Row Cover Effects on Air and Soil Temperatures and Yield of Muskmelon

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Abstract. Three row covers (spunbonded polyester, double-slitted, and perforated polyethylene) used in combination with clear polyethylene mulch and trickle irrigation for muskmelon (Cucumis melo L.) production in 1985 and 1986, increased soil (5-cm depth) minimum and maximum temperatures and air (15-cm height) maximum temperatures compared to clear mulch alone. Increased minimum air temperatures resulted from the use of all row covers in 1985. All row covers enhanced earliness in both years. However, in 1985, there were no total marketable yield differences; in 1986, total marketable yield was greater with the spunbonded and double-slitted row covers than with the no row cover treatment. Within row cover treatment, the use of the perforated row cover in 1986 resulted in lower total marketable yields than with the spunbonded row cover. Excessive air temperatures with the perforated row cover may have resulted in reduced marketable yield. Lower minimum air temperatures in 1986 may have resulted in lower yields than in 1985.

The use of clear polyethylene mulch frequently promotes yield increases in comparison to crops grown with black polyethylene mulch, especially in northern regions (Downes, 1966; Hopen, 1965; Pollack et al., 1969). In addition to polyethylene mulches, row covers or row tunnels have been used increasingly in crop production systems in the northeastern (Wells and Loy, 1985) and western United States (Hemphill and Mansour, 1986; Shadbolt and McCoy, 1960). The environmental factors modified by row covers include: light, soil and air temperature, humidity, and air movement (Hull, 1971; Shadbolt and McCoy, 1960). Row covers are reported to increase early and total yield of muskmelons in New Hampshire (Loy and Wells, 1982) and Oregon (Hemphill and Mansour, 1986).

Previous research in North Carolina evaluated polyethylene mulches and slitted row covers for muskmelon production (Bonanno and Lamont, 1987). Black and clear polyethylene mulch increased early yields 2 years and increased total yields 1 out of 2 years. The use of double-slitted row covers increased early muskmelon yield 2 years, with total marketable yield unaffected.

This study is a continuation of previous research in North Carolina (Bonanno and Lamont, 1987). The objectives were to determine the effects of three row covers on temperatures, earliness, and total yield of muskmelons grown with polyethylene mulch in the southeast coastal plain of the United States.

The study was conducted in 1985 and 1986 at the Central Crops Research Station, Clayton, N.C., on a Norfolk loamy sand (Typic paludands-fine-loamy, siliceous, thermic) with pH 5.7 and 0.4% humic matter.

‘Magnum 45’ muskmelons were seeded in 3-cm square plastic cell trays containing Metro mix 350 growing medium (W.R. Grace & Co., Cambridge, Mass.) and placed in a greenhouse for 25 and 27 days in 1985 and 1986, respectively. Clear polyethylene mulch was installed on 25 Apr. 1985 and 24 Apr. 1986 with trickle irrigation biwall tubing placed at a 2-cm depth and 8 cm off center of raised beds 8 cm high × 76 cm wide. Muskmelon transplants were hand-transplanted 4 days after laying mulch; the row cover treatments were applied the same day. Single-row plots, 6.1 m long × 1.5 m wide, were used. In-row plant spacing was 40 cm, with a resultant plant population of 16,667 ha. Fertilizer (136N–34P–13K, kg·ha⁻¹) was incorporated before planting. Plots were irrigated using a low-pressure trickle irrigation system when soil water potential measured with tensionometers reached −0.25 kPa.

The row cover treatments were spunbonded polyester (Reemay, Du Pont), double-slitted clear polyethylene (Ken-Bar, Inc., Reading, Mass.), perforated clear polyethylene (Agiplast-Leco, Ellenton, Fla.), and a no row cover (control). All row cover materials were suspended on wire hoops 38 cm over the mulched bed. Reemay was suspended on wire hoops and not used as a floating row cover to eliminate variability from potential plant abrasion (Wells and Loy, 1985). The row covers were left on until the first female flower opened; i.e., 18 days in 1985 and 21 days in 1986. A randomized complete block design with four replications was used.

In 1985, soil and air temperatures were measured twice daily on the same plots, at 07:00 and 15:00 hr, for 17 days after transplanting. These times of day correspond to the minimum and maximum identified earlier (Bonanno and Lamont, 1987). Temperatures were measured using a digital handheld thermometer (Cole Palmer Instrument Co., Chicago). In 1986, temperatures were measured for 13 days after transplanting using shielded copper–constantan thermocouples and recorded hourly on a CR 21-X micrologger (Campbell Scientific Inc., Logan, Utah). Soil temperatures were measured at a depth of 5 cm under the polyethylene mulch in the center of the bed and air temperatures were measured at a height of 15 cm above the polyethylene mulch. Two replications were used.

Muskmelons were harvested semiweekly at the half-slip stage for a total of 10 harvests. The first harvest in 1985 was 25 June (37 days after transplanting) and in 1986 the first harvest was on 27 June (60 days after transplanting). Fruit weighing <0.8 kg and those that were misshapen were considered culls. Weight and number were recorded for both marketable and cull fruit.
Table 1. Influence of row covers on average air and soil temperatures.2

<table>
<thead>
<tr>
<th>Row cover treatment</th>
<th>Air temp (°C)</th>
<th>Soil temp (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perforated</td>
<td>17.5</td>
<td>20.8</td>
</tr>
<tr>
<td>Double-slitted</td>
<td>17.2</td>
<td>20.2</td>
</tr>
<tr>
<td>Spunbonded polyester</td>
<td>17.4</td>
<td>20.7</td>
</tr>
<tr>
<td>No row cover</td>
<td>17.2</td>
<td>18.9</td>
</tr>
</tbody>
</table>

LSD* 4, 0.2, 0.4, 0.7

*Early yields = harvests 1, 2, and 3.
*Two-row cover, five-centimeter height.
*Five-centimeter depth.
*Mean separation by LSD at P = 0.05.

In both years, the maximum air temperatures were higher with all row covers than with no row cover (Table 1). In a comparison of row cover materials, perforation resulted in the highest maximum air temperatures both years and spunbonded polyester in the lowest. Minimum air temperatures among row covers differed by 0.2°C or less, and averaged ±0.3°C higher than the controls. Also, the average maximum air temperatures for the control treatment were similar in both years (Table 1).

Average minimum and soil temperatures were higher in all row cover treatments than in the non-row covered controls in both years (Table 1). In 1985, use of the perforated row cover produced the highest minimum and maximum soil temperatures. In 1986, use of perforated row covers increased maximum soil temperature over all other row cover treatments. Use of spunbonded polyester resulted in the lowest minimum soil temperatures of all row covers both years.

Use of row covers did not increase total marketable yield in 1985 (Table 2). In 1986, total marketable yields, from the use of spunbonded polyester and double-slitted row covers, were greater than for the no row cover treatment. Among row cover treatments, marketable yields in 1986 from the spunbonded polyester treatment were greater than with the perforated row cover treatment.

Percent culls by number and weight were equal for all row cover treatments in 1985 and 1986, but there were more culls in 1985 than in 1986 (data not shown). Mean fruit weight of marketable melons was greater for all row cover treatments in 1985 (Table 2); however, mean marketable fruit weight was less for the perforated row cover treatment in comparison to all other treatments in 1986. This decreased total marketable yield and weight per fruit resulting from the use of the perforated row cover compared to the spunbonded polyester row cover in 1986 may be attributed to excessively high air temperatures (Table 1).

A general temperature guideline for optimal growth of muskmelons is a range of 18.3 to 23.9°C (Lorenz and Maynard, 1980); however, it has been reported that muskmelons can tolerate temperatures in excess of 30°C (Lorenz and Maynard, 1980; Wells and Loy, 1985). Excessive air temperatures, as a result of the use of row covers, may have contributed to temperature stress and plant vigor reduction in Oregon (Hemphill and Mansour, 1986).

Total marketable yields in 1985 were greater than in 1986 (Table 2). The average minimum air temperature in 1986 was ±6°C less than the minimum air temperature in 1985 (Table 1). The influence of minimum air temperature on muskmelon yield was previously noted in North Carolina (Bonnano and Lamont, 1987).

Early yields (first three harvests) were increased in all row cover treatments as compared to the no row cover treatment both years (Table 2). In 1985, differences in earliness were not noted among row covers; however, the use of spunbonded polyester row cover in 1986 resulted in greater early yields than the perforated row cover treatment. Results from this study and previous research (Bonnano and Lamont, 1987) show that slitted row covers increased earliness in three of four tests and 2 of 3 years. However, total marketable yield was increased in only one of four tests and 1 of 3 years.

The additional number of melons per hectare from the use of row covers over the no row cover treatment for the early harvests in 1985, are ±4200, 3330, and 3550 for perforated, double-slitted, and spunbonded polyester, respectively (Table 2). In 1986, the numbers of additional muskmelons were ±2100, 2370, and 3550 for perforated, double-slitted, and spunbonded polyester, respectively. The increased revenue resulting from this additional early marketable fruit must exceed the estimated costs of row covers of about $1700/ha (Gerber et al., 1983).

In summary, row covers were effective in increasing earliness of muskmelons, but were not consistent in increasing total yields under conditions that prevail in the Coastal Plain of North Carolina. High temperatures, which are common in this area, may limit the use of perforated row covers. Marketing strategy will be necessary to maximize prices of early melons to pay for row covers.

Literature Cited


Hopenhay, H.J. 1965. Effects of black and transpar-

Table 2. Marketable yield of muskmelons as influenced by row cover treatment.

<table>
<thead>
<tr>
<th>Row cover treatment</th>
<th>Total marketable yield (No./ha, thousands)</th>
<th>Fruit wt (kg/fruit)</th>
<th>Early yield (No./ha; thousands)</th>
<th>Additional early melon prices required to pay for row cover cost (§)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perforated</td>
<td>41.6</td>
<td>24.7</td>
<td>1.17</td>
<td>1.15</td>
</tr>
<tr>
<td>Double-slitted</td>
<td>41.0</td>
<td>28.2</td>
<td>1.20</td>
<td>1.22</td>
</tr>
<tr>
<td>Spunbonded polyester</td>
<td>39.0</td>
<td>29.9</td>
<td>1.17</td>
<td>1.25</td>
</tr>
<tr>
<td>No row cover</td>
<td>39.8</td>
<td>21.5</td>
<td>1.16</td>
<td>1.21</td>
</tr>
</tbody>
</table>

LSD* NS 4, 0.7, 0.05, 0.21

*Early yield = harvests 1, 2, and 3.
*Based on row cover cost of $1678/ha.
*Mean separation by LSD at P = 0.05.
Triploid Watermelon Seed Orientation Affects Seedcoat Adherence on Emerged Cotyledons

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Abstract. Seedcoat adherence to emerged cotyledons of seedless watermelons (Citrullus lanatus (Thunb.) Matsum & Naki) results in distortion of seedlings that effectively restricts the number of productive plants in a planting. Significantly fewer seedcoats adhered to cotyledons when seeds were oriented with the radicle end up at a 45° or 90° angle than when seeds were oriented horizontally or with the radicle end down at a 45° or 90° angle. Emergence was not affected by seed orientation.

The procedure for production of seedless watermelons has been known for ~50 years and commercial cultivars have been available for ~20 years, but interest in and hectarage of seedless watermelons has remained small. Erratic performance, poor seed germination, high seed costs, and inadequate cultivars resulted in lack of grower interest in seedless watermelon production. In addition, adherence of seedcoats to emerged cotyledons (Fig. 1) is a troublesome problem, causing distorted seedlings and sometimes loss of the plant. Thicker seedcoats in polyploid watermelons (Kihara, 1951; Ner-son et al., 1985) may increase seedcoat adherence.

In preliminary experiments (Maynard, 1988), optimum germination occurred at 28°C, and seedcoat adherence was reduced when seed was oriented at a 45° angle with the radicle end up as compared to horizontally placed seed. The object of this study was to determine the effects of other seed placements on seedcoat adherence to cotyledons and emergence of seedless watermelon seeds.

Two distinct, but similar, seed orientation trials were conducted. In the first experiment, seeds were a well-mixed composite of remnants of seedless watermelon seeds from a cultivar evaluation trial. Seeds of a single cultivar were impossible to obtain at the time of this trial. Later, seeds of 'King of Hearts' were obtained and used in the second experiment.

In both experiments, seeds were individually planted in modified, 50-cell units cut from Todd planter flats (2.0 x 2.0 x 4.4-cm cells), containing a commercial peat-lite growing mix. Seeds were carefully oriented so that the radicle pointed down at 90°, down at 45°, was horizontal, pointed up at 45°, or up at 90° (Fig. 2), and covered with ~0.6 cm of the growing mix. The flats were thoroughly watered, allowed to drain, and enclosed in individual ventilated polyethylene bags supported by 10-cm plant stakes to provide space for the emerging seedlings. The flats were placed in an incubator at a constant 28°C with 12 hr light (15.8 W·m⁻²) from incandescent and cool-white fluorescent sources and 12 hr dark. The growing mix was watered periodically to prevent drying during each cycle. Emerged watermelon seedlings and the number of seedcoats adhering to cotyledons were counted after 14 days. Each experiment was replicated three times over time as incubator space was available. Percentage data were subjected to arc-sin transformation before analysis of variance and mean separation.

Emergence was not affected by seed orientation in Expt. 1 (mixed seed) and reduced only when the radicle was down at 45° compared with up at 45° in Expt. 2 ('King of Hearts') (Table 1). Variable results have been obtained in previous studies relating cucurbit seed orientation to emergence. cucumber and watermelon emergence was lower when the radicle of the seed pointed up rather than down or placed horizontally (Nettles, 1971). The highest emergence occurred in cucumber and watermelon when the seed was oriented with the radicle 45° down, whereas, in squash, radicle ends pointed down at 90° resulted in the highest emergence relative to radicle ends pointed up at 45° or 90° and being horizontal (Gomaa, 1980). In laboratory and greenhouse tests, seed orientation did not affect germination or emergence of 'Poinsett' cucumbers (Cantliffe, 1984). Accordingly, the reduced emergence noted when the radicle was 45° down in Expt. 2 may have been an anomaly.

However, seed orientation greatly affected adherence of seedcoats to emerged cotyledons (Table 2). Significantly fewer seedcoats adhered to cotyledons when seeds were positioned so that radicles were up compared to down or horizontal in respect to gravity. The foot, or peg, a special morphological modification involved in germination of Cu

Table 1. Triploid watermelon seed emergence and seedcoat adherence as influenced by seed orientation.

<table>
<thead>
<tr>
<th>Seed orientation</th>
<th>Mixed seed</th>
<th>King of Hearts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed emergence (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radicle down, 90°</td>
<td>50 a</td>
<td>73 ab</td>
</tr>
<tr>
<td>Radicle down, 45°</td>
<td>61 a</td>
<td>62 b</td>
</tr>
<tr>
<td>Horizontal</td>
<td>53 a</td>
<td>73 ab</td>
</tr>
<tr>
<td>Radicle up, 45°</td>
<td>48 a</td>
<td>78 a</td>
</tr>
<tr>
<td>Radicle up, 90°</td>
<td>51 a</td>
<td>71 ab</td>
</tr>
</tbody>
</table>

*Mean separation in columns by Duncan's multiple range test, 1% level.

Fig. 1. Seedcoats adhering to triploid watermelon cotyledons.