Smooth pigweed (*Amaranthus hybrids* L.) interference with snap bean (*Phaseolus vulgaris* L.) quality[1]

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ABSTRACT

Field experiments were conducted at Fayetteville, Arkansas, in spring and fall of 1989 and 1990 to determine the effect of smooth pigweed density and the duration of interference on snap bean quality. Pod length, percentage of fiber, seed weight, sloughing, pod firmness and color of snap bean were not affected by smooth pigweed densities, which ranged from 0 to 75 plants per square meter. Smooth pigweed interference for 38 days increased snap bean pod fiber and firmness. Full-season interference (for 49 days after emergence) delayed snap bean pod maturity. To prevent delay in pod maturity, smooth pigweed should be controlled 28 days after snap bean emergence or before snap bean bloom.

Key words: weed interference, large crabgrass, snap bean, quality

RESUMEN

Interferencia del bledo (*Amaranthus hybridus* L.) sobre la calidad de la habichuela tierna (*Phaseolus vulgaris* L.)

Varios experimentos de campo se realizaron en Fayetteville, Arkansas, durante el verano y la primavera del 1989 y 1990 para determinar el efecto de las densidades de bledo y la duración de su interferencia sobre la calidad de la habichuela tierna. Las densidades del bledo (0 a 75 plantas por metro cuadrado) no afectaron el largo de la vaina, el porcentaje de fibra, el peso de las semillas, la firmeza de la vaina ni el color de la vaina. La interferencia del bledo durante los primeros 38 días después de la emergencia de la habichuela aumentó la fibra y la firmeza de la vaina de habichuela. La interferencia durante toda la época de crecimiento (por 49 días después de la emergencia) retardó la madurez de la habichuela. Para evitar la madurez tardía de las vainas, el bledo debe ser controlado 28 días después de la emergencia o antes de la florecida de la habichuela.

INTRODUCTION

Quantification of the duration of weed interference and density is valuable information in the development of better and more economic practices for weed control. In snap bean, high quality is as important as high yield (Sistrunk et al., 1989). Williams et al. (1973) found that

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full-season redroot pigweed interference reduced snap bean yield by reducing both number of pods per plant and the average pod size. Studies with smooth pigweed revealed that it is a highly competitive weed and may cause serious yield reductions to agronomic and horticultural crops (Holm et al., 1977; Moolani et al., 1964; Nave and Max, 1971). However, studies that quantify the effect of weeds on snap bean quality are limited.

Knowing the time at which smooth pigweed begins to interfere with snap bean will determine the optimum timing for weed control practices. Likewise, smooth pigweed density studies should provide information to predict quality reduction from specific populations. The objective of this study was to determine whether smooth pigweed densities and interference duration affect snap bean quality.

MATERIALS AND METHODS

Two field experiments per season were conducted in spring and fall of 1989 (S-89, F-89) and spring and fall of 1990 (S-90, F-90) at the Main Agricultural Experiment Station at Fayetteville, Arkansas. The soil was a Captina silt loam (fine-silty, mixed, mesic Typic Fragiudult) with a pH of 5.4 to 6.3 and 1.1% organic matter. In the field used in S-89, lime was applied at the rate of 4,490 kg/ha to increase soil pH from 5.4 to 5.8. The experimental area was fumigated with 268 kg/ha of methyl bromide to prevent germination from soil seed bank in S-89. Because of some early transient snap bean injury from methyl bromide in that trial, a rate of 157 kg/ha was used in subsequent experiments. Applications were made two weeks before the establishment of the experiments. Methyl bromide was injected into the soil from a tractor-mounted fumigator, and the soil was immediately covered with 2-mm thick clear plastic. The plastic cover was removed a week after application, and the soil was allowed to aerate for a week before planting. During that period, fertilizer (10-20-10) at the rate of 336 kg/ha was broadcast and incorporated into the soil by disking. Snap bean seeds of the cultivar 'Benton' were planted 2 to 2.5 cm deep in the center of each row with a mechanical planter. Snap bean was planted at 30 seeds per meter. Smooth pigweed seeds were planted on each side within a 7- to 10-cm band from the snap bean drill in each plot. Smooth pigweed was planted at a rate of 2.5 kg/ha to a depth of 1.5 to 2.0 cm. To provide uniformity of smooth pigweed density, half the density of the weeds was established on each side of the snap bean drill. Two weeks after snap bean emergence, snap beans plants were hand thinned to a uniform density of 23 plants per square meter.

Density studies

Each experiment contained 27 to 30 single-row plots (4-m by 1-m) arranged as a completely randomized design. In order to obtain a more precise regression equation, we used a wide range of smooth pigweed densities (0 to 75 plants/m^2). Regression analysis was used to model the relationship between independent (density) and dependent (snap bean quality parameters) variables. In the majority of the experiments, smooth pigweed density varied by two plants/m^2 intervals. Initial smooth pigweed densities ranged from 0 to 50 plants/m^2 in S-89; from 0 to 75 plants/m^2 in F-89, and from 0 to 70 plants/m^2 in S-90 and F-90. In F-90, smooth pigweed densities were replicated twice. Smooth pigweed densities were established by hand thinning to a uniform stand, and the weeds were allowed to interfere full-season. After the smooth pigweed densities were established, other weeds were eliminated by handweeding.

Interference duration study

The experimental design was a randomized complete block with four replications. Plots consisted of two rows one meter apart and 6 m long (12 m^2). One week after emergence, smooth pigweed density was adjusted to 70 plants/m^2. In 1989, duration intervals of smooth pigweed interference were 0 (weed-free), 14, 28, 42, and 49 days after snap bean emergence (DAE). Full-season interference was equivalent to 49 DAE, when the snap beans were harvested. Since the objective was to determine the time that weeds affect the crop the most, and 42 days was close to harvest, in 1990, 35 days replaced the 42-day interference duration interval. Smooth pigweed was removed from the plots by hoeing at indicated interference, and the plots were weed free thereafter. Handweeding eliminated other weeds.

Plot maintenance

To control insects and diseases, preventive measures were taken every two weeks. These measures consisted of application of copper sulfate at a rate of 1.12 kg/ha and carbaryl at the rate of 1.68 kg/ha. Overhead sprinkler irrigation was applied to add approximately 38 mm precipitation for each 7 to 10-day interval. At flower initiation, nitrogen as ammonium nitrate was side dressed at 29 kg/ha.

Harvesting procedure

Weed-free plots were used to determine the time of harvest. When a majority of the pods were sieve size 4 and 5, harvest began. In the density studies, the interior 3 m of each plot was harvested; in the interference duration study, the interior 2 m of each row. All pods were hand-pulled from the plants and graded into sieve sizes with a commercial bean grader. Pods of snap bean used for canning are usually graded on the basis of sieve sizes. Sieve size 1, 2, and 3 are immature pods, and sieve size 6 pods are the overmature. Pods of sieve size 4 (10 mm) and 5 (11 mm) were used for quality analyses.

Quality analyses

Quality parameters were analyzed in the Food Science Laboratory at the University of Arkansas by the procedure described by González et al. (1989). Pod length, percentage fiber, seed weight, sloughing, pod firmness and color were the quality parameters evaluated. After weighing, pod length was taken from a random sample of 10 pods of sieve-sizes 4 and 5. Pods were mechanically snipped, cut into 3.8 cm pieces, blanched in water at 79° C for two minutes, and a 260 g sample of beans was placed in a 303 (425 cm^3) enamel can. Cans were filled with boiling 2% brine solution, sealed and processed at 116° C for 20 minutes. Once cooled, the cans were packed in cardboard boxes and stored for two months at room temperature until time of analysis. For the color determination, the Gardner color CDM value was used. The color difference meter was standardized with a light green plaque (L = 50.8, -a = 24.7, b = 6.1, where L, -a, and b are values for darkness, greenness and yellowness of the pods, respectively).

Statistical analysis

In the density study, two cans were averaged per sieve 4 and 5. In the interference duration study, three cans per sieve size 4 and 5 were used. A regression analysis was conducted to measure the change of quality caused by smooth pigweed density. Covariance analyses were performed to determine differences between years and seasons. In the interference duration study, to test for differences between years and seasons, a split plot design was used in which the whole plot was the factorial arrangement of years and seasons, and the split plot was the interference duration treatment. Means were separated by a protected least significant differences (LSD) at $P \leq 0.05$ where appropriate.

RESULTS AND DISCUSSION

Density Studies

There was no significant regression for any of the quality parameters measured: pod length, percentage fiber, seed weight, sloughing, pod firmness and color. The variation explained by the regression (R^2)

was low (Table 1). Smooth pigweed densities did not provide estimation for snap bean quality parameters.

Interference Duration

The interactions of the interference duration by years and interference duration by seasons for snap bean quality parameters were not significant. Therefore, data for quality parameters were combined for years and seasons. Average of 38 (DAE) was obtained by using 35 and 42 days (DAE). As compared with shorter durations of interference, full season interference (49 DAE) increased pods of sieve sizes 1, 2 and 3 and decreased pods in sieve size 4 and 5 (Table 2). However, when smooth pigweed was removed from 14 to 38 DAE, the pod sieve size distribution was not affected. Thus, full-season interference delayed pod maturity.

Pod firmness (shear press) increased when smooth pigweed remained in the field 28 and 38 DAE as compared with the weed-free check (Table 3). There was a significant increase in fiber content and seed percentage when smooth pigweed remained in the field 38 DAE. Fiber content was above USDA acceptable levels and considered substandard, above 0.15% (Sistrunk et al., 1989). The increase in pod firmness probably was a consequence of high seed percentage and fiber content. Increased pod firmness is associated with the development of the fiber in the pod walls (Sistrunk et al., 1989). Correlations between

TABLE 1.—*Mean and coefficient of determination from the regression analysis between smooth pigweed density and snap bean quality.*

Parameter	R^2	Mean
Pod length (SS4)[1]	0.009	12.6 mm
Pod length (SS5)[2]	0.003	13.6 mm
Percent fiber	0.007	0.08%
Seed weight	0.001	3.9%
Sloughing	0.010	9.5 ml/100 ml
Pod firmness[3]	0.007	29.6 kg/150 g
Color values		
L	0.001	41.7
-a	0.003	3.6
b	0.001	19.2

[1]SS4 = pod sieve size 4.
[2]SS5 = pod sieve size 5.
[3]Measured as resistance to shear.

TABLE 2.—*Effect of smooth pigweed interference on snap bean sieve size distribution averaged for spring and fall of 1989 and 1990.*

Interference duration	Sieve size distribution[1]		
	1, 2 and 3	4 and 5[2]	6
DAE[3]	%		
0	20	68	12
14	22	69	9
28	21	69	10
38	20	68	12
49	37	54	9
LSD (0.05)	4	4	NS

[1]Sieve size (SS) 1 = 5 mm; SS 2 = 7 mm; SS 3 = 8.5 mm, SS 4 = 10 mm, SS 5 = 11 mm; SS 6 = > 11 mm.

[2]Sieve sizes used for canning.

[3]DAE = days after emergence.

fiber content and shear press values were highly significant (data not shown). Full-season interference did not increase fiber and shear press and seed percentage because of delayed maturity (Table 3). Sloughing, color and pod length were not affected by duration of smooth pigweed interference. Mean values for these parameters were for color L = 43; -a = 4; b = 20. Pod length values were sieve size 4 = 12 cm and sieve size 5 = 13 cm.

These experiments were harvested by hand. Under mechanical harvesting conditions, weeds may increase the amount of foreign material in the end product as well as interfere with harvesting efficiency.

TABLE 3.—*Effect of smooth pigweed interference duration on snap bean quality averaged for spring and fall of 1989 and 1990*[1].

Interference duration	Sloughing	Pod Seed	Firmness[2]	Fiber
DAE[3]	ml/100 ml	%	kg/150 g	%
0	8	4.6	31.1	0.067
14	8	4.8	31.6	0.068
28	9	5.1	33.8	0.096
38	9	5.7	34.4	0.169
49	10	5.1	31.4	0.081
LSD (0.05)	NS	0.6	1.3	0.040

[1]Analyses were conducted with pods from sieve sizes 4 and 5 combined.

[2]Measured as resistance to shear.

[3]DAE = Days after emergence.

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