Spiny Amaranth (*Amaranthus spinosus* L.), A Serious Competitor to Crisphead Lettuce (*Lactuca sativa* L.)

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Additional index words. weed–crop interference, weed competition

Abstract. Three field studies on high-organic-matter soils were conducted to determine the zone of influence of spiny amaranth on lettuce head quality. Spiny amaranth reduced lettuce head firmness at all distances from the weed, ≤105 cm. Lettuce ribbiness increased at 15 and 45 cm compared with the weed-free control. Untrimmed lettuce head weight was not affected by spiny amaranth presence beyond 45 cm. Trimmed lettuce head weight was reduced at all distances compared with the control. Stem diameter and core length were not affected by spiny amaranth competition. The presence of a single spiny amaranth plant significantly influenced some lettuce quality traits at ≤105 cm.

Lettuce marketability depends on production of a high-quality product (Ryder, 1979). Weed competition reduces lettuce yield and quality (Dusky and Shrefler, 1992; Giannopolitis et al., 1989; Roberts et al., 1977; Shrefler et al., 1991). Frequent cultivation and hand-weeding are required to produce lettuce on Florida's high-organic-matter soils (Histosols) because few efficacious herbicides are registered (Dusky et al., 1988). Spiny amaranth is particularly troublesome in southern Florida lettuce production because it is ubiquitous and difficult to control with available herbicides. For cultivation, hand-weeding, or herbicide application to be cost-effective, thresholds and time of occurrence of crop losses due to weed competition must be known (Swanton and Weise, 1991).

Weeds cause yield loss in lettuce by reducing crop quality. Head firmness, leaf size (Roberts et al., 1977), and nitrate and carotene content (Giannopolitis et al., 1989) are quality traits sensitive to weed interference. The relative effect of weed competition on these traits,

however, is not known, and additional traits also may be affected.

Many traits contribute to the quality of crisphead lettuce (Kader et al., 1973; Ryder, 1979), and numerical evaluation systems have been described for some of these systems (Kader et al., 1973). Lettuce quality evaluation has been useful in the assessment of soil

fertility practices (Costigan and Heaviside, 1988) and environmental suitability of cultivars (Burdine and Sanchez, 1990). Research with celery [*Apium graveolens* L. var. *dulce* (Mill.) Pers.] suggests that interference by spiny amaranth can influence quality traits more than yield (Dusky, 1988). However, it is not known which quality traits in crisphead lettuce are most influenced by weed interference. Our objectives were to assess the sensitivity of crisphead lettuce head weight and quality traits to interference by spiny amaranth and to determine the zone of competitive influence between lettuce and spiny amaranth.

Materials and Methods

Studies were conducted at the Everglades Research Station, Belle Glade, Fla., in Nov. 1992 and Mar. 1993 and in Zellwood, Fla., in Oct. 1990. Soil types at Belle Glade and Zellwood are classified as a Pahokee muck (Euic, hyperthermic Lithic Medisaprists) and a Montverde muck (Euic, hyperthermic Typic Medifibrists), respectively. Soil fertility was adjusted as recommended by soil test for commercial lettuce production (Sanchez, 1990). Insects and diseases were managed using recommended practices (Maynard et al., 1995).

Eight beds, 46 cm wide at the top and 15 cm high, were formed on 92-cm centers. Crisphead lettuce ('Southbay') seed was sown in two rows, spaced 30 cm apart on each bed. Three weeks after planting, the lettuce was thinned to an in-row spacing of 30 cm.

Spiny amaranth was seeded into styrofoam transplant trays (Todd planter flats, model 150-5M; Hummert International, Earth City, Mo.) containing potting soil (Fafard mix no. 2; Conrad Fafard, Agaway, Mass.) and were

Table 1. Effects of spiny amaranth on lettuce head weight and quality at selected distances from the weed.^z

Weed distance (cm)	Firmness ^y	Ribbiness ^x	Untrimmed head (kg)	Trimmed head (kg)
15	2.9	2.5	0.88	0.57
45	3.1	2.2	0.90	0.58
75	3.1	1.9	0.96	0.60
105	3.1	1.7	0.96	0.61
Weed-free control	3.4	1.8	0.98	0.64
Single degree-of-freedom contrasts				
Control vs.				
All	**	*	*	*
15 cm	***	*	**	**
45 cm	*	*	**	*
75 cm	*	NS	NS	*
105 cm	*	NS	NS	*
15 cm vs.				
45 cm	NS	NS	NS	NS
75 cm	NS	*	*	*
105 cm	NS	*	*	*
45 cm vs.				
75 cm	NS	NS	*	NS
105 cm	NS	*	*	*
75 cm vs. 105 cm	NS	NS	NS	NS

Received for publication 24 July 1995. Accepted for publication 31 Dec. 1995. Published as Florida Agricultural Expt. Station Journal Series no. R-03984. 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.

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^zData are means of three studies.

^yRating scale for head firmness is 1 to 5 based on hand pressure, with 1 being a soft, easily compressed or spongy head and 5 being an extra-hard, over-mature head (Kader et al., 1973).

^xRating scale for ribbiness is 1 to 5, with 1 being a head with flat midribs and 5 being a head that is highly ribbed (Burdine and Sanchez, 1990).

NS, *, **, ***Nonsignificant or significant at $P \leq 0.05$, 0.01, and 0.001, respectively.

grown in the greenhouse for 3 weeks. At lettuce thinning, a single 3-week-old spiny amaranth plant was transplanted into each lettuce row between two lettuce plants in all treatment plots except the weed-free controls. Spiny amaranth plants were placed 2 m apart within the two rows of each bed to prevent intraspecific competition. These plots were maintained free of all other weeds by hand-cultivation throughout the season. Plots were eight beds (16 rows) wide and 6 m long, with the two outside beds serving as borders. The design was a randomized complete block with four replications.

Lettuce was harvested 65 to 75 days after seeding based on maturity of the control plots. Lettuce heads on both sides of the spiny amaranth plant were harvested successively at 15, 45, 75, and 105 cm from the spiny amaranth plant (two lettuce heads per distance) from each row. The center six beds of each plot were harvested. An equal number of lettuce plants were harvested from the weed-free control plots.

Quality traits were measured on all harvested lettuce heads. Untrimmed weight was determined before removal of loose, though intact, wrapper leaves. Trimmed weight was obtained following removal of wrapper leaves not tightly wrapping the heads. Firmness of individual heads, an indicator of maturity, was scored based on hand pressure (Kader et al., 1973), where 1 = soft and 5 = over-mature. Ribbiness (Burdine and Sanchez, 1990) was evaluated by scoring individual heads from 1 (flat midribs) to 5 (highly raised midribs). Stem diameter at the base of the head after trimming and length of the core also were measured.

Data were subjected to analysis of variance to test for single-factor effects and interactions. Study by treatment interactions were not significant ($P > 0.05$); therefore, data were combined for the three studies. Single degree-of-freedom contrasts were performed to compare treatments, the absence or presence of spiny amaranth, and head weight and quality traits at distances between the weed and lettuce. The effect of distance between the weed and lettuce on head weight (trimmed and un-

trimmed) was characterized using regression analysis.

Results and Discussion

Weed competition did not influence stem diameter or core length ($P > 0.05$; data not shown). Spiny amaranth competition reduced lettuce head firmness at all distances from the weed compared to the weed-free control (Table 1). Although head firmness ratings were between 3 and 4 (a rating between 3 and 4 being ideal), except at 15 cm, the presence of a single spiny amaranth plant significantly reduced head firmness compared with the control, indicating the potential impact of weed competition on this lettuce quality trait.

Ribbiness often causes wrapper leaves to break off when lettuce is packed for shipment, reducing market value appreciably. At distances of ≥ 75 cm from spiny amaranth, ribbiness did not differ from the weed-free control. Competition from spiny amaranth caused lettuce heads to be more conical with ribby outer leaves, also reducing marketability.

Linear regression analysis of untrimmed ($y = 0.869 + 0.000955x$; $R^2 = 0.87$; $P < 0.05$) and trimmed ($y = 0.566 + 0.00031x$; $R^2 = 0.93$; $P < 0.05$) head weights indicated that, as the distance between spiny amaranth and lettuce increased, head weight increased. However, untrimmed head weight increased more than untrimmed weight. Single degree-of-freedom contrasts showed that untrimmed head weight did not differ from the control at ≥ 75 cm from the weed (Table 1). At a distance of 105 cm, untrimmed lettuce head weight was 9% higher than at 15 cm. Trimmed weight, considered the most important characteristic, was reduced at all distances from the weed compared with the weed-free control (Table 1). Trimmed head weight was 11% less and 5% less than the control at 15 and 105 cm from the weed, respectively. Therefore, spiny amaranth presence influenced trimmed head weight to at least 105 cm away from the weed.

These studies showed that the presence of spiny amaranth at a low density can significantly influence lettuce head weight and qual-

ity at distances ≤ 105 cm. Further studies need to determine the effects of density, duration of interference, early vs. late-season interference on lettuce yield and quality, as well as identification of the mechanisms of competition so that integrated weed management decisions may be made judiciously.

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