YIELD OF POLYETHYLENE-MULCHED BELL PEPPER (CAPSICUM ANNUUM L.) AS AFFECTED BY TIME OF EMERGENCE AND POPULATION DENSITY OF SMOOTH PIGWEED (AMARANTHUS HYBRIDUS L.)

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Abstract. A field experiment was conducted in 2001 in Live Oak, Fla., to study the effect of smooth pigweed time of emergence and density on the fruit yield and grade of plastic-mulched bell pepper. Smooth pigweed was grown from seed placed alongside the pepper stems. ‘Camelot’ bell pepper was grown from transplants. The weed plant densities were 0, 1, 2, 4, and 6 per m², and weeds were allowed to emerge at 1, 2, 3, 4, and 5 weeks after transplanting (WAT) the crop. Once emerged, the weeds were allowed to interfere with the crop the remainder of the season. As pigweed emerged earlier and/or weed density increased, pepper fruit yield, pepper plant dry weight and concentration of nitrogen in pepper leaf petioles decreased. Maximum yield loss (61%) occurred at the pigweed plant density of 6 per m² emerging 1 WAT. At the weed plant densities of 4 and 6 per m², yield losses in pepper were lower than 10% when pigweed emerged later than 4 WAT. At the pigweed plant densities of 1 and 2 per m², pepper losses were lower than 10% if pigweed emerged later than 2 WAT. These results show that smooth pigweed interference on bell pepper is affected by density and time of emergence. Interference by pigweed emerging later than 4 WAT may not cause critical pepper yield losses.

Pigweeds or amaranths (Amaranthus spp.) are abundant and troublesome weeds in most crops (Holm et al., 1991). In vegetables crops in Florida, the most important weedy pigweeds are smooth pigweed (Amaranthus hybridus L.), livid amaranth (Amaranthus lividus L.), and spiny amaranth (Amaranthus spinosus L.). One pigweed plant can produce several thousand viable seed several weeks after emergence, and in spite of the implementation of mechanical, chemical or biological means of control, pigweeds are commonly found infesting vegetable crops, emerging at variable densities and at different times during the crop season. Moreover, herbicide-resistant pigweeds have been found competing with Florida vegetables and herbs (William Stall, pers. comm.).

In Puerto Rico, pigweeds caused yield losses of 40% in sweetpotato (Ipomoea batatas L. Poir.) (Lugo et al., 2000). In the Dominican Republic, eggplant (Solanum melongena L.) and Caribbean bonnet pepper (Capsicum frutescens L.) yield losses of 60 and 70% were reported, respectively (Morales-Payan et al., 2002a and 2002c). In Florida, a smooth pigweed plant density of 6 per m² caused total yield loss in muskmelon (Cucumis melo L. Reticulatus Group) (Terry et al., 1997). Berry et al. (2001) reported yield reductions of about 45% in cucumber (Cucumis sativus L.) infested season-long by livid and smooth pigweeds. Bell pepper (Capsicum annuum L.) yields were reduced by 67% when competing with livid amaranth season-long (Morales-Payan et al., 2002b). Therefore, important yield losses may be expected when pigweeds interfere with a number of crops.

Due to the numerous viable seeds produced by pigweed, some seedlings of this weed emerge even when highly effective preemergence herbicides are utilized. In non-mulched vegetables in Florida, pigweeds are found growing on the beds and the row middles. In polyethylene-mulched vegetables, row middles are more commonly infested by pigweeds, but pigweeds also emerge in the perforations made in the polyethylene for transplanting the crops. In extreme cases, pigweed can be found growing alongside every crop plant (William Stall, pers. obs.).

Bell peppers are among the most important horticultural products of Florida, with a value over $250 million annually. Estimated losses due to interference of various weeds exceed 10% of potential pepper yields (Florida Agricultural Statistics, 2001). The magnitude of weed interference with crops is density and duration dependent (Cousens, 1991), and mathematical models describing crop yield as a function of weed density and periods of interference are essential for sound decision-making in weed control programs.

Models describing the relationship between density and duration of interference of livid amaranth with bell pepper were reported by Morales-Payan and Stall (2002). However, such information is not available for smooth pigweed infesting polyethylene-mulched pepper. The objective of this study was to determine the effect of the time of emergence and density of smooth pigweed on polyethylene-mulched bell pepper growth and yield.

Materials and Methods

A field study was conducted in the fall of 2001 at the University of Florida Suwannee Valley Research and Education Station at Live Oak, Fla. The experimental units were soil beds 0.7 m wide and 3-m long, mulched with white polyethylene. Soil beds were fumigated with methyl bromide to suppress the natural population of weeds, mimicking a situation in which weed species other than smooth pigweed were controlled.

‘Camelot’ bell pepper (12 cm tall, 3 to 4 true-leaf stage) was transplanted in double rows at 30 cm spacing. Smooth pigweed seeds from Gainesville, Florida, were sown in the bell pepper transplanting hole, at different plant densities (0, 1, 2, 3, 4, or 6 per m²) and times after transplanting the crop (emerging about 1 week after sowing; at 1, 2, 3, 4, or 5 weeks after transplanting the crop, WAT). The combinations of times of emergence and densities were a factorial of additive series (Radosevich, 1997) established in randomized com-
complete blocks with three replications. Emerged smooth pigweed plants were thinned to desired density 10 d after emergence and were allowed to interfere with the crop for the remainder of the crop season, which lasted 13 WAT. Except for weed management, the crop was managed according to University of Florida recommendations.

The variables measured in pepper were nitrate concentration in petiole sap, shoot height and dry weight, and fruit yield. For pigweed, shoot dry weight and plant height were determined at the end of the experiment (13 WAT). For the crop and the weed, shoot dry weight was determined by cutting the plants at soil level and drying them in an oven for 48 h at 80 °C. Nitrate in sap was determined with samples from the petioles of recent fully expanded pepper leaves, using a nitrate meter (Spectrum Technologies, Inc., Plainfield, IL). Pepper yield was obtained by harvesting the marketable fruit (>5 cm in diameter and 5 cm in height) three times at 5-d intervals. Analysis of variance and regression (5% significance level) were performed on the resulting data.

**Results and Discussion**

Time of emergence and density of pigweed affected pigweed plant height and shoot dry weight, and pepper shoot dry weight, concentration of nitrate in sap, and fruit yield, but not pepper plant height. Pigweed plant height decreased at all densities as time of emergence was delayed, averaging 60, 55, 32, 18, and 11 cm when pigweed emerged at 1, 2, 3, 4, and 5 WAT, respectively. This response may be attributed to the shading effect caused by larger and denser canopies produced by pepper as the season progressed. Pigweed accumulated more shoot dry weight as density increased, but at any given density less shoot biomass was accumulated as the weed emerged later in the season (Fig. 1).

Differences by density in pigweed shoot dry weight accumulation were more pronounced when the weed emerged earlier. When pigweed emerged 1 WAT, at the plant density of 6 per m², it produced about nine times the amount of biomass produced at the plant density of 1 per m², whereas when pigweed emerged 4 WAT the plant density 6 per m² produced 4-fold the dry weight produced at 1 per m² (Fig. 1). Thus, pigweed emerging later was more shaded by the crop, accumulated less biomass and grew shorter. The uptake of nutrients from the soil by pepper may also partially account for the lower shoot dry weight accumulation in pigweed emerging later in the season.

Pepper yield decreased as the weed emerged earlier and as weed density increased (Fig. 2). At the pigweed plant density of 6 per m² emerging 1 WAT, pepper yield was reduced by 61% compared with weed-free pepper. Yield loss was about 22% at the pigweed plant density of 1 per m² emerging 1 WAT (Fig. 1). The relationship between pepper yield loss and pigweed time of emergence was best fitted to the regression equations $Y = 112.7 - 39.4e(0.2x)$, $r^2 = 0.91$ for the pigweed plant density of 6 per m², $Y = -13.29 + 89.67e(-0.33x)$, $r^2=0.98$ for the pigweed plant density of 4 per m², $Y = 35.26 + 6.6x$, $r^2 = 0.98$ for the pigweed plant density of 2 per m² and $Y = 10.41 + 42.88e(-0.26x)$, $r^2 = 0.97$, for the pigweed plant density of 1 per m². Pepper shoot dry weight at final harvest also decreased as pigweed emerged earlier and the weed density increased (data not shown), and was positively correlated with pepper fruit yield ($r = 0.83$).

Weeds interfere with crops by competing for nutrients, light, and water, and by releasing allelopathic compounds in the soil and air. Our results suggest that the impact of pigweed on pepper shoot dry weight and fruit may be attributed in part to competition for nitrogen and light. In general, concentration of nitrogen in nitrate (NO₃-N) in the sap of pepper petiole at fruit harvest was above sufficiency levels (800 ppm) when pigweed emerged later than 3 WAT, whereas deficient nitrate levels (Maynard et al., 2001) were detected in pepper when pigweed emerged earlier. Competition for other nutrients might have taken place, as it has been documented that pigweeds are strong competitors for nutrients other than nitrogen (Shreffler et al., 1994). Competition for light may have occurred, as pepper plant height was about 44 cm regardless of pigweed density and time of emergence, and pigweeds emerging 1 to 2 WAT were taller than pepper. Shading by pigweeds has been associated with yield loss in cucumber (Berry et al., 2001). Pigweeds have been found to be allelopathic to other plant species (Holm et al., 1991). However, when allelopathy occurs in additive series experiments...
such as this one, the allelopathic effects are confounded with the effects of competition for nutrients, light, and water.

The threshold for tolerable yield loss due to weed interference is commonly set at 10%. Our results show that at the pigweed plant densities of 4 and 6 per m², yield losses in pepper were lower than 10% when pigweed emerged >4 WAT. At the pigweed plant densities of 1 and 2 per m², pepper losses were <10% if pigweed emerged >2 WAT. These findings indicate that in order to maintain yield losses due to pigweed interference below the 10% threshold, a weed program implemented in polyethylene-mulched pepper should suppress pigweed emergence during the first 2 WAT (for weed plant densities of <2 per m²) to 4 WAT (for weed plant densities of 4 to 6 per m²), as pigweed emerging later would not be likely to reduce pepper yield below acceptable levels.

**Literature Cited**


