Clear Plastic Mulch Improved Seedling Emergence of Direct-seeded Pepper

J. Cavero, R. Gil Ortega, and C. Zaragoza
Servicio de Investigacion Agraria, Apartado 727, 50080 Saragossa, Spain

Abstract. Pepper (Capsicum annuum L., ‘Piquillo de Lodosa’) was seeded and then covered with clear plastic mulch, and various cultural practices to improve seedling emergence were compared. Planting dates (8, 12, and 25 Apr. 1991), seeding systems (raised bed vs. flat, 1991), and one or two rows per bed (1991 and 1992, respectively) were evaluated for their effects on stand establishment and yield. Plant stand was 60% when seed was under plastic mulch, compared to 0% when no mulch was used. Maximum plant stand was obtained 4 weeks after seeding in mulched soil. With plastic mulch, earlier (on or before 12 Apr.) season plantings were best because soil temperatures were so high (>25°C) later as to reduce plant stands. The risk of excessive high temperatures was greater when seed was on a raised bed rather than flat ground; however, using plastic mulch, temperatures were higher, often resulting in acceptable plant stands regardless of bed arrangement. Higher yields were realized with raised beds compared to flat ground sowing. When two rows per bed were used, higher temperatures on the south side reduced emergence compared to the north side of the east–west-oriented beds. Direct seeding of pepper appears to be commercially acceptable in our Mediterranean conditions, provided seed is under plastic mulch and seeding is completed on or before 12 Apr.

Received for publication 16 May 1995. Accepted for publication 28 Oct. 1995. We thank Instituto Nacional de Investigacion Agraria for providing financial support to conduct this study. We also thank J.D. Abbott, W.J. Lamont, and J.R. Schultheis for their helpful critical review of the manuscript. Mention of a trademark, proprietary product, or vendor does not constitute a guarantee or warranty of the product by the Spain Dept. of Agriculture and does not imply its approval to the exclusion of other products or vendors that also may be suitable. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked advertisement solely to indicate this fact.

Direct field seeding is a common commercial practice with vegetable crops, such as onions (Allium cepa L.) and processing tomatoes (Lycopersicon esculentum Mill.), but not peppers in Spain. Direct seeding of vegetables can be more cost effective than transplanting, particularly when the crop is destined for processing. With direct seeding, plant densities can be increased (Costa, 1991) with reduced labor and planting costs to improve yields (Stoffella and Bryan, 1988; Sundstrom et al., 1984).

Pepper is a species that requires relatively high soil temperatures for optimal germination and emergence, the optimum being between 25 and 31°C (Bierhuizen et al., 1978; Coons et al., 1989; O’Sullivan and Bouw, 1984; Watkins and Cantiliffe, 1983). When pepper is seeded directly in the field, soil temperature often can be suboptimal. For example, in the Middle Valley of the Ebro River (one of the commercial pepper production areas in Spain), the soil mean averages 10 to 20°C at the 2- to 4-cm depth on typical seeding dates. Suboptimal soil temperatures result in delayed nonuniform pepper emergence. The problem is exacerbated as the length of time to emergence increases because the probability of soil crust formation becomes greater. This problem with pepper has been documented by numerous researchers in Spain (Costa, 1991; Rodriguez and Ayuso, 1988) and the United States (Gerson and Honna, 1978; McGrady and Cotter, 1984; Orzoke and Daum, 1984; Randle and Honna, 1981; Schultheis and Cantiliffe, 1988). Obtaining ideal plant stands can be difficult, even with species that are less demanding in regard to temperature, such as tomato (Bussell and Gray, 1976; Herner, 1986; Maluf and Tischelaar, 1980).

Direct seeding under clear polyethylene mulch reduces soil crusting, increases soil temperature, and has been used successfully in cotton (Gossypium hirsutum L.) (Marquez, 1990) and tomato (Guerrard, 1990; Lopez, 1990; May, 1991). Our principal goal was to improve stand establishment and yields of direct-seeded pepper using this technique. Specific cultural management practices, such as planting dates, seeding system (raised bed or flat ground), and rows per bed, were evaluated to improve plant stands and pepper yields.

Materials and Methods

Emergence 1991. Seeding date and system were evaluated (see Table 1). ‘Piquillo de Lodosa’ (Piquillo) sweet pepper was field-seeded on mulched raised beds on 8, 12, and 25 Apr. in a loamy soil (37.2% sand, 43.8% silt, 19.0% clay, 1.76% organic matter, pH 8.3) in Saragossa, Spain (lat. 41°43’ N, long. 2°52’ W). Plots were irrigated before each seeding such that soils were near field capacity at seeding. Mulched raised beds were 1 m wide and 20 cm high, with single rows 1.5 m apart (a distance between rows greater than that recommended commercially because the equipment was set for commercial direct-seeded tomatoes). Mulched flat ground culture comprised the second seeding system and was only included in the 12 Apr. planting; but in this case, seeds were seeded in single rows 1.2 m apart because of equipment constraints. For observation, one 30-m-long bed with the same characteristics of raised mulched beds, but without

*Fig. 1. Plastic mulch covering (a) one row or (b) two rows when seeded in the bed in 1991 and 1992, respectively.*

Table 1. Seeding systems tested for emergence of bell pepper seed.

<table>
<thead>
<tr>
<th>Year and seeding system</th>
<th>Seeding date (April)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991 (one row)</td>
<td></td>
</tr>
<tr>
<td>Mulched raised bed</td>
<td>8, 12, 25</td>
</tr>
<tr>
<td>Mulched flat ground</td>
<td>12</td>
</tr>
<tr>
<td>Nonmulched raised bed</td>
<td>(one plot) 12</td>
</tr>
<tr>
<td>1992 (two rows)</td>
<td></td>
</tr>
<tr>
<td>Mulched raised bed</td>
<td>8</td>
</tr>
<tr>
<td>Mulched flat ground</td>
<td>8</td>
</tr>
<tr>
<td>Nonmulched raised bed</td>
<td>(one plot) 8</td>
</tr>
</tbody>
</table>

Treatments where yields also were recorded.

Emergence data were not recorded.
Table 2. Average temperature differences (± standard deviation) between mulched soil under transparent polyethylene and bare soil in the pepper beds at various time intervals.

<table>
<thead>
<tr>
<th>Year and time interval</th>
<th>Temp mulched soil – temp bare soil (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td></td>
</tr>
<tr>
<td>10–30 Apr.</td>
<td>5.3 ± 1.9</td>
</tr>
<tr>
<td>1–16 May</td>
<td>7.1 ± 0.6</td>
</tr>
<tr>
<td>16–30 May</td>
<td>2.7 ± 1.7</td>
</tr>
<tr>
<td>1992</td>
<td></td>
</tr>
<tr>
<td>1–20 Apr.</td>
<td>6.6 ± 1.9</td>
</tr>
<tr>
<td>20 Apr.–12 May</td>
<td>5.0 ± 2.5</td>
</tr>
</tbody>
</table>

Fig. 2. ( ) Maximum, ( ) minimum, and (——) mean daily temperature (°Celsius) at seed depth in a mulched soil in 1991 and 1992.

HortScience, Vol. 31(1), February 1996

ridge was slightly higher than the remainder of the top of the bed. This procedure helped move rain water away from the furrows where the seeds were placed (Fig. 1b). Rain water, if excessive, can cause rotting of seeds and seedlings at the germination and emergence phases.

The experimental plot unit consisted of three raised beds, each 8 m long (with two rows in it), which was replicated 15 times. One observational plot consisting of a 30-m-long, raised, east–west-oriented bed without plastic mulching also was seeded, as in 1991. The soil temperature of beds under mulched and bare soil was recorded and emergence evaluation was performed as in 1991; however, rows on the north and south sides were recorded separately for each bed. Paired data were analyzed using a t test.

Yield. The effect of seeding system (raised bed or flat ground) on yield of Piquillo pepper was studied in both years. In 1991, the plots of 12 Apr. seeding were used. In 1992, plots seeded on flat ground with the same row placement as in raised beds were used in addition to those seeded in beds for the emergence study. The experimental plot unit was the same as in the emergence studies, but peppers were harvested only from the central 4 m of the central bed. At 7 weeks after seeding, plants were thinned to have 14.5 plants/m in the row in 1991. In 1992, the same plant rate was distributed between the two rows. Eight replications per system were used in a completely randomized design. Marketable red fruit (Boletin Oficial del Estado, 1995) were harvested three times (23 Sept. and 8 and 23 Oct. 1991, and 16 Sept. and 7 and 21 Oct. 1992), and yields were compared with a t test.

Fields used both years had been laser-planed in 1990. Crop management was according to recommended cultural practices (Elejabeitia, 1970). Chlorpyriphos at 3.5 kg/ha and 10N–7.9P–13.3K fertilizer (calcium nitrate, superphosphate, and potassium chloride) at 600 kg/ha were incorporated in the soil before sowing. A top dressing before bloom consisted of N at 50 kg/ha as NH₄NO₃. Furrow irrigation was used. In the 1991, plots were irrigated first on 21 May, and plastic was removed on 30 May. In the 1992, the first irrigation was on 22 Apr., and plastic was removed on 12 May. Thereafter, plots were irrigated every 10 to 15 days until the end of August. Weed control was manual.
Results

Temperatures

In the beds, plastic mulch (compared to bare soil) increased the soil mean 5 to 7°C from 1 Apr. to 16 May, the minimum 2 to 5°C through 30 May, and the maximum 7 to 13°C from 1 Apr. to 16 May (Table 2). Thus, the mean daily temperature of soil at seeding depth under plastic mulch in the furrow was >15°C almost every day, the daily minimum was >10°C in 1991 and >7°C in 1992, and daily maximum ranged between 13 and 43°C (Fig. 2). Plastic perforation ameliorated the increase in soil temperatures relative to bare soil (Table 2).

Emergence

Emergence was absent on nonmulched beds in both years.

1991. Maximum percent emergence for all the planting dates was attained 4 weeks after seeding (Fig. 3). Emergence (81%) ($P \leq 0.05$) was highest for the 12 Apr. seeding date. Plots seeded on 25 Apr. had the lowest emergence (27%), which was significantly lower ($P \leq 0.05$) than for the 8 Apr. seeding. Emergence for the last seeding date likely was low due to the high soil temperatures under the polyethylene mulch (maxima >35°C almost every day from 2 weeks after seeding). Percent emergence at other record dates were similar for the 8 and 12 Apr. seeding dates, probably because only 4 days separated seeding. The high soil temperatures recorded under plastic mulch after 10 May resulted in death of many plants and reduced plant stands (25% of emerged plants died in the 8 Apr. seeding, while 60% died in the 12 Apr. seeding).

For the 12 Apr. seeding, the percentage of emergence was similar for raised beds and flat ground 3 weeks after seeding but was higher on raised beds 4 weeks after seeding (Fig. 4). However, during the following 3 weeks, more plants died on beds than on the flat ground. Thus, 7 weeks after seeding, plant stands on beds were significantly lower ($P \leq 0.05$) than on flat ground, probably because temperatures were higher in beds (Fig. 4) and soil moisture was higher in flat ground (visual observation).

Piquillo pepper ripened regardless of seeding date, although ripening was delayed 1 to 2 weeks with the last sowing date (25 Apr.). For the 8 and 12 Apr. seeding dates, fruit ripened at about the same time as commercial peppers grown in adjacent farms where transplanting was used.

1992. At 3 to 6 weeks after seeding, emergence percentages on beds were significantly higher ($P \leq 0.05$) in the rows located on the north compared to the south side of the beds (Fig. 5). Soil on the south side may have dried because the plastic mulch on the south side was partially removed for several hours by high-speed wind. In addition, the maximum daily temperatures in the south-oriented rows were higher (>35°C for many days) than in those of north-oriented rows (Fig. 5). After 20 Apr., soil temperatures in the south side were
unavailable because of a problem with the data logger. Maximum plant stands were reached 4 weeks after seeding. Later, some plants in the north and south rows died, presumably due to high temperatures (Fig. 5).

Yield

In both years, significantly higher yields were obtained with raised beds compared to flat ground (Table 3).

Discussion

Our results indicate that using plastic mulch in the Saragossa area of Spain and similar climates provides an option for obtaining acceptable plant stands if pepper is direct-seeded in early April. At that time, the mean soil temperature of polyethylene-mulched beds is >15°C, which is recommended for seeding pepper (Somos, 1984). The success of similar direct seeding, followed by mulch, in other crops and countries (Guerard, 1990; Marquez, 1990; May, 1991) indicates that this cultural practice can be extended to other areas where pepper is grown and low soil temperatures early in the season are a major constraint for pepper emergence.

High soil temperatures (>35°C) under the polyethylene mulch killed seedlings. Although pepper plants may tolerate high temperatures for a short period, pepper emergence becomes too high. If plastic is perforated at the seedling stage, the plastic can be ridged at the center of the bed (Fig. 1b), which allows the rain water to collect on the outside of the bed. This shape also is advantageous if the plastic is perforated at seeding time. The emergence differences found between the two rows in 1992 suggest that north–south-oriented beds should be tested to obtain a more uniform temperature in the bed and similar emergence in both rows.

When considering only emergence, raised bed and flat ground seeding are recommended. Raised beds increase soil drainage (Marquez, 1990), which is important for emergence and yield in medium or heavy soils (as used in our work). However, supraoptimal temperatures that reduce stands and yield may be encountered more frequently when seeding on raised beds (Marquez, 1990).


<table>
<thead>
<tr>
<th>Seeding system</th>
<th>Yield (kg ha⁻¹)¹</th>
<th>1991</th>
<th>1992</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raised bed</td>
<td>9.244 b</td>
<td>11.730 a</td>
<td></td>
</tr>
<tr>
<td>Flat ground</td>
<td>4.018 a</td>
<td>7.854 a</td>
<td></td>
</tr>
</tbody>
</table>

¹For each year, mean separation according to a t test at P≤0.05.

Fig. 5. Progress of emergence in (◻) north and (◼) south sides of bed and maximum daily temperature at seed depth in the (---) north and (―) south sides in soil under clear plastic mulch in 1992. Numerals in parentheses indicate the number of weeks after seeding.

Literature Cited


