Interference and Seed-Rain Dynamics of Jimsonweed (*Datura stramonium* L.) in Peanut (*Arachis hypogaea* L.)

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ABSTRACT

Jimsonweed has been shown to be a problematic weed in North Carolina and Virginia; however, its effects of interference in peanut have not been evaluated. Therefore, the objectives of this study were to determine peanut yield and growth reductions caused by jimsonweed interference. Experiments were conducted in 2004 at the Upper Coastal Plain Research Station located near Rocky Mount, North Carolina and the Cherry Research Farm near Goldsboro, North Carolina. With the exception of jimsonweed, the experimental area was kept weed-free utilizing herbicides and hand hoeing. Jimsonweed seedlings at the cotyledon to 2-leaf stage were transplanted into plots immediately after peanut planting at the following densities: 0, 1, 2, 4, 8, 16, or 32 plants per 6 m of row. Peanut diameter, measured as canopy row width at four random locations, increased over time at the lower jimsonweed densities. At the two highest jimsonweed densities, peanut diameters never exceeded 25 cm (70 cm less than weed-free peanut). Thus, peanut diameter does not appear to be a reliable predictor of peanut productivity or jimsonweed interference. Jimsonweed plant and seed pod weights decreased logarithmically as jimsonweed density increased. When jimsonweed was grown at lower densities, seed production amounted to nearly 30,000 per plant, which was reduced to 10,000 per plant when densities increased to 32 plants per 6.1 m of row. However, overall seed production increased from 60,000 seed per plot at the lowest jimsonweed density to 640,000/plot at the highest density. Peanut height increased from 44 to 57 cm as jimsonweed density increased from 0 to 5.25 plants/m of row. Similarly, jimsonweed heights increased from 97 to 139 cm as jimsonweed density increased from 0 to 5.25 plants/m of row. A rectangular hyperbola equation described the effect of density on percent yield loss with *i* and *a* values of 10.7 and 98, respectively.

Key Words: Competition, economic thresholds, models, peanut diameter, peanut height, weed biomass, weed density, weed height, and yield loss.

Jimsonweed possesses many characteristics that make it a competitive summer annual broadleaf weed. It is capable of very high growth rates, prodigious seed production, and rapid seed germination (Scott *et al.*, 2000). Jimsonweed is native in the continental U.S. States except Wyoming (Anonymous, 2006). While jimsonweed is not typically considered to be a problematic peanut weed in all of the peanut-producing states, it can be a problematic weed in the mid-Atlantic peanut production region including North Carolina and Virginia (Oliver *et al.*, 1991). Jimsonweed can reach heights of 67 cm (Scott *et al.*, 2000) and the resulting canopy can intercept light and reduce peanut productivity. According to the 2005 North Carolina Peanut Production manual, jimsonweed has a rank of 5.8 on a competitive index, based on a 10-point scale, with 10 being most competitive (Jordan, 2006).

Jimsonweed interference has been evaluated in cotton (*Gossypium hirsutum* L.) (Scott *et al.*, 2000) and soybean (*Glycine max* L.) (Frazee and Stoller, 1974; Hagood *et al.*, 1981; Oliver *et al.*, 1991; Paterson and Flint, 1983; Stoller and Woolley, 1985), and both crops suffered yield loss as a result of jimsonweed infestation. Jimsonweed height was not affected by either cotton or soybean; however crop height was decreased as weed density increased in both cases (Scott *et al.*, 2000; Hagood *et al.*, 1981). Scott *et al.*, (2000) reported decreased seed pods per jimsonweed plant with increasing density; however, the number of seed pods per acre was increased.

Currently registered postemergence herbicides allow growers to successfully manage jimsonweed in peanut; however, questions exist concerning treatment threshold levels. Additionally, weed seed production has been cited as a concern of growers and other agricultural personnel (Czapar *et al.*, 1997). By comparison, common ragweed (*Ambrosia artemisiifolia* L.) is considered a problematic weed whose interference in peanut had negative impacts including increased disease incidence,

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peanut size and yield reductions (Clewis *et al.*, 2001). Common ragweed is ranked at 3.8 on a competitive index, 2 points less than jimsonweed (Jordan, 2006).

Not only do weeds cause yield loss in peanut but also peanut inversion can be affected, thus causing reduced harvesting efficiency (Clewis *et al.*, 2001). Jimsonweed has been noted as a problematic weed in North Carolina and Virginia and the effects of interference in peanut have not been evaluated. Therefore, objectives of this study were to determine yield and growth reductions caused by jimsonweed interference in peanut.

Materials and Methods

Experiments were conducted in 2004 at the Upper Coastal Plain Research Station located near Rocky Mount, NC and the Cherry Research Farm near Goldsboro, NC. The soil types were Norfolk loamy sand (fine-loamy siliceous thermic Typic Paleudults) with 2.1% organic matter and pH 6.1 and Wickham loamy sand (fine-loamy, mixed, thermic Typic Hapludults) with 2.1% organic matter and pH 5.8, respectively. The soil was disked and seedbeds were conventionally prepared (Jordan, 2006). The peanut cultivars 'Perry' and 'VA-98R' were planted 5.0 cm deep at 134 kg/ha on May 10, 2004 in Goldsboro and May 12, 2004 in Rocky Mount.

The experimental design was a randomized complete block with 3 replications. Individual plots consisted of four rows spaced 91 cm apart that were 6.1 m long. Fertilization, insect, and disease management practices were standard for peanut production in North Carolina (Brandenburg, 2005; Jordan, 2005; Shew, 2006).

Greenhouse-grown jimsonweed seedlings at the cotyledon to 2-leaf stage were planted into plots immediately after peanut planting at the following densities: 0, 1, 2, 4, 8, 16, or 32 plants per 6.1 m of row or 0, 0.16, 0.33, 0.66, 1.31, 2.62, or 5.25 plants per m of row. Jimsonweed seedlings were planted into the center two rows of each plot with the two outer rows left as weed-free borders. The transplanting method allowed the establishment of plants with uniform size and distribution along the row. Although jimsonweed seedlings were transplanted at peanut planting, an acclimation period of 1 to 2 wk was required before the jimsonweed plants resumed growth (data not shown). Peanut emerged within 1 wk of planting and had nearly equaled jimsonweed height at the first measuring interval 2 wk after planting. Herbicide applications of clethodim at 0.28 g ai/ha over the top and a hooded application of acifluorfen at 0.14 kg ai/ha plus bentazon at 0.28 g ai/ha (to keep the herbicide treatments off of the jimsonweed) were made six weeks after planting to control weeds other than jimsonweed. Clethodim does not control or injure jimsonweed (Jordan, 2006). In addition to herbicide application, the experimental area was kept weed-free by weekly hand removal.

Height measurements were recorded for up to four jimsonweed plants (one treatment contained only two jimsonweed plants in a plot) and four peanut plants and peanut canopy diameter measurements were taken bi-weekly during the season. At the end of the growing season, up to four jimsonweed plants were harvested in each plot, and the remaining plants were cut at ground level to facilitate peanut inversion and harvest. At jimsonweed harvest, seed pods were hand-removed from plants, kept separate, and seed production was quantified. Plants and pods were dried and dry weights were taken for each sample. Peanut yield was determined by inverting the middle two rows of each plot and allowing the peanuts to air-dry in the field for approximately 1 wk. Finally, peanuts were harvested with a combine modified for small-plot research and weighed.

Statistical Analyses. Data were tested for homogeneity of variance prior to statistical analysis by plotting residuals. Analysis of variance (ANOVA) was performed on peanut yield loss, jimsonweed dry biomass, jimsonweed seed weight and number, and jimsonweed pod weight. Linear, quadratic, and higher-order effects were tested by partitioning sums of squares (Draper and Smith, 1981). Location was considered a random variable, and the weed-density main effects were tested by the error associated with the appropriate location by weed-density interaction (McIntosh, 1983). Significant effects were explained using appropriate regression. Nonlinear models were used if ANOVA indicated that higher-order polynomial effects of jimsonweed density were more significant than linear or quadratic effects. Iterations were performed to determine parameter estimates with least sums of squares for all nonlinear models using the Gauss-Newton method via PRO NLIN in SAS ([SAS] 1998).

Plant height was measured at different time intervals after planting each location. Therefore, the Gompertz equation (Equation 1, Draper and Smith, 1981) was fitted to plant height of each species in each plot:

$$Y_h = Ae^{Be^{KT}} \qquad (1)$$

Where Y_h is plant height in centimeters, A is the upper asymptote for late-season plant height, B

and K are constants, e is the base of natural logarithms, and T is time in weeks after planting. Multivariate analysis of variance was conducted on the three estimated parameters for each fitted curve to test for location, weed-density, and location by weed-density effects.

The relationship between jimsonweed density per meter of row and percent peanut yield loss was fitted to the rectangular hyperbola (Equation 2) (Cousens, 1998).

$$Y_L = (ID)/[1 + (ID/A)] \qquad (2)$$

Yield loss (YL) is based on percent reduction of weed-free yield. A is the asymptote for yield loss and was constrained to 100%. D is the density per meter of crop row and I is the yield loss per weed as weed density approaches zero.

Coefficients of determination (R^2) were calculated for all regressions. For linear equations, R^2 values were calculated as 100 times the ratio of regression sums of squares to corrected total sums of squares (Askew *et al*., 2001; Draper and Smith, 1981). Where a nonlinear equation was fitted to the data, an approximate R^2 value, was calculated by other researchers (Askew *et al*., 2001; Draper and Smith, 1981; Jasieniuk *et al*., 1999), was obtained by subtracting the ratio of residual sums of squares to corrected total sums of squares from Equation 1. The R^2 and residual mean squares were used to determine goodness of fit to nonlinear models.

Results and Discussion

Plant diameter and height. Peanut diameter, measured as canopy row width at four random locations, increased over time in plots with low jimsonweed density. However, in the two highest density jimsonweed plots, peanut diameters were less than 25 cm. Average peanut diameter at the lower jimsonweed densities was near 85 cm (93% of row width) at harvest. Thus, peanut diameter does not seem a reliable predictor of peanut productivity or jimsonweed interference.

Analysis of variance on estimated parameters of the Gompertz equation (Equation 1) (Draper and Smith, 1981) indicated that jimsonweed and peanut heights were both significantly affected by jimsonweed density while location affects were not significant. Data were therefore pooled to explain the effect of jimsonweed density on jimsonweed and peanut heights (Figure 1). Furthermore, trends in plant height over time indicated that maximum jimsonweed density effects occurred at 11 weeks after planting (WAP). Peanut height increased
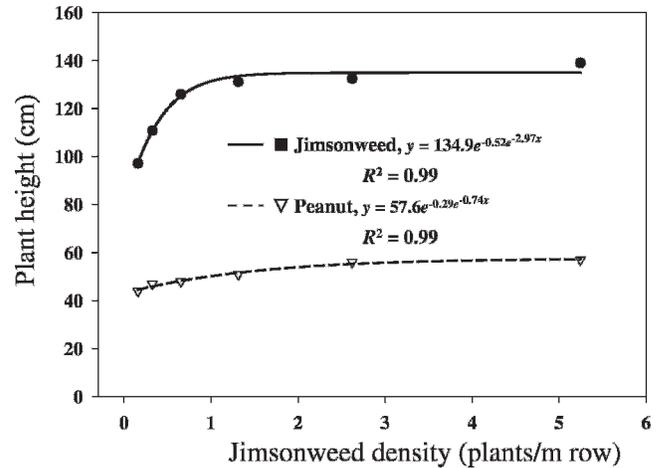

Fig. 1. Relationship between jimsonweed density and peanut height and jimsonweed height over the growing season, averaged over location.

from 44 to 57 cm as jimsonweed density increased from 0 to 5.25 plants/m of row (Figure 1). Likewise, jimsonweed heights increased from 97 to 139 cm as jimsonweed density increased from 0 to 5.25 plants/m of row.

Jimsonweed biomass. There was no location effect for jimsonweed plant and seedpod weights; therefore, data were combined over locations. Jimsonweed plant and seedpod weights were significantly influenced by jimsonweed density (Figure 2). As jimsonweed density increased, plant and pod weight decreased logarithmically, indicating intra-specific weed interference weed interference at the higher weed densities. Plant weight in Figure 2 consists of dry vegetative matter and totaled 620 g when plants were grown at the lowest jimsonweed density. The 918 g total plant weight was 68% vegetative matter and 32% pods (Figure 2). Thus, reproductive structures contribute a substantial amount of jimsonweed dry biomass at
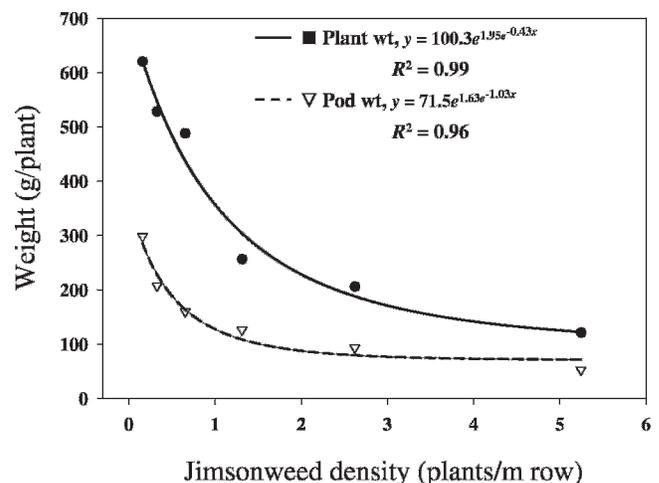

Fig. 2. Relationship between jimsonweed density per meter of crop row and jimsonweed total plant weight and total pod weight, averaged over location.
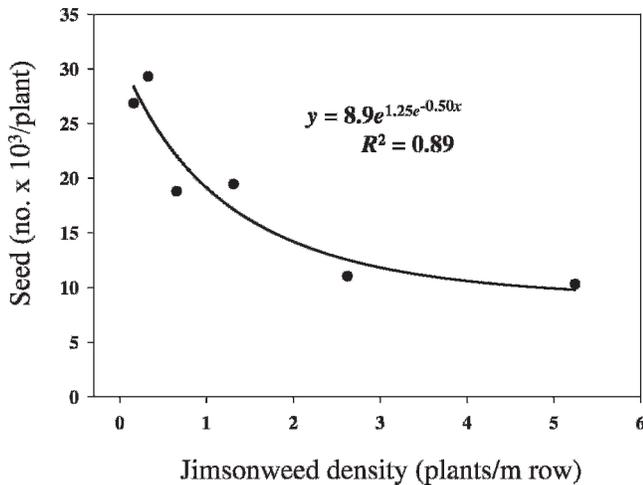
Fig. 3. Relationship between jimsonweed density per meter of crop row and jimsonweed seed production, averaged over location. A hyperbolic function ($Y = ID/1+ID/A$) was used where I is the initial slope and A is the asymptote of seed production/m^2.

Fig. 4. Relationship between jimsonweed density and peanut yield loss, averaged over location. A hyperbolic yield loss function ($Y_L = ID/1+ID/A$) was used where I is the initial slope, D is the density per meter of crop row, and A is the asymptote of percent yield loss (100%).

peanut harvest. When jimsonweed were grown at the highest density, vegetative weight was 121 g (70% of total) and pods contributed 52 g (30% of total). Although both plant weight and pod weight decreased as jimsonweed density increased, jimsonweed's competitive index remained more stable at between 30 and 32% based on trends in Figure 2.

Jimsonweed seed production. There was no location effect for jimsonweed seed production; therefore, data were combined over locations. Number of seed produced per plant decreased with increasing jimsonweed density (Figure 3). When jimsonweed was grown at lower densities, seed production amounted to nearly 30,000 per plant, which was reduced to 10,000 per plant when densities increased to 5.25 plants per m of row. However, overall seed production increased from 60,0000 seed/plot at the lowest density to 640,000 seed/plot at the highest density (data not shown). Increasing jimsonweed density also decreased seed per plant and increased total seed produced when grown in competition with cotton (Scott *et al.*, 2000).

Peanut yield loss. Analysis of variance on estimated parameters of the rectangular hyperbola equation (Equation 2) (Cousens, 1987) indicated that peanut heights were significantly affected by jimsonweed density while location effects were not significant. Data were therefore pooled to explain the effect of jimsonweed density on peanut yield (Figure 4). Percent peanut yield reduction increased with increasing jimsonweed density. Jimsonweed density on percent peanut yield loss resulted in *i* and *a* values of 10.7 and 98, respectively (Figure 4). Jimsonweed's competitiveness with peanut at lower densities is similar to competitiveness in cotton (Scott *et al.*, 2000). As
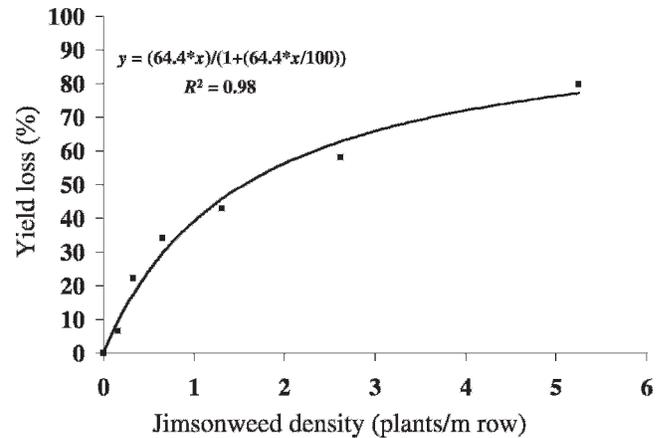
additional comparisons in peanut, the *i* value for common ragweed was 68 (Clewis *et al.*, 2001) and 149.5 for cocklebur (Royal *et al.*, 1997), indicating common ragweed and cocklebur were more competitive in peanut than jimsonweed. Common cocklebur (Royal *et al.*, 1997), common ragweed (Clewis *et al.*, 2001), Florida beggarweed (Cardina and Brecke, 1989), and tropic croton (Thomas *et al.*, 2004) plant biomass were also inversely related to peanut yield. Similarities between locations reflect the similarity of peanut yield and weed dry biomass accumulation at each location, however it should be noted that weeds affect crop yield more when yield potential is higher (Swanton *et al.*, 1999).

Predicted peanut yield loss from season-long interference of one jimsonweed plant per meter of crop row was 40% (Figure 4). Using the hyperbolic function (Cousens, 1987) and asymptotic values constrained to 100% yield loss, maximum peanut yield loss when grown with one wild poinsettia (Bridges *et al.*, 1992), tropic croton (Thomas *et al.*, 2004), horsenettle (Hacket *et al.*, 1987), and bristly starbur (Walker *et al.*, 1989) plant per meter of crop was 17, 17, 14, and 13%, respectively. Jimsonweed is more competitive than these weeds; however, its interference is similar to common ragweed and less than common cocklebur. Common ragweed reduced peanut pod yield 40% at one weed per meter of crop row (Clewis *et al.*, 2001), while common cocklebur reduced peanut pod yield 70% at the same density (Royal *et al.*, 1997).

Conclusions

Peanut diameter did not accurately predict peanut productivity or jimsonweed interference.

Weed biomass response to plant density indicated that intra-specific weed interference occurred at higher weed densities. Weed biomass was also inversely related to peanut yield. The high growth rate of jimsonweed coupled with the height of the jimsonweed observed in this study makes jimsonweed one of the most competitive weeds in peanut. When jimsonweed is present and emerges at or before peanut emergence, treatment should be eminent as population densities of jimsonweed rarely occur below economic thresholds. Future studies need to focus on yield loss caused by infestations emerging during the growing season.

Acknowledgements

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