Characteristics and Effectiveness of Photodegradable Mulch for Use in Watermelon Production

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Abstract. Two formulations of a black polyethylene photodegradable mulch (Plastigone brand) were evaluated in the field for sunlight-induced breakdown characteristics and effectiveness in producing watermelons (Citrullus lanatus (Thumb.) Matsum and Nakai). A relatively early degrading formulation (221B) and late degrading formulation (2B) of photodegradable mulch were as effective as nondegradable black polyethylene in enhancing early yields, but only the late degrading mulch was as effective as nondegradable polyethylene mulch in enhancing total season-long fruit production. The late degrading formulation of photodegradable mulch was successfully used at a commercial melon growing site.

Introduction

The use of polyethylene (plastic) mulch has increased substantially in vegetable production (Bhella, 1986). Benefits of polyethylene mulch with cucurbits include increased early and total yields (Bhella, 1986; Bonanno and Lamont, 1987; Maiero et al., 1987). These benefits have been primarily attributed to more favorable root zone temperatures under the polyethylene mulch (Bonanno and Lamont, 1987) and reduced nutrient leaching (Bhella, 1986).

A major problem with the use of polyethylene mulch is the labor intensive process of removing the polyethylene from the field at the end of the cropping season (Stall and Bryan, 1981). Commercial mulch removers are available but are too costly for small acreage growers. Field burning of the polyethylene can be done but may be hazardous to the environment. A mulch that systematically degrades during or shortly after the growing season would solve this problem (Carnell, 1980; Sanders, 1988).

Photodegradable mulches have been used extensively in other countries, such as Israel, for the past several years (Gilead, 1985), but use in the U.S. has been limited primarily due to lack of information on the effectiveness of these mulches for commercial production of the more widely grown vegetable and fruit crops (Johnson, 1989). Also, many of the evaluations of photodegradable mulches during the mid-1970s and early 1980s concluded that none of the materials that were available at that time was commercially acceptable either due to incomplete breakdown (Matthews and Chu, 1983; Wien, 1981), or product variability between sites, years and plastic lots (Wells and Courter, 1975; Wien, 1981). Recently, several new photodegradable materials have been introduced (Sanders, 1988) that have been favorably evaluated for use with strawberries and many early transplanted vegetables (Clough and Reed, 1989; Johnson, 1989; Kostewicz and Stall, 1989; Sanders et al., 1989).

This report describes two field studies that were conducted to determine the characteristics and effectiveness of some formulations of a relatively new photodegradable mulch product (Plastigone) in the production of watermelons (Citrullus lanatus (Thumb.) Matsum & Nakai). The first study was conducted at the experiment station in Blackville, South Carolina in 1987 and the second at a commercial melon growing site in Denmark, South Carolina in 1988.

Materials and Methods

Experiment Station Evaluation

Two formulations of a Plastigone brand (Idealmasters, Inc., Miami, FL) polyethylene photodegradable mulch were compared to nonphotodegradable mulch and bare soil culture for effectiveness in watermelon production.
during the summer of 1987 at Clemson University's Edisto Research and Education Center in Blackville, SC. Fertilizer at N, P, and K rates of 135, 196, and 448 kg/ha (120, 175, and 400 lb/A), respectively, was incorporated into the top 0.2 m (8 in.) of a Norfolk sandy loam soil (Typic paleudults) immediately prior to the field application of the mulch treatments on 23 April 1987. No herbicides were used, and weeds were routinely removed from the bare soil treatment and from between the rows. All mulch material was black, 1.5 m wide, 0.03 mm thick, and covered beds 0.8 m wide and 0.1 m high. One formulation (221B) of photodegradable mulch was developed by the manufacturer to degrade after approximately 30 to 40 days exposure to sunlight, and the second formulation (2B) was developed to degrade after 60 to 90 days. Treatments were arranged in a split plot design with four replications; mulch treatments were randomized as the main plots in the design and cultivars were the subplots.

Transplants of three cultivars of triploid watermelons ("Farmer's Wonderful," "Fenshan No. 1," "Super sweet") were placed in the mulch treatments on 24 April 1987 at an in-row spacing of 1.5 m with rows 1.5 m apart. A diploid cultivar ("Crimson Sweet") was planted every fifth row on bare soil for pollination of the triploid cultivars. Bee hives were located near the field and recommended pesticide sprays (Cook et al., 1985) were applied. Overhead irrigation was used to supplement natural rainfall when needed. Mature fruit (Cook et al., 1985) was harvested once a week. Fruit harvested during the first 2 weeks of harvest was considered early yield.

Commercial Grower Evaluation

The second field study was conducted in 1988 at a commercial melon growing site in Denmark, SC to determine effectiveness and potential grower acceptance of the Plastigone 2B formulation of the photodegradable mulch. The 2B mulch was compared to the bare ground culture that had been traditionally used by the cooperating grower. Field preparation, mulch application, and plant spacings were similar to the 1987 study. Fertilizer was applied at N, P, and K rates of 60, 181, 363 kg/ha (54, 161, and 324 lb/A), respectively prior to mulch application on 10 April 1988.

Transplants of a triploid cultivar ("Jack of Hearts") and a diploid cultivar (SC7) were placed in the mulch and bare ground treatments on 11 April 1988. A split plot design with four replications, similar to the 1987 evaluation, was used except that there were only two main plot treatments (mulch and bare ground) and two subplot treatments (cultivars). After two weeks of fruit harvest (early harvest period), hail on 16 June 1988 destroyed most vines and the evaluation was terminated. For discussion, potential total fruit harvest of the plots was estimated by multiplying the number of visible fruit on the vines at the time of the hailstorm by the average fruit weight recorded during the early harvest period for each cultivar.

Results and Discussion

Experiment Station Evaluation

Photodegradable Mulch Breakdown Characteristics

The first observed characteristic of sunlight-induced breakdown of the photodegradable mulches in 1987 was a splitting of the plastic originating from the holes where the transplants were placed. Splitting was first observed in 221B mulch after 15 days in the field and in the 2B mulch after 29 days. With advanced splitting and cracking of the plastic, sections of the photodegradable mulches had been
blown by winds out of the plots. After 55 days in the field, most of the 221B mulch was missing from the plots (except for edges not exposed to the sun) and the 2B mulch had only larger lateral splits (Fig. 1). With advanced time in the field, degradation of the photodegradable polyethylene was extended to the buried edges of the plastic. Several weeks after the last harvest, field clean-up consisted of hand removing the nondegradable mulch, and discing the photodegradable mulches. Photodegradable mulch residue was not a problem for field preparation in 1988.

Mulch Effects on Watermelon Production

In general, both formulations of photodegradable mulch were equally effective as the nondegradable mulch in enhancing early watermelon yield as compared to bare soil culture (Table 1). Plants in the bare soil were smaller and generally flowered later than those in the mulch treatments. Similar effects of polyethylene mulch on early yield and growth had been previously reported for watermelon (Bhella, 1986) and muskmelon (Bonnano and Lamont, 1987; Maiero et al., 1987). Greatest total yields were recorded in the nondegradable and the 2B photodegradable mulch treatments. The 221B photodegradable and bare soil had lower total yields than the other two treatments. Mulch treatments had no effect on average fruit size or fruit soluble solids (data not presented). These results suggest that the 221B mulch appears to photodegrade too rapidly for production of a relatively long growing season crop such as watermelon.

### Table 1. Influence of photodegradable polyethylene mulches on the production of watermelons at the Experiment Station site in 1987

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Early</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mulch</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nondegradable</td>
<td>8.59 a</td>
<td>49.86 a</td>
</tr>
<tr>
<td>2B photodegradable</td>
<td>12.29 a</td>
<td>51.67 a</td>
</tr>
<tr>
<td>221B photodegradable</td>
<td>11.03 a</td>
<td>21.95 b</td>
</tr>
<tr>
<td>Bare soil</td>
<td>3.51 b</td>
<td>19.12 b</td>
</tr>
<tr>
<td>Significance</td>
<td>a</td>
<td>b</td>
</tr>
<tr>
<td>Cultivar</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Farmer’s Wonderful</td>
<td>13.17 a</td>
<td>60.25 a</td>
</tr>
<tr>
<td>Fengshan No. 1</td>
<td>8.44 b</td>
<td>23.91 b</td>
</tr>
<tr>
<td>Supersweet</td>
<td>4.98 b</td>
<td>22.78 b</td>
</tr>
<tr>
<td>Significance</td>
<td>a</td>
<td>b</td>
</tr>
</tbody>
</table>

*Significance is indicated by * (significant at P = 0.05), or ** (significant at P = 0.01). Mean separation within treatments and columns by L.S.D. (5%). There were no significant mulch x cultivar interactions. Mg/ha x 0.446 = tons/A.

### Table 2. Influence of 2B photodegradable polyethylene mulch on the production of watermelons at the grower site in 1988

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Early</th>
<th>Total (Estimated)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mulch</td>
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<td></td>
</tr>
<tr>
<td>2B photodegradable</td>
<td>8.31</td>
<td>18.20</td>
</tr>
<tr>
<td>Bare soil</td>
<td>2.55</td>
<td>12.40</td>
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<tr>
<td>Significance</td>
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<td>b</td>
</tr>
<tr>
<td>Cultivar</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jack of Hearts</td>
<td>5.65</td>
<td>15.44</td>
</tr>
<tr>
<td>SC7</td>
<td>5.21</td>
<td>15.16</td>
</tr>
<tr>
<td>Significance</td>
<td>ns</td>
<td>ns</td>
</tr>
</tbody>
</table>

*Significance is indicated by ns (nonsignificant at P = 0.05), * (significant at P = 0.05), or ** (significant at P = 0.01). There were no significant mulch x cultivar interactions. Fruit harvest was terminated after two weeks of harvest due to plant injury from a hailstorm, and potential total yields were estimated from remaining immature fruit. Mg/ha x 0.446 = tons/A.

Commercial Grower Evaluation

The 2B photodegradable mulch in 1988 increased early yields by 325% and total yields (estimated) by 47% (Table 2) as compared to the traditional bare soil culture at the commercial melon growing site. There was no significant difference in the early yields between cultivars. At the time of the hailstorm, the 2B mulch was intact with only small transverse cracks. There was good grower interest in and acceptance of the 2B photodegradable mulch.

Conclusions

These results suggest that the late degrading formulation of Plastigone brand photodegradable mulch (2B) can be successfully used in the production of watermelons. Both formulations of photodegradable mulch (2B and 221B) were equally effective as the nondegradable polyethylene mulch in enhancing early watermelon yield as compared to bare ground culture, but only the 2B mulch was as effective as the nondegradable in enhancing total yield. The early degrading mulch (221B) appears to photodegrade too quickly for effective season-long watermelon production.

Acknowledgments. This research was supported in part by Experiment Station Project No. 1187, S.C. Watermelon Board Grant 1968, and a United States Department of Agriculture Special Grant P. L. 89-106. Use of trade names in this publication is solely for identification.
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References


