, black, aluminum, and white polyethylene mulches and aluminum on paper backing increased the yield and early fruit set of spring-grown tomatoes (8). Black and transparent polyethylene mulches have been shown to increase soil temperature, resulting in sweet corn yields earlier and higher than those from unmulched soil (5). Reflective mulches also reduced the incidence of aphid-born viruses and deterred such pests as aphids, thrips, leaf miners, and Diabrotica sp. on field, ornamental, and vegetable crops (1–4, 6–8). The purpose of this work was to determine the biological effect of different mulches on fall-grown tomatoes.

These tests were conducted during a 3-year period on Edisto Glossaquic Hapludalfs with loamy sand. Each plot consisted of three mulched rows 7.3 m long and spaced 2 m apart. Mulches were applied shortly before planting by machine. The control in all tests was bare ground (no mulch). Each row contained 12 plants of the cultivar Tempo spaced 61 cm apart. Only the center row of a plot was used for growth and yield data. Soil temperatures were recorded (YSI Model 42SC Tele Thermometer) daily at mid-day (2:00 pm) from the surface (directly under the mulches or on bare ground) and at 7-cm depths for each treatment. Fruit quality was classified by using U.S. standards for grades of fresh tomatoes and consisted of extra large (XL), large (L), medium (M), small (S), and extra small (ES) (9). Plant vigor consisted of 9 categories, where 1 was highest and 9 poorest. The experimental design was a randomized complete block with four replications in all tests. Means were separated using Duncan’s multiple range test at the 0.05% level and correlations were run at the 0.05% level.

The first test (Test I) was designed to determine seedling survival (percentage of stand), growth (height in centimeters), and plant vigor when grown on different mulches. Plants were transplanted 3 Aug. 1979 and data taken on 8 and 16 Aug. Yield and insect data were not recorded in this experiment. The mulches used were aluminum, aluminumized plastic, black plastic, and the control (bare ground).

Test II plants were transplanted on 8 Aug. 1981. Data were taken on percentage of stand, height, fruit quality and maturity, insect defecacy, and fruit damage caused by insect feeding. Yellow pan traps (25 cm in diameter, 8 cm in height, one per center row) containing water were used to attract insects to the different treatments. Mulch treatments were aluminum over black plastic, aluminum, black plastic, and the control. The aluminum covering the black plastic was removed on 22 Sept. when soil temperatures were about 33°C. This procedure permitted the reflective aluminum mulch during the warmer periods to reduce soil temperatures and the black plastic during the cooler periods to increase soil temperatures.

Test III plants were transplanted 2 Aug. 1982 and data were recorded similar to Test II. The mulch treatments and aphid traps were the same as in Test II; however, the aluminum over black plastic was removed on 9 Sept. when soil surface temperatures were about 28°C.

In Test I, surface and soil temperatures were highest under black plastic and the control (Table 1), significantly reducing plant stand and height and decreasing plant vigor in these treatments (Table 2). Comparatively lower temperatures of the reflective mulches were associated with higher survival, taller plants, and greater plant vigor ($r = -0.931^*$, $r = -0.896^*$, and $r = 0.967^*$, respectively).

In Test II, the mean seasonal surface temperatures were 2.4°C lower in the controls than the previous experiment (Table 1). Plant survival between treatments did not differ significantly. Plant height was best in all mulch treatments for August. In September, plant height was best for aluminum plus black plastic, aluminum, and black plastic alone. Aluminum plus black plastic and black plastic alone did not differ from the control in October for plant height (Table 3). Very few aphids were collected from the aluminum plus black plastic and aluminum treatments. There were no differences between treatments for fruit injury caused by the southern green stink bug [Nezara viridula (Linneaus)] (SGSB), tomato pinworm [Keferia lycopersicella (Walsingham)] (TPW), and tomato fruitworm [Heliothis zea (Boddie)] (TFW). Generally increased yields of XL and L fruits were obtained from aluminum plus black plastic and aluminum alone on 20 Oct. (15 and 18 and 4 and 6 mean kg/plot, respectively). Black plastic and the control yields were reduced (11 and 5 and 4 and 2 mean kg/plot, respectively). No differences between treatments were found for the remaining harvests (30 Oct., 4 Nov., and 13 Nov.). Generally, M, S, and ES fruit yields were harvested late in the season and were higher in the controls (13, 7, and 10 mean kg/plot, respectively) than in mulched plots. There was no difference between the mulch treatments. Total yields between treatments for all fruit sizes were not significant (aluminum plus black plastic, 78; aluminum, 74; black plastic, 71; and the control, 73 mean kg/plot).

In Test III, mean seasonal surface temperatures in the controls were 6.9°C lower than Test I and 4.5°C lower than Test II (Table 1). Plant survival was 100% and plant vigor rated 1 in all plots, resulting in no differences between treatments. Plant height was increased in the aluminum mulch plus black plastic and aluminum treatments (Table 4). Plants grown on the control plots were intermediate in height, while black plastic produced the shortest plants. The number of aphids collected from the aluminum treatment was significantly lower than from the control plots, while the aphid count from the black plastic plots was intermediate. Fruit injury by the SGSB was low and nonsignificant. The combined fruit injury by the
Table 1. Mean monthly mid-day (2:00 pm) temperatures of mulch and bare ground treatments planted with ‘Tempo’ tomatoes, Tests I, II, and III.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Soil surface</th>
<th>August</th>
<th>September</th>
<th>October</th>
<th>( \bar{X} )</th>
<th>July</th>
<th>August</th>
<th>September</th>
<th>October</th>
<th>( \bar{X} )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Black plastic</td>
<td>46.9</td>
<td>31.6</td>
<td>37.7</td>
<td>38.7</td>
<td>39.9</td>
<td>26.2</td>
<td>28.7</td>
<td>31.6</td>
<td>28.7</td>
</tr>
<tr>
<td></td>
<td>White plastic</td>
<td>39.6</td>
<td>27.9</td>
<td>31.3</td>
<td>32.9</td>
<td>34.5</td>
<td>25.9</td>
<td>25.7</td>
<td>28.7</td>
<td>25.7</td>
</tr>
<tr>
<td></td>
<td>Aluminum</td>
<td>38.5</td>
<td>28.2</td>
<td>30.0</td>
<td>32.2</td>
<td>33.4</td>
<td>24.9</td>
<td>25.3</td>
<td>27.9</td>
<td>27.9</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>41.0</td>
<td>28.9</td>
<td>32.3</td>
<td>34.1</td>
<td>34.8</td>
<td>25.9</td>
<td>24.9</td>
<td>28.5</td>
<td>28.5</td>
</tr>
</tbody>
</table>

**Treatment 28 Aug.**

- Aluminum mulch cover removed from black plastic on 22 Sept.
- Aluminum and black plastic on 9 Sept.

**Rating where 1 = highest and 9 = poorest vigor.**

- Mean separation in columns by Duncan’s multiple range test, \( P = 5\% \).

Table 2. The influence of reflective mulch (mean/plot) on plant survival, height, and vigor for fall-grown ‘Tempo’ tomatoes, Test I.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Stand (%)</th>
<th>Height (cm)</th>
<th>Plant vigor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum</td>
<td>99 a</td>
<td>21 a</td>
<td>2 c</td>
</tr>
<tr>
<td>Aluminized plastic</td>
<td>99 a</td>
<td>21 a</td>
<td>3 c</td>
</tr>
<tr>
<td>White plastic</td>
<td>91 a</td>
<td>21 a</td>
<td>4 b c</td>
</tr>
<tr>
<td>Black plastic</td>
<td>49 b</td>
<td>18 c</td>
<td>8 a</td>
</tr>
<tr>
<td>Control (no mulch)</td>
<td>67 b</td>
<td>19 c</td>
<td>6 ab</td>
</tr>
</tbody>
</table>

**Transplanted on 3 Aug. 1979. Data recorded on 8 and 16 Aug., respectively (12 plants/plot).**

Table 3. The influence of reflective mulch on (mean/plot) plant height and insect numbers to ‘Tempo’ tomatoes, Test II.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Height (cm)</th>
<th>No. aphids</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>28 Aug.</td>
<td>9 Sept.</td>
</tr>
<tr>
<td>Aluminum and black plastic</td>
<td>31 a</td>
<td>56 a</td>
</tr>
<tr>
<td>Aluminum</td>
<td>30 a</td>
<td>55 ab</td>
</tr>
<tr>
<td>Black plastic</td>
<td>31 a</td>
<td>59 a</td>
</tr>
<tr>
<td>Control (no mulch)</td>
<td>24 b</td>
<td>49 b</td>
</tr>
</tbody>
</table>

**Mean aphids collected from single yellow pan traps per plot on 2, 4, and 9 Sept. 1981.**

Table 4. The influence of reflective mulch (mean/plot) on plant height, insect numbers, and insect damage to ‘Tempo’ tomatoes, Test III.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Height (cm)</th>
<th>No. aphids</th>
<th>Fruit damage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>TFW and TPW</td>
</tr>
<tr>
<td>Aluminum and black plastic</td>
<td>54 a</td>
<td>8 bc</td>
<td>23 a</td>
</tr>
<tr>
<td>Aluminum</td>
<td>53 a</td>
<td>1 c</td>
<td>25 a</td>
</tr>
<tr>
<td>Black plastic</td>
<td>46 c</td>
<td>11 b</td>
<td>16 b</td>
</tr>
<tr>
<td>Control (no mulch)</td>
<td>50 b</td>
<td>31 a</td>
<td>17 b</td>
</tr>
</tbody>
</table>

**Recorded 9 Sept. 1982.**

- The combined fruit damage (over total fruits produced) caused by the tomato fruitworm (TFW) (Heliothis zea Boddie) and tomato pinworm (Keiferia cypersicella (Walsingham)).
- Aluminum mulch cover removed exposing black plastic mulch on 9 Sept.
- Mean separation in columns by Duncan’s multiple range test, \( P = 5\% \).
Improved the photosynthetic efficiency of many crop plants has been pursued. Some of the methods used have included genetic selection, 2, and environmental manipulation, 4. Breeding for plants having leaves with erect angles of elevation to absorb sunlight more effectively and CO₂ enrichment of plant environment are good examples, 4, 10.

The heavy foliage cover formed by the vining habit of the fresh-market cucumber restricts light penetration to lower leaves. However, the cucumber canopy can be efficient in absorption of sunlight if the plants are positioned properly. The dense vining canopy also restricts air movement and promotes humid conditions favorable for the growth of fruit rot organisms. Even when plant populations are low, the dense canopy and vining habit prevents effective fungicide application and results in more bellyrots. This disease is caused mostly by Rizoctonia solani and is known to be a severe deterrent to cucumber production in southern states. 7, 8.

Most of the new cucumber cultivars used for commercial production are gynoecious hybrids. Many of the female flowers produced by these cultivars abort, and others set fruit but do not develop into marketable size. One way to improve marketable yield of these cultivars would be to increase net photosynthesis within the cucumber plant to increase assimilates for developing fruits; another would be to reduce the incidence of fruit rot.

It has been reported that trellising cucumber can improve yield and quality, 1, 3. Konsler and Strider (3) found that trellising aided fruit and disease control in two cucumber cultivars. They also suggested improved photosynthetic efficiency as one of the reasons for increased yield, but no evidence was provided. We, therefore, initiated this study to 1) evaluate the yield response of a wide range of cucumber germplasm to vertical training, 2) investigate the indirect evidence of the relationship between improved photosynthesis and productivity in vertically trained cucumber plants, 3) evaluate the effects of in-row spacing of plants on yield and quality, and 4) determine if supplemental foliar fertilization with N-P-K would increase yield.

Twelve and 13 cucumber cultivars (Table 1) were planted in June 1982 and 1983, respectively. Two cultural methods were used—staked vs. unstaked treatments. Experimental design was 12 x 2 and 13 x 2 (cultivar x cultural method) factorial arranged in a randomized complete block with three and four replications, respectively. In the staked treatments, the main stem of the plant was tied to a 1.8-m x 1.6-m reinforcing bar with cloth ties. No pruning was done. In the unstaked treatments, plants were left to vine on the ground. Plot size was 4.5 x 3 m, and plants were spaced 30 cm apart within the row. Wide spacing (3 m) between rows was used to prevent shading of the unstaked treatments. Fertilizer was applied preplant broadcast and disked in at rates of 75N–32P–60K (kg·ha⁻¹). At that time, S(O, O-disopropyl phosphorodithioate) ester of N-(2-mercaptoethyl) benzenesulfonamide (bensulide) was incorporated at a rate of 5.6 kg·ha⁻¹. Postplant fertilizer consisted of N at 38 kg·ha⁻¹ applied as a sidedress when plants began to run. In the 1983 test, 10 female flowers selected at random from each treatment were tagged at the time of anthesis, and fruit set was recorded at harvest.

In Fall 1983, "Dasher II" cucumber was planted in a 2 x 2 x 2 factorial experiment arranged in a randomized complete block with