

ABSTRACT

MEYERS, STEPHEN LAWRENCE. Interference and Control of Palmer Amaranth (*Amaranthus palmeri*) in Sweetpotato. (Under the direction of Katie Jennings and Jonathan Schultheis.)

The most common and troublesome weed in North Carolina sweetpotato is Palmer amaranth, an upright, branching, annual weed with rapid growth and high fecundity.

Field studies were conducted in 2007 and 2008 to develop a Palmer amaranth management program in sweetpotato using density models to establish thresholds, and herbicides for control.

Palmer amaranth was established at 0, 0.5, 1.1, 1.6, 3.3, and 6.5 plants/m within the sweetpotato row and densities maintained season-long. Jumbo, no. 1, and marketable sweetpotato yield loss ranged from 56 to 94%, 30 to 85%, and 36 to 81%, respectively for 0.5 to 6.5 Palmer amaranth/m. Yield loss displayed a positive linear relationship with Palmer amaranth light interception. Light intercepted by the Palmer amaranth canopy increased linearly from 0.5 to 6.5 plants/m and was greater than 42% regardless of density. Palmer amaranth height was greater than 2 m for all treatments and plant canopy width (66 to 136 cm) and shoot dry biomass/plant (0.3 to 1.1 kg) decreased linearly as density increased. Volumetric soil water content differed by treatment at one location. Soil moisture 8 weeks after transplanting (WAP) was greatest at a Palmer amaranth density of 3.3 plants/m.

Preemergence herbicide treatments consisted of flumioxazin applied 2 days before transplanting at 91 or 109 g ai/ha alone or followed by (fb) *S*-metolachlor at 0.8,

1.1, or 1.3 kg ai/ha applied immediately after transplanting or 2 WAP. Palmer amaranth control was similar for all rates of *S*-metolachlor. In 2008, flumioxazin at 109 g/ha provided greater control than 91 g/ha. Flumioxazin fb *S*-metolachlor immediately after transplanting provided over 90% season long Palmer amaranth control. Flumioxazin fb *S*-metolachlor 2 WAP provided over 90% control in 2007 but 38 to 79% control in 2008. *S*-metolachlor applied alone immediately after transplanting provided 80 to 93% and 92 to 96% control in 2007 and 2008, respectively. *S*-metolachlor applied alone 2 WAP did not provide acceptable Palmer amaranth control. Visual crop injury due to treatment was less than 3%. Sweetpotato yield corresponded to Palmer amaranth control. Sweetpotato root shape was unaffected by all treatments.

Glyphosate applied through a Dixie wick applicator was evaluated for Palmer amaranth control and safety to sweetpotato. In 2007, treatments consisted of glyphosate wicked 6 and 8 WAP and glyphosate wicked 6 and 8 WAP fb rotary mowing 9 WAP. In 2008, treatments consisted of glyphosate wicked once 4 or 7 WAP, wicked sequentially 4 and 7 WAP, mowed once 4 WAP, and mowed 4 WAP fb wicking 7 WAP. Palmer amaranth contacted by the wicking apparatus was controlled, but plants shorter than the wicking height escaped treatment. Interference prior to and between glyphosate treatment applications contributed to large sweetpotato yield losses. Treatments of glyphosate applied 7 or 8 WAP (in 2007 and 2008, respectively) frequently had greater no. 1 and marketable yields compared to the weedy control. However, jumbo, no. 1, and marketable yields for all glyphosate and mowing treatments were generally less than half the weed-free control. No additional control was provided by mowing. Cracked

sweetpotato roots were observed in glyphosate treatments and percent cracking (by weight) ranged from 0 to 12 for no. 1 grade roots and 0 to 9 for marketable roots. No cracked roots were observed in weedy, weed-free, or mowing once 4 WAP treatments.

Relatively low Palmer amaranth densities contribute to large sweetpotato yield losses. Palmer amaranth should be managed below the sweetpotato canopy with a preemergence program consisting of flumioxazin pretransplant and *S*-metolachlor after transplanting.

Interference and Control of Palmer Amaranth (*Amaranthus palmeri*) in Sweetpotato

by
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DEDICATION

To all those who see potential in a seed.

BIOGRAPHY

Stephen Lawrence Meyers was born August 31, 1984, to Lawrence and Pamela Meyers. One of five children he discovered a passion for horticulture in the sandy-loam soil of his Rensselaer, IN vegetable garden. He graduated from Rensselaer Central High School in 2003. In 2007, Stephen graduated from Purdue University with a Bachelor of Science Degree in Horticultural Production and Marketing with emphases in Plant Biology and Weed Science. While at Purdue University Stephen was fortunate to work closely with researchers and extension specialists in the fields of viticulture, weed science, 4-H, and consumer research. While working for the Department of Youth Development and Agricultural Education, he contributed text and photographs to the newest Indiana 4-H Floriculture curriculum.

He married Jessica Ponsford June 2, 2007, and moved shortly thereafter to Raleigh, NC in pursuit of a Master of Science Degree at North Carolina State University. Under the direction of Drs. Katie Jennings, Jonathan Schultheis, and David Monks, Stephen conducted research evaluating the interference and control of Palmer amaranth in sweetpotato.

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Short Title: Meyers et al.: Palmer amaranth interference in sweetpotato

Interference of Palmer Amaranth (*Amaranthus palmeri*) in Sweetpotato

Stephen L. Meyers, Katherine M. Jennings, Jonathan R. Schultheis, and David W.
Monks

Field studies were conducted in 2007 and 2008 at Clinton and Faison, NC to evaluate the influence of Palmer amaranth density on 'Beauregard' and 'Covington' sweetpotato yield and quality and to quantify the influence of Palmer amaranth on light interception and soil moisture. Palmer amaranth was established at 0, 0.5, 1.1, 1.6, 3.3, and 6.5 plants m^{-1} within the sweetpotato row and densities maintained season-long. Jumbo, no. 1, and marketable sweetpotato yield loss were fit to a rectangular hyperbola model and yield loss ranged from 56 to 94%, 30 to 85%, and 36 to 81%, respectively for Palmer amaranth densities of 0.5 to 6.5 plants m^{-1} . Percent jumbo, no. 1, and marketable sweetpotato yield loss displayed a positive linear relationship with Palmer amaranth light interception as early as 6 to 7 weeks after planting ($R^2 = 0.96, 0.85, \text{ and } 0.91$, respectively). Light intercepted by the Palmer amaranth canopy increased linearly from 0.5 to 6.5 plants m^{-1} ; light interception was greater than 42% regardless of density. Palmer amaranth height was greater than 2 m for all treatments and plant width (66 to 136 cm) and shoot dry biomass $plant^{-1}$ (0.3 to 1.1 kg) decreased linearly as density increased. Volumetric soil water content ($m^3 m^{-3}$) differed by treatment at one location. Soil moisture eight weeks after planting (0.32) was greatest at a Palmer amaranth density of 3.3 plants m^{-1} .

Nomenclature: Palmer amaranth, *Amaranthus palmeri* S. Wats. AMAPA; sweetpotato, *Ipomoea batatas* L. Lam. 'Beauregard' and 'Covington' IPOBA.

Key words: weed density, light interception, competition, rectangular hyperbola model, shoot dry biomass, volumetric soil moisture.

Sweetpotato [*Ipomoea batatas* (L.) Lam.] production in the United States is concentrated in the Southeast. North Carolina ranks first in sweetpotato hectareage with 40% of the nation's total in 2007 (USDA-NASS 2009). North Carolina combined with Alabama, Florida, Georgia, Louisiana, Mississippi, and South Carolina (southeastern states) produce 80% of all sweetpotato hectareage (USDA-NASS 2009). North Carolina sweetpotato produces an average of 23,000 kg of marketable roots ha⁻¹ (NCDA & CS 2008), but yield and quality can be limited by various pests, including weeds (Seem et al. 2003; Treadwell et al. 2007; Brill 2005). Sweetpotato production in the Southeast consists of crop rotation with soybean (*Glycine max* L. Merr.), tobacco (*Nicotiana tabacum* L.), cotton (*Gossypium hirsutum* L.), and corn (*Zea mays* L.) (Haley and Curtis 2006). Palmer amaranth (*Amaranthus palmeri* S. Watson) and other *Amaranthus* species are among the most troublesome weeds in Louisiana, Mississippi, and North Carolina cotton; Alabama and North Carolina soybean; North Carolina tobacco; and Alabama and Mississippi corn production (Webster 2004, 2005). Palmer amaranth is the most common and troublesome weed species in North Carolina sweetpotato production (Webster 2006).

Palmer amaranth is a member of the amaranth family. Members of the amaranth family grow on a variety of soils and thrive under hot, fertile conditions (Uva et al. 1997). Palmer amaranth and other *Amaranthus* species have become increasingly troublesome in the southern United States from 1974 to 1995 (Webster and Coble 1997). Though often regarded collectively as “pigweeds,” *Amaranthus* species differ greatly in growth parameters including germination, seed production, height, biomass, and leaf area (Guo

and Al-Khatib 2003; Bensch et al. 2003; Sellers et al. 2003; Horak and Loughin 2000).

Palmer amaranth expresses more rapid growth shortly after emergence and greater biomass accumulation when compared to other *Amaranthus* species (Sellers et al. 2003; Horak and Loughin 2000).

The competitive ability of Palmer amaranth has been well documented. The use of C₄ photosynthesis results in a lower CO₂ compensation point and greater photosynthetic rate, growth rate, and water use efficiency (Black et al. 1969; Horak and Loughin 2000; Massinga et al. 2003). Under optimal growing conditions, Palmer amaranth has the potential to grow 0.18 to 0.21 cm per growing degree day, reaching heights over 2 m (Horak and Loughin 2000; Sellers et al. 2003). This growth rate was greater than those observed for common waterhemp (*A. rudis* Sauer), redroot pigweed (*A. retroflexus* L.), and tumble pigweed (*A. albus* L.) (Horak and Loughin 2000).

Norsworthy et al. (2008) reported a maximum Palmer amaranth height of 395 cm in plasticulture-grown bell pepper. Female plants of the dioecious species have been reported to produce up to 600,000 seeds (Keeley et al. 1987). Each seed measures approximately 1 mm in diameter (USDA-NRCS 2009).

Competition studies with Palmer amaranth have been reported in corn, soybean, peanut, cotton, and sorghum. Season-long Palmer amaranth densities from 0.5 to 8 plants m⁻¹ of row reduced corn yields 11 to 91% (Massinga et al. 2001). Soybean yield was reduced 17 to 68% at densities from 0.33 to 10 plants m⁻¹ (Klingaman and Oliver 1994). Similarly Bensch et al. (2003) reported a 79% yield loss in soybean at 8 Palmer amaranth plants m⁻¹ of row. One Palmer amaranth m⁻¹ of crop row reduced peanut yield 28%

(Burke et al. 2007). Cotton yields decreased 13 to 54% at Palmer amaranth densities from 1 to 10 plants 9.1 m^{-1} of row (Morgan et al. 2001). Sorghum grain yield was decreased 1.8 to 3.5% for each Palmer amaranth 15 m^{-1} of row (Moore et al. 2004).

Though competition studies between Palmer amaranth and agronomic crops have been reported, the authors are aware of few studies reporting results of competition between Palmer amaranth and horticultural crops. Studies that have been reported are limited to Solanaceous crops (Garvey 1999; Norsworthy et al. 2008). Competition studies in sweetpotato have been conducted with different species of *Amaranthus* other than Palmer amaranth. Semidey et al. (1987) reported results for competition of spleen amaranth (*A. dubius* Mart. ex Thall) in 'Miguela' sweetpotato in Puerto Rico. The researchers reported that sweetpotato yield and *A. dubius* density displayed an inverse linear relationship and yield losses ranged from 44 to 91% for *A. dubius* densities of 4 to 91 plants m^{-2} (Semidey et al. 1987). In a critical weed-free period study, Seem et al. (2003) reported a reduction in yield of 'Beauregard' sweetpotato grown in competition with a community of weed species that included *A. retroflexus*.

Sweetpotato growers in the southeastern United States have few postemergence herbicide options for control of Palmer amaranth (Holmes and Kemble 2008). Ninety-five percent of growers cultivate sweetpotato fields an average of 2.9 times per growing season (Haley and Curtis 2006). Nineteen percent of growers apply postemergence herbicides via a wicking apparatus between rows an average of 1.6 times per growing season (Haley and Curtis 2006). However, cultivation and wicking may not remove Palmer amaranth in the planted row. Sixty-two percent of growers remove weeds by

hand-hoeing or pulling an average of 1.4 times per growing season (Haley and Curtis 2006). Implementation of weed control measures is often determined with the use of thresholds (Coble and Mortensen 1992). Thresholds compare costs associated with the treatment of a stimulus against the estimated costs of inaction. The costs associated with Palmer amaranth in sweetpotato include potential yield and quality losses, and the contribution of seeds into the soil seed bank. The existence of acetolactate synthase (ALS) inhibitor and glyphosate resistant Palmer amaranth emphasizes the importance of managing soil seed bank contributions as sweetpotato is commonly rotated with Roundup Ready[®] soybean, corn, and cotton. Therefore, studies were conducted to (1) determine the impact of season-long Palmer amaranth density on sweetpotato yield and quality, and (2) to quantify the influence of Palmer amaranth competition on light interception and soil moisture in sweetpotato.

Materials and Methods

Studies were conducted on farm in organically produced sweetpotato in Faison, NC in 2007 and 2008, and in conventionally produced sweetpotato at the Horticultural Crops Research Station, Clinton, NC in 2008. Two fields at Faison (GPS coordinates -78.2344, 35.0772 and -78.1183, 35.0785) were transplanted with certified organic ‘Covington’ sweetpotato slips on June 20, 2007 and June 28, 2008 on a Norfolk loamy sand (fine-loamy, siliceous, thermic Typic Paleudults) with pH 6.5 and 0.52% humic matter and a Wagram loamy sand (loamy, siliceous, thermic Arenic Paleudults) with pH 6.2 and 0.85% humic matter, respectively. Conventional ‘Covington’ and ‘Beauregard’

slips were transplanted in separate fields at Clinton (GPS coordinates -78.2798, 35.0222 and -78.2794, 35.0227) May 30, 2008 on an Orangeburg loamy sand (fine-loamy, siliceous, thermic Typic Paleudults) with pH 5.8 and 0.80% humic matter and June 5, 2008 on a Norfolk loamy sand with pH 5.9 and 0.71% humic matter, respectively. Plot size was two rows each 106 cm wide by 5.5 m long. The experimental design was a randomized complete block with 4 replications for conventional 'Covington' grown at Clinton in 2008 (CC08), 5 replications for organic 'Covington' grown at Faison in 2007 (OC07) and conventional 'Beauregard' grown at Clinton in 2008 (CB08), and 6 replications for organic 'Covington' grown at Faison in 2008 (OC08).

Sweetpotato slips (no roots) were transplanted 30.5 cm apart into fields with historically high Palmer amaranth densities. Treatments of 0 (weed-free check), 0.5, 1.1, 1.6, 3.3, and 6.5 Palmer amaranth m^{-1} were established within one planted row of each plot by hand thinning when Palmer amaranth was approximately 15 cm tall. Densities were maintained season-long by hand removing newly emerged Palmer amaranth seedlings. All other weed species were removed by hand weekly. The second row of each plot was maintained weed-free. Cultural sweetpotato management practices were followed for conventionally produced sweetpotato (Holmes and Kemble 2008).

In 2008 data recorded included light interception, soil moisture, Palmer amaranth height, width, fresh weight, and dry weight, and sweetpotato yield by weight and grade. In 2007 data recorded were limited to yield by weight and grade.

Light interception data were collected on clear, bright days between 1000 and 1300 h by placing a line quantum sensor¹ perpendicularly to the planted row at one

position above the Palmer amaranth canopy and two positions above the sweetpotato canopy in each plot. Light interception was calculated by using Equation 1

$$\{L_{AMAPA} - [(L_{IPOBA1} + L_{IPOBA2})/2]\}/L_{AMAPA} [1]$$

where L_{AMAPA} is ambient light measured above the Palmer amaranth canopy and L_{IPOBA1} and L_{IPOBA2} are light measured at the sweetpotato canopy. Light interception was measured 3 and 10 wk after planting (WAP) at OC08, 6 and 13 WAP at CC08, and 7 and 14 WAP at CB08.

Soil moisture measurements were collected by inserting a Theta probe² 12 cm into two randomly selected locations within the planted row of each plot. Volumetric soil moisture for each plot was calculated as the mean of the two measurements. The zone of water depletion for Palmer amaranth is concentrated in the upper 30 cm of the soil profile (Massinga et al. 2003). Sweetpotato roots are concentrated in the same zone of soil (Woolfe 1992). Soil moisture measurement data were collected 3, 4, and 7 WAP at OC08, 6 and 7 WAP at CC08, and 7 and 8 WAP in CB08.

Five Palmer amaranth plants were measured in each plot from soil level to the top of the tallest Palmer amaranth growth. Three Palmer amaranth plants were measured for plots with a density of 0.5 plants m^{-1} row. Measurements were collected 3, 4, 7, and 16 WAP at OC08, 7 and 16 WAP at CC08, and 8 and 18 WAP at CB08. Five Palmer amaranth plants were randomly harvested for data collection in each plot (three plants from plots with a Palmer amaranth density of 0.5 plants m^{-1} row) 16 WAP at OC08 and CC08, and 18 WAP at CB08. Palmer amaranth width was determined by measuring the greatest distance between the tips of two branches that extended above the sweetpotato

canopy. Main stem branches were counted and internode length between branches calculated as portion of total plant height. Three plants were cut at soil level and placed into a polyethylene pool measuring 150 cm in diameter to prevent loss of plant material. These plants were cut into small pieces using loppers and placed into a two-ply paper bag measuring 40 by 30 by 89 cm. Fresh weight was recorded and the bag discarded. Two different plants were harvested in a similar manner and placed in the same type of bag. Fresh weight was recorded and the sample dried in a forced air drier at 65.5°C for 72 h. The sample was removed and weighed to determine dry weight. Observed fresh and dry weight per plant data were multiplied by the density of Palmer amaranth plants in a plot to determine Palmer amaranth biomass per plot.

Sweetpotatoes at OC07 and OC08 were harvested 121 and 110 d after planting (DAP), respectively using a tractor-mounted disc-type digger. Sweetpotatoes at CC08 and CB08 were harvested 118 and 124 DAP, respectively using a tractor-mounted two row chain digger. Roots were hand graded into jumbo (> than 8.9 cm in diameter), no. 1 (> than 4.4 cm but < 8.9 cm), and canner (> 2.5 cm but < 4.4 cm) (USDA 2005) and weighed. Total marketable yield was calculated as the sum of jumbo, no. 1, and canner yields. Yield loss for each grade was calculated as a percent of the weed-free check plot in each replication.

Data were subjected to analysis of variance using SAS³ PROC Mixed. Means were compared by differences of least square means. Because each location contained only one cultivar, the effect of location was indistinguishable from effect of cultivar. All data were tested for location by treatment interaction using the fixed effects model.

Percent sweetpotato yield loss was fitted to the rectangular hyperbola model (Cousens 1985) in Equation 2

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

where Y_L is predicted percent sweetpotato yield loss (by grade) due to weed competition, I is percent yield loss per unit weed density as density approaches zero, D is weed density, and A is percent yield loss as density approaches infinity. Weed-free plots were excluded from analysis of yield loss because percent yield loss of weed-free treatments equaled zero.

Results and Discussion

Due to a lack of significant location by density interaction, light interception data were combined across all locations for 2008. Light interception data collected 6 WAP at CC08 and 7 WAP at CB08 were combined. Data collected 13 WAP at CC08 and 14 WAP at CB08 were combined. The effect of Palmer amaranth density on light interception was not significant 3 WAP (data not shown). Palmer amaranth light interception 6 to 7 WAP increased from 50 to 75% at Palmer amaranth densities of 0.5 to 6.5 m⁻¹ row (Figure 1). Light interception 10 and 13 to 14 WAP increased from 49 to 81% and 42 to 72%, respectively. Overall light interception was greatest 10 WAP. At 13 to 14 WAP Palmer amaranth leaves had begun to senesce, allowing for more light to reach the sweetpotato canopy. Regardless of Palmer amaranth density, light interception was always greater than 42%. Increased Palmer amaranth branching and plant width contributed to relatively high light interception at low densities. Massinga et al. (2003)

reported that 5 to 15% of Palmer amaranth leaf area occurs 0 to 0.5 m above the ground with the greatest portion of leaf area (80%) partitioned above 1 m. Sweetpotatoes have a vining growth habit and develop a canopy less than 0.5 m tall. Much of the Palmer amaranth canopy and leaf area occur well above the sweetpotato canopy.

Volumetric soil moisture content was analyzed by date across all locations. The effect of Palmer amaranth density on volumetric soil water content 3, 4, 6, and 7 WAP was not significant (data not shown). Average volumetric soil water content ($\text{m}^3 \text{m}^{-3}$) across all treatments 3, 4, 6, and 7 WAP was 0.20, 0.25, 0.21, and 0.24, respectively. Volumetric soil water content was statistically greatest 8 WAP when Palmer amaranth density was 3.3 plants m^{-1} row (Table 1). Adequate rainfall in 2008 (approximately one inch per wk) contributed to a consistent supply of water. On the days volumetric soil water content data were collected, water was not a growth limiting factor.

Palmer amaranth height was not statistically different at any density used and height at harvest averaged across all locations ranged from 210 to 253 cm (Table 2). Palmer amaranth width averaged across all locations decreased linearly from 131 to 66 cm at densities of 0.5 to 6.5 plants m^{-1} (Figure 2). Though no data were reported, Massinga et al. (2003) observed Palmer amaranth plants at lower densities were generally branched and those at greater densities were tall with less lateral growth. The present research confirms the findings of Massinga et al. (2003).

A location by density interaction for the effect of Palmer amaranth density on internode length and main stem branch number was observed. The effect of Palmer amaranth density on internode length and main stem branch number was not significant

at OC08 and CC08 (data not shown). Internode length and main stem branch number averaged across all treatments were 4.4 cm and 49 main stem branches at OC08 and 2.8 cm and 54 main stem branches at CC08, respectively. Internode length and main stem branch number at CB08 ranged from 3.9 to 5.2 cm and 42 to 65 nodes, respectively (Table 2). Palmer amaranth densities of 1.6 and 6.5 plants m^{-1} had the fewest mainstem branches and longest internodes. Jha et al. (2008) reported a reduction in branch appearance rate in Palmer amaranth as artificial shading increased 47 to 87%. Similarly Brainard et al. (2005) reported increased partitioning of dry weight to Powell amaranth (*Amaranthus powellii* S. Watson) stem tissues in plants grown in competition with broccoli. Shading at greater densities contributes to decreases in photosynthetically active radiation (PAR) and in the red to far-red ratio of light transmitted through the Palmer amaranth canopy.

Palmer amaranth shoot dry biomass $plant^{-1}$ decreased linearly from 1.1 to 0.3 kg $plant^{-1}$ as Palmer amaranth density increased from 0.5 to 6.5 plants m^{-1} row (Figure 3). In additive density experiments, individual plant weight is expected to decrease as density increases (Radosevich 1987). Palmer amaranth shoot dry biomass $plot^{-1}$ increased from 3.5 to 11.1 kg $plot^{-1}$ at densities of 0.5 to 3.3 plants m^{-1} (data not shown). Palmer amaranth shoot dry biomass was greatest when Palmer amaranth density was 3.3 plants m^{-1} row. However, shoot dry biomass $plot^{-1}$ at 3.3 plants m^{-1} was not statistically greater than shoot dry biomass at 1.6 and 6.5 plants m^{-1} .

Palmer amaranth density significantly influenced sweetpotato yield and quality. Sweetpotato yield loss was fit to the rectangular hyperbola model (Cousens 1985) (Figure

4). Parameter I, incremental yield loss at low Palmer amaranth densities, was calculated as 259, 86, 12, and 121% for jumbo, no. 1, canner, and marketable grades, respectively. Parameter A, the maximum possible percent yield loss, was calculated as 100, 100, 142, and 90% for jumbo, no. 1, canner, and marketable grades, respectively. Most parameter estimates had a standard error less than half of the value of the estimate. This result indicates an accurate fit (Koutsouyiannis 1973). However, the I parameter estimate for canner grade sweetpotato was 12% with a standard error of 12%. Canner grade roots are generally more variable and less valuable than other grades. Theoretically, losses greater than 100% of the weed-free check are not possible. However, other researchers have presented such values (Massinga et al. 2001; O'Donovan and Blackshaw 1997; Streibig et al. 1989; Swinton et al. 1994). Though the value of A can be constrained to 100% (Clewis et al. 2001; Burke et al. 2007), doing so may influence estimates of I and result in a less accurate description of the data (Streibig et al. 1989). I parameter estimates for Palmer amaranth interference were reported as 39% in peanut (Burke et al. 2007), 61.5% in corn (Massinga et al. 2001), and 11.8 to 104.6% in soybean (Bensch et al. 2003). I parameter estimates in the present study indicate that the effect of Palmer amaranth on initial yield loss in sweetpotato is greater than those observed in peanut, corn, and soybean. Predicted yield loss of jumbo, no. 1, canner, and marketable grades ranged from 56 to 94%, 30 to 85%, 6 to 50%, and 36 to 81%, respectively for Palmer amaranth densities of 0.5 to 6.5 plants m^{-1} . The greatest predicted yield losses were observed in jumbo grade sweetpotato. This observation is most likely due to the inability of sweetpotato roots to grow large enough under Palmer amaranth competition to reach

jumbo grade size. The inability of sweetpotato to produce jumbo grade storage roots is likely due to the intense shading caused by Palmer amaranth which reduced photosynthate being transported to the storage roots. Relatively higher yield losses are to be expected from higher yielding sweetpotato cultivars such as those used in the present study (La Bonte et al. 1999).

Sweetpotato yield loss displayed a strong linear relationship with Palmer amaranth light interception 6 to 7, 10, and 13 to 14 WAP. Much of the variability observed in predicted jumbo, one, and marketable sweetpotato yield loss was due to the effect of light interception. The effect of Palmer amaranth light interception on predicted sweetpotato yield loss was observed 6 to 7 WAP (Figure 5). Results were similar 10 and 13 to 14 WAP (data not shown). Canner grade sweetpotato yield loss was less strongly correlated to light interception 6 to 7, 10, and 13 to 14 WAP (average $R^2 = 0.58$).

The effect of Palmer amaranth density on jumbo, no. 1, and marketable sweetpotato yield loss fit the rectangular hyperbola model (Cousens 1985). Predicted yield loss was a result of competition between Palmer amaranth and sweetpotato for light resources. Palmer amaranth quickly grew taller than the sweetpotato crop and was more than 2 m tall at the time of destructive data collection. Palmer amaranth plants at lower densities grew laterally shading adjacent sweetpotato plants and intercepting more than 42% of available light regardless of density. Palmer amaranth is more competitive in sweetpotato compared to competition studies conducted in peanut, corn, and soybean. At the lowest density used, 0.5 Palmer amaranth m^{-1} row, predicted marketable sweetpotato yield loss was 36%. Sweetpotato growers in the southeast can use yield loss information

to determine an action threshold for Palmer amaranth in sweetpotato. Currently most sweetpotato fields containing Palmer amaranth have a density that will likely require the implementation of control strategies to avoid large crop losses due to competition.

Sources of Materials

¹ Li-Cor LI-191 line quantum sensor, Li-Cor® Biosciences, 4647 Superior Street, Lincoln, NE 68504.

² Theta probe ML2x moisture sensor with 12 cm rods, Delta-T Devices Ltd., 128 Low Road, Burwell, Cambridge, CB5 0EJ, England.

³ SAS, 2004. SAS/STAT® 9.1 User's Guide. SAS Institute Inc., 100 SAS Campus Drive, Cary, NC 27513.

Literature Cited

- Bensch, C. N., M. J. Horak, and D. Peterson. 2003. Interference of redroot pigweed (*Amaranthus retroflexus*), Palmer amaranth (*A. palmeri*), and common waterhemp (*A. rudis*) in soybean. *Weed Sci.* 51:37-43.
- Black, C. L., T. M. Chen, and R. H. Brown. 1969. Biochemical basis for plant competition. *Weed Sci.* 17:338-344.
- Brainard, D. C., R. R. Bellinder, and A. DiTommaso. 2005. Effects of canopy shade on the morphology, phenology, and seed characteristics of Powell amaranth (*Amaranthus powellii*). *Weed Sci.* 53:175-186.
- Brill, N. 2005. Effects of Grower Practices and Field Characteristics on Insect Damage to Sweetpotato (*Ipomoea batatas* (L.) Lam.) Roots. M.S. thesis. North Carolina State University, Raleigh, NC.
- Burke, I. C., M. Schroeder, W. E. Thomas, and J. W. Wilcut. 2007. Palmer amaranth interference and seed production in peanut. *Weed Technol.* 21:367-371.
- Clewis, S. B., S. D. Askew, and J. W. Wilcut. 2001. Common ragweed interference in peanut. *Weed Sci.* 49:768-772.
- Coble, H. D. and D. A. Mortensen. 1992. The threshold concept and its application to weed science. *Weed Technol.* 6:191-195.
- Cousens, R. 1985. A simple model relating yield loss to weed density. *Ann. Appl. Biol.* 107:239-252.
- Garvey, P. V., Jr. 1999. Goosegrass (*Eleusine indica*) and Palmer Amaranth (*Amaranthus palmeri*) Interference in Transplanted Plasticulture Tomato. Ph.D

- dissertation. North Carolina State University, Raleigh, NC.
- Guo, P. and K. Al-Khatib. 2003. Temperature effects on germination and growth of redroot pigweed (*Amaranthus retroflexus*), Palmer amaranth (*A. palmeri*), and common waterhemp (*A. rudis*). *Weed Sci.* 51:869-875.
- Haley, J. and J. Curtis. 2006. Sweetpotato grower survey report of results for 2005 crop. Report for USDA CSREES grant: Risk Avoidance and Mitigation Program (RAMP): Development of grower decision management tools to reduce risk and enhance sustainability of Southern sweetpotato pest management systems.
- Holmes, G. J. and J. M. Kemble, eds. 2008. Vegetable Crop Handbook for the Southeastern United States 2009. Lincolnshire, IL: Vance Publishing Corp. Pp. 93-94, 269.
- Horak, M. J. and T. M. Loughin. 2000. Growth analysis of four *Amaranthus* species. *Weed Sci.* 48:347-355.
- Jha, P., J. K. Norsworthy, M. B. Riley, D. G. Bielenberg, and W. Bridges, Jr. 2008. Acclimation of Palmer amaranth (*Amaranthus palmeri*) to shading. *Weed Sci.* 56:729-734.
- Keeley, P. E., C. H. Carter, and R. J. Thullen. 1987. Influence of planting date on growth of Palmer amaranth (*Amaranthus palmeri*). *Weed Sci.* 35:199-204.
- Klingaman, T. E. and L. R. Oliver. 1994. Palmer amaranth (*Amaranthus palmeri*) interference in soybeans (*Glycine max*). *Weed Sci.* 42:523-527.
- Koutsoyiannis, A. 1973. Theory of Econometrics: An Introductory Exposition of Econometrics Methods. London: MacMillan. pp. 68-95.

- La Bonte, D. R., H. F. Harrison, and C. E. Motsenbocker. 1999. Sweetpotato clone tolerance to weed interference. *Hort Sci.* 34:229-232.
- Massinga, R. A., R. S. Currie, M. J. Horak, and J. Boyer Jr. 2001. Interference of Palmer amaranth in corn. *Weed Sci.* 49:202-208.
- Massinga, R. A., R. S. Currie, and T. P. Trooien. 2003. Water use and light interception under Palmer amaranth (*Amaranthus palmeri*) and corn competition. *Weed Sci.* 51:523-531.
- Moore, J. W., D. S. Murphy, and R. B. Westerman. 2004. Palmer amaranth (*Amaranthus palmeri*) effects on the harvest and yield of grain sorghum (*Sorghum bicolor*). *Weed Technol.* 18:23-29.
- Morgan, G. D., P. A. Baumann, and J. M. Chandler. 2001. Competitive impact of Palmer Amaranth (*Amaranthus palmeri*) on cotton (*Gossypium hirsutum*) development and yield. *Weed Technol.* 15:408-412.
- Norsworthy, J. K., M. J. Oliveira, P. Jha, M. Malik, J. K. Buckelew, K. M. Jennings, and D. W. Monks. 2008. Palmer amaranth and large crabgrass growth with plasticulture-grown bell pepper. *Weed Technol.* 22:296-302.
- [NCDA and CS] North Carolina Department of Agriculture & Consumer Services. 2008. North Carolina Agricultural Statistics. Raleigh, NC: N.C. Department of Agriculture.
- O'Donovan, J. T. and R. E. Blackshaw. 1997. Effect of volunteer barley (*Hordeum vulgare* L.) interference on field pea (*Pisium sativum* L.). *Weed Sci.* 45:249-255.
- Radosevich, S. R. 1987. Methods to study interactions among crops and weeds. *Weed*

- Technol: 1:190-198.
- Seem, J. E., N. G. Creamer, and D. W. Monks. 2003. Critical weed-free period for 'Beauregard' sweetpotato (*Ipomoea batatas*). *Weed Technol.* 17:686-695.
- Sellers, B. A., R. J. Smeda, W. G. Johnson, J. A. Kendig, M. R. Ellersieck. 2003. Comparative growth of six *Amaranthus* species in Missouri. *Weed Sci.* 51:329-333.
- Semidey, N., L. C. Liu, and F. H. Ortiz. 1987. Competition of pigweed (*Amaranthus dubius*) with sweetpotato (*Ipomoea batatas*). *J. Agric. Univ. Puerto Rico.* 71:7-11.
- Streibig, J. C., J. H. Combellack, G. H. Pritchard, and R. G. Richardson. 1989. Estimation of threshold for weed control in Australian cereals. *Weed Res.* 29:117-126.
- Swinton, S. M., D. D. Buhler, F. Forcella, J. L. Gunsolus, and R. P. King. 1994. Estimation of crop yield loss due to interference by multiple weed species. *Weed Sci.* 42:103-109.
- Treadwell, D. D., N. G. Creamer, J. R. Schultheis, and G. D. Hoyt. 2007. Cover crop management affects weeds and yield of organically managed sweetpotato systems. *Weed Technol.* 21:1039-1048.
- [USDA] U.S. Department of Agriculture. 2005. United States Standards for Grades of Sweet Potatoes. Washington, DC: US Department of Agriculture.
- [USDA-NASS] U.S. Department of Agriculture- National Agricultural Statistics Service. 2009. 2007 Census of Agriculture. Washington D.C.: U.S. Department of

Agriculture.

- [USDA-NRCS] U.S. Department of Agriculture- Natural Resources Conservation Service. PLANTS Profile- *Amaranthus palmer* S. Watson, Carelessweed. Available at <http://plants.usda.gov/java/nameSearch?keywordquery=amaranthus+Palmeri&mode=sciname>. Accessed April 27, 2009.
- Uva, R. H., J. C. Neal, and J. M. DiTomasso. 1997. Weeds of the Northeast. New York: Cornell University Press. pp. 90-97.
- Webster, T. M. and H. D. Coble. 1997. Changes in the weed species composition of the southern United States from 1974-1995. *Weed Technol.* 11:308-317.
- Webster, T. M. 2004. Weed survey-southern states. *Proc. South Weed Sci. Soc.* 57:404-426.
- Webster, T. M. 2005. Weed survey-southern states. *Proc. South Weed Sci. Soc.* 58:291-306.
- Webster, T. M. 2006. Weed survey-southern states. *Proc. South Weed Sci. Soc.* 59:260-277.
- Woolfe, J. A. 1992. *Sweet Potato: An Untapped Food Resource*. New York, NY: Cambridge University Press.

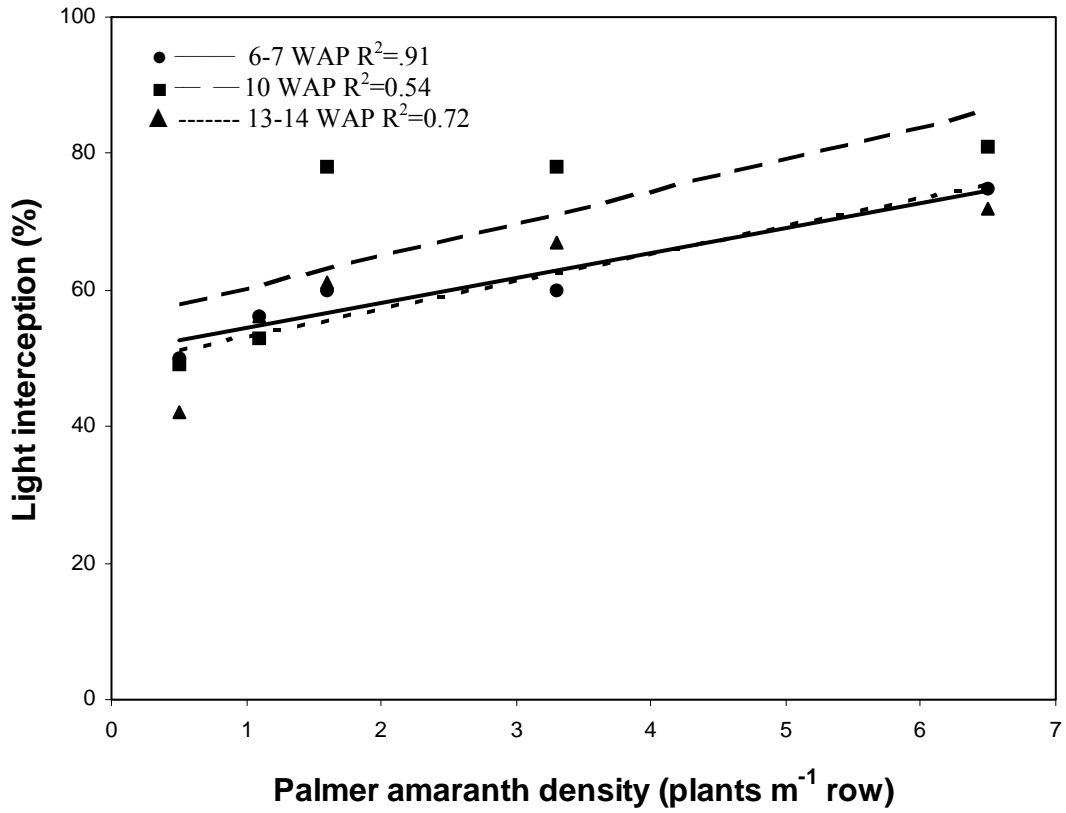


Figure 1.1. Relationship between Palmer amaranth density and Palmer amaranth light interception. Points represent mean data from OC08, CC08, and CB08.

Table 1.1. Volumetric soil water content at a depth of 12 cm at CB08, Clinton, NC 2008.^a

| Palmer amaranth density | Soil moisture 8 WAP |
|-------------------------------|---|
| -----m ⁻¹ row----- | --Volumetric soil water content (m ³ m ⁻³)-- |
| 0.5 | 0.27 a |
| 1.1 | 0.28 a |
| 1.6 | 0.27 a |
| 3.3 | 0.32 b |
| 6.5 | 0.29 a |

^a Means followed by the same letter are not significantly different (P < 0.05).

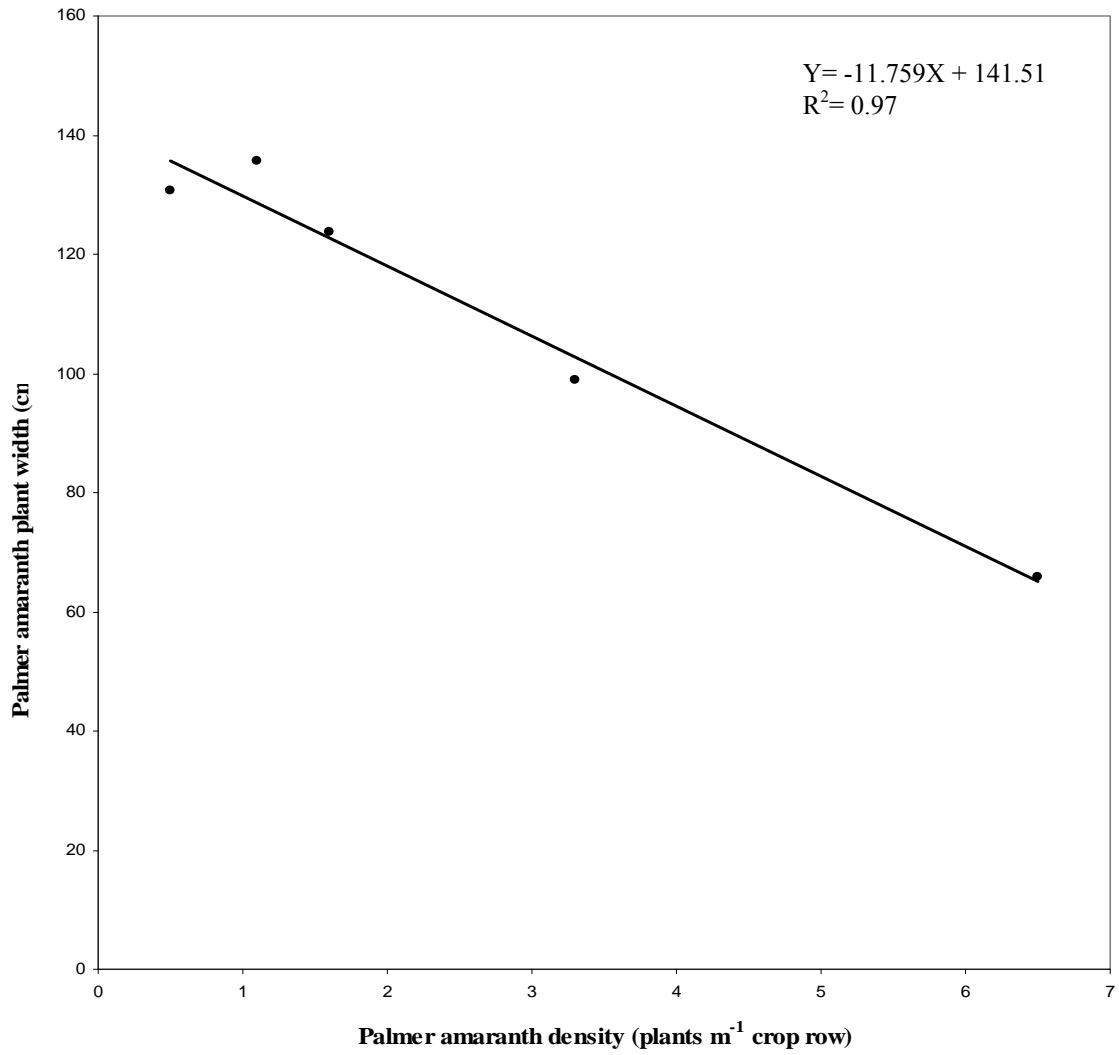


Figure 1.2. Relationship between Palmer amaranth density and Palmer amaranth plant width in centimeters. Points represent mean data from OC08, CC08, and CB08.

Table 1.2. Palmer amaranth height, width, internode length, and mainstem branch number averaged across locations.^a

| AMAPA density | All locations | | CB08 | |
|-------------------------------|---------------|--------|--------------------------------|--------------------|
| | | | AMAPA ^b | |
| | Height | Width | Internode length | Main stem branches |
| -----m ⁻¹ row----- | -----cm----- | | -----plant ⁻¹ ----- | |
| 0.5 | 253 a | 131 c | 3.9 a | 65 b |
| 1.1 | 215 a | 136 c | 3.9 a | 55 b |
| 1.6 | 218 a | 124 bc | 5.2 b | 42 a |
| 3.3 | 212 a | 100 b | 4.2 a | 53 b |
| 6.5 | 210 a | 66 a | 5.0 b | 42 a |

^a Means within a column followed by the same letter are not significantly different ($P < 0.05$).

^b AMAPA = Palmer amaranth (*Amaranthus palmeri*)

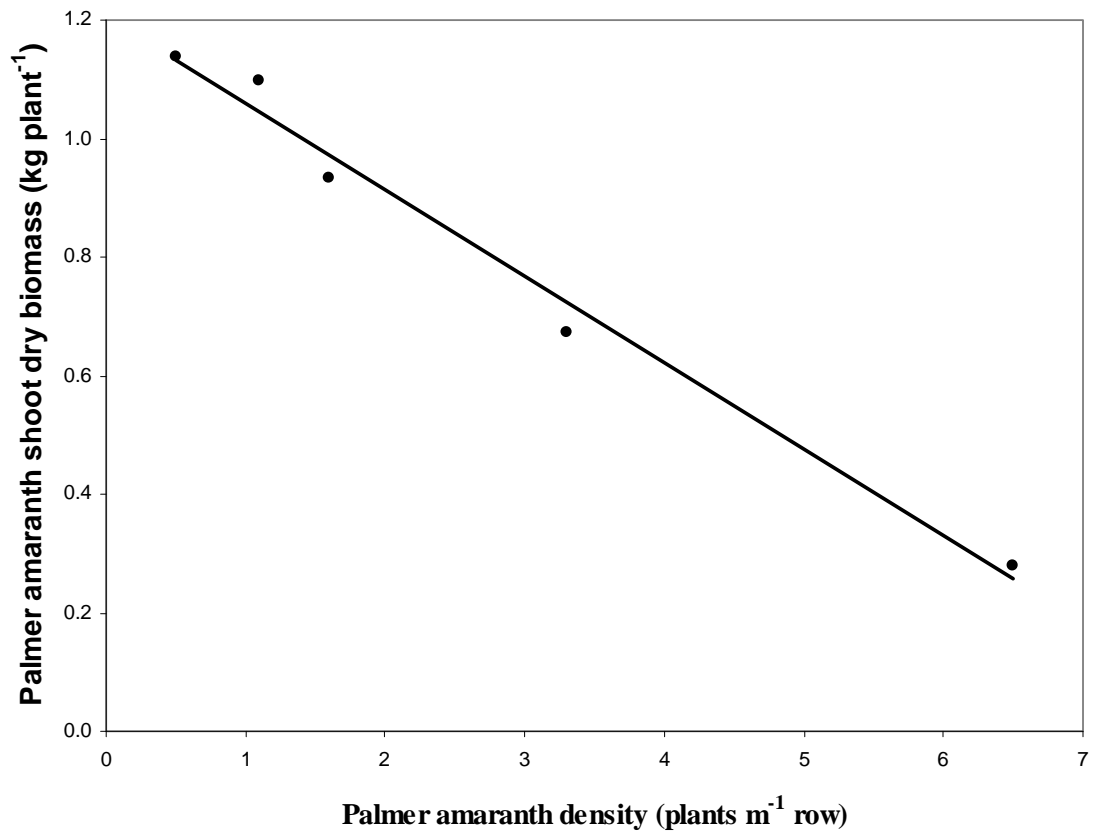


Figure 1.3. Relationship between Palmer amaranth density and Palmer amaranth shoot dry biomass. Points represent mean data from OC08, CC08, and CB08.

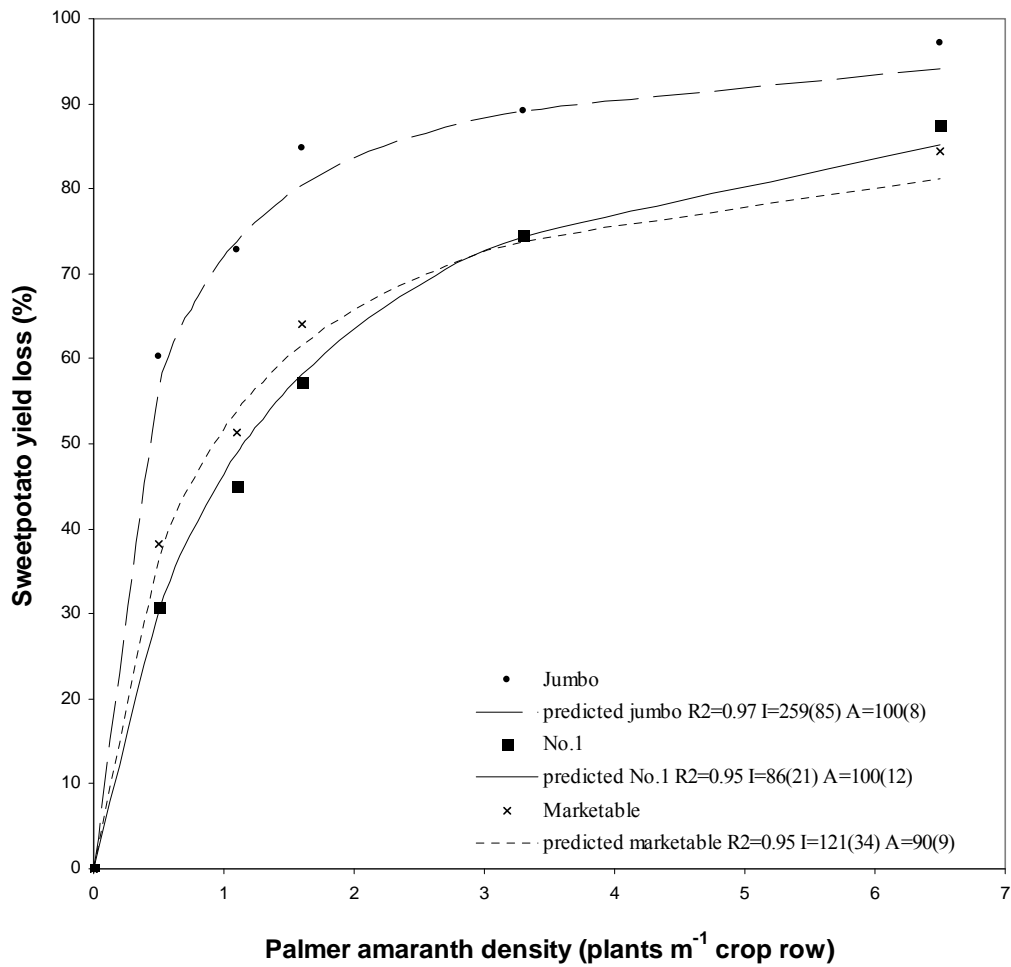


Figure 1.4. Relationship between Palmer amaranth density and sweetpotato yield loss. Points represent mean observed data from OC07, OC08, CC08, and CB08. Lines represent predicted values from the rectangular hyperbola model in Equation 2. I and A parameters are followed by standard error values in parentheses.

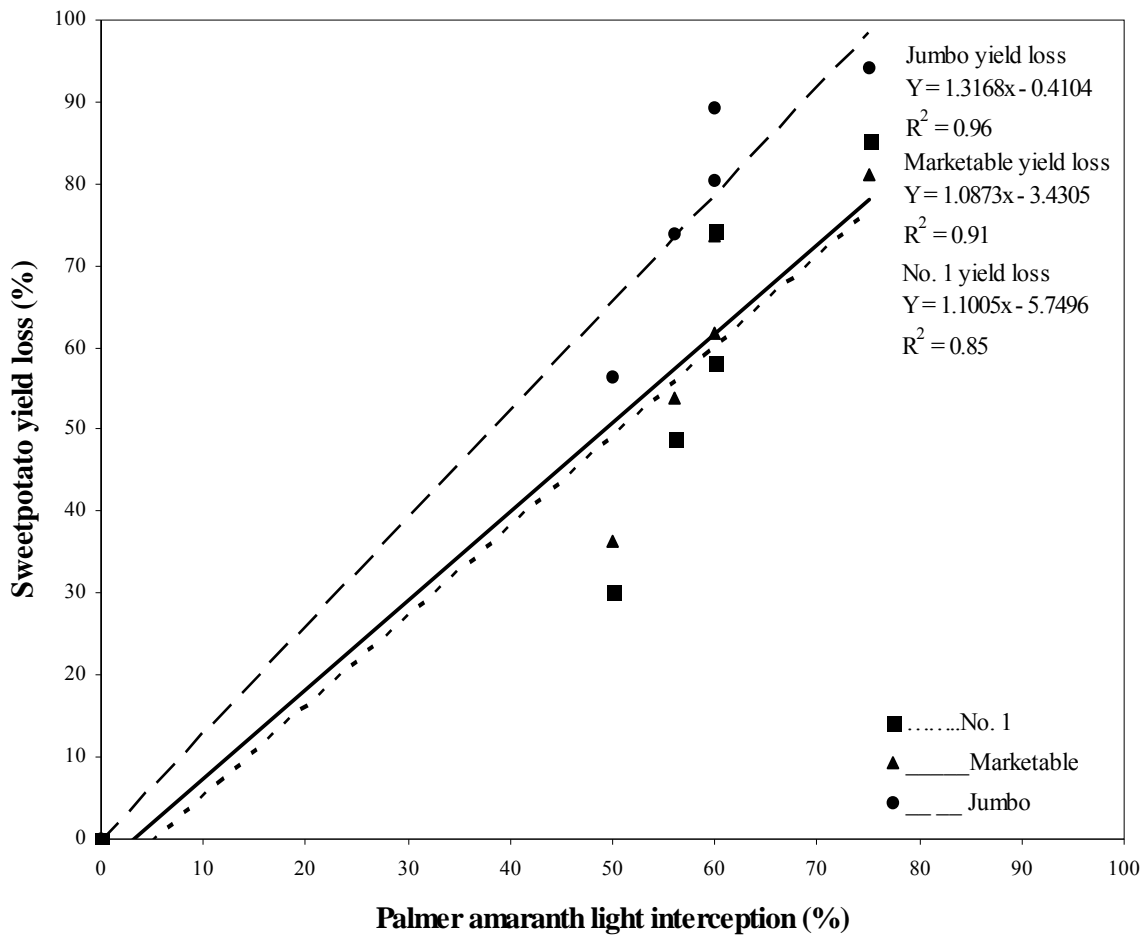


Figure 1.5. Relationship between Palmer amaranth light interception and predicted sweetpotato yield loss. Points represent mean data from OC08.

Short Title: Meyers et al.: Flumioxazin and *S*-metolachlor in sweetpotato

Evaluation of Flumioxazin and *S*-metolachlor Rate and Timing for Palmer

Amaranth (*Amaranthus palmeri*) Control in Sweetpotato

Stephen L. Meyers, Katherine M. Jennings, Jonathan R. Schultheis, and David W.

Monks

Studies were conducted in 2007 and 2008 at Clinton, NC to determine the effect of flumioxazin and *S*-metolachlor rate and timing on Palmer amaranth control and ‘Beauregard’ and ‘Covington’ sweetpotato yield, quality, visual crop injury, and root shape. Treatments consisted of flumioxazin applied preemergence 2 d before transplanting at 91 or 109 g ai/ha alone or fb *S*-metolachlor at 0.8, 1.1, or 1.3 kg ai/ha applied immediately after transplanting or two wk after transplanting (WAP). Palmer amaranth control was similar for all rates of *S*-metolachlor. In 2008, flumioxazin at 109 g/ha provided greater control than 91 g/ha. Flumioxazin fb *S*-metolachlor immediately after transplanting provided excellent (> 90%) season long Palmer amaranth control. Flumioxazin fb *S*-metolachlor 2 WAP provided >90% control in 2007 but variable control (38 to 79%) in 2008. *S*-metolachlor applied alone immediately after transplanting provided 80 to 93% and 92 to 96% control in 2007 and 2008, respectively. *S*-metolachlor applied alone 2 WAP did not provide acceptable Palmer amaranth control. Visual crop injury due to treatment was <3%. Sweetpotato yield was directly related to Palmer amaranth control. Sweetpotato root shape was unaffected by all treatments.

Nomenclature: Palmer amaranth, *Amaranthus palmeri* S. Wats. AMAPA;

sweetpotato, *Ipomoea batatas* L. Lam. 'Covington', 'Beauregard'; flumioxazin;

S-metolachlor.

Key words: weed control, crop injury, yield loss.

Abbreviations: PRE, preemergence; fb, followed-by; WAP, weeks after transplanting.

Sweetpotato [*Ipomoea batatas* (L.) Lam.] production in North Carolina accounted for 17,000 ha in 2007 (USDA-NASS 2009). These hectares yielded 339 million kg of marketable sweetpotato roots at a gross farm value of \$136 million (NCDA & CS 2008). North Carolina ranks first among all states in sweetpotato production and accounted for 40% of the nation's total hectareage in 2007 (USDA-NASS 2009). Sweetpotatoes provide 1.6% of cash receipts from agricultural commodities in North Carolina, the greatest among vegetable crops (NCDA & CS 2008). North Carolina sweetpotatoes average yields of 23,000 kg/ha of marketable roots (NCDA & CS 2008), but yield and quality can be limited by various pests, including weeds (Treadwell et al. 2007; Brill 2005; Seem et al. 2003; La Bonte et al. 1999; Porter 1993; Glaze and Hall 1990; Semidey et al. 1987).

Palmer amaranth (*Amaranthus palmeri* S. Watson) is the most common and troublesome weed species in North Carolina sweetpotato production (Webster 2006). Female Palmer amaranth plants have the potential to produce up to 600,000 seeds/plant; each seed measuring no greater than 1.0 mm in diameter (Keeley et al. 1987; Sellers et al. 2003; USDA-NRCS). Palmer amaranth has the potential to grow 0.18 to 0.21 cm per growing degree day (base temperature = 10° C) (Horak and Loughlin 2000) and accumulate 2.5 g/d of biomass (Monks and Oliver 1988), reaching heights over 2 m (Norsworthy et al. 2008; Horak and Loughlin 2000; Sellers et al. 2003). Within weeks after emergence (WAE) Palmer amaranth easily establishes, and as early as 6 WAE may stand 1 m tall (Burke et al. 2007), well above the canopy of the sweetpotato. Meyers et al. (unpublished data) reported season long Palmer amaranth interference in 'Beauregard' and 'Covington' sweetpotato reduced total marketable sweetpotato yield 36 to 81% at

densities of 0.5 to 6.5 plants/m of crop row and that many North Carolina sweetpotato fields containing Palmer amaranth quickly exceed acceptable densities.

Seem et al. (2003) reported the critical weed free period for 'Beauregard' sweetpotato grown in a weed community that contained redroot pigweed (*A. retroflexus* L.) was 2 to 6 wk after transplanting (WAP). By delaying establishment of this weed until after 6 wk, sweetpotato developed sufficiently to compete with emerging weeds. However, Palmer amaranth and other pigweed species, including *A. retroflexus*, vary greatly in growth parameters and therefore, competitive ability (Guo and Al-Khatib 2003; Bensch et al. 2003; Sellers et al. 2003; Horak and Loughin 2000). Jha and Norsworthy (2005) reported soybean canopy formation had minimal potential to affect temporal Palmer amaranth emergence and that Palmer amaranth displays photosynthetic and morphological plasticity under conditions of 87% or less shading (Jha et al. 2008). However, a delay in Palmer amaranth emergence has been reported to decrease the influence of Palmer amaranth on crop yield loss in corn and soybean (Massinga et al. 2001; Bensch et al. 2003). Keeley et al. (1987) reported that Palmer amaranth planted from July to October produced less dry matter and inflorescences compared to those planted from March to June. The study further reported that plants emerging later in the season flowered sooner after planting (Keeley et al. 1987).

To limit sweetpotato yield loss due to Palmer amaranth competition, fields should be maintained weed-free during the 2 to 6 WAP interval. This can be accomplished with the use of PRE or POST herbicides, cultivation, mowing, or hand removal. PRE options include clomazone, DCPA, napropamide, flumioxazin, and *S*-metolachlor (Holmes and

Kemble 2008). Currently five POST herbicides are registered for use in sweetpotato (Holmes and Kemble 2008), but none are registered for in-row application for Palmer amaranth control. Clethodim, fluazifop, and sethoxydim control annual and perennial grasses, but not pigweed species (Porter 1993; Parker et al. 1985; Glaze and Hall 1990). Glyphosate and carfentrazone-ethyl must be POST-directed to row middles to avoid crop injury (Holmes and Kemble 2008). Nineteen percent of growers apply glyphosate through a wicking apparatus an average of 1.8 times per growing season (Haley and Curtis 2006). According to Haley and Curtis (2006) 96% of North Carolina sweetpotato growers utilize cultivation as a means of weed control with an average of 3.2 cultivation events each growing season. Mowing and hand removal were reportedly used one to three and one to four times a season by 31 and 65% of North Carolina sweetpotato growers, respectively (Haley and Curtis 2006).

Flumioxazin is a soil-applied herbicide that inhibits protoporphyrinogen oxidase, an enzyme important to the synthesis of chlorophyll (Vencill 2002; Hess 2000). Flumioxazin is registered for control of pigweed species in many crops including sweetpotato (Anonymous 2004a). Kelly et al. (2006) reported flumioxazin applied PRE to 'Beauregard' sweetpotato at rates of 36, 72, and 109 g ai/ha controlled 90% of spiny amaranth and when combined with clomazone at 840 g ai/ha gave 100% control of redroot pigweed. Sweetpotato injury was less than 4% 9 d after treatment (DAT) for all PRE treatments applied to field grown transplants (Kelly et al. 2006). Kelly et al. (2006) utilized both flumioxazin and clomazone to broaden the spectrum of weed species controlled. While flumioxazin provides residual control of many common broadleaf

weeds found in sweetpotato, it only suppresses grass weed species (Anonymous 2004a). Haley and Curtis (2006) reported that only 1% of North Carolina sweetpotato growers used flumioxazin in 2005. However, in more recent years, its use has expanded greatly due in part to the increasing distribution and population of Palmer amaranth in North Carolina sweetpotato fields (B. Little, personal communication).

S-metolachlor is a soil-applied chloroacetanilide that inhibits the biosynthesis of fatty acids, lipids, proteins, isoprenoids, and flavanoids (Vencill 2002). *S*-metolachlor is registered for use in sweetpotato in North Carolina by a section 24(c) special local need label at a rate of 0.8 to 1.1 kg ai/ha. When applied alone, *S*-metolachlor controls many species of perennial and annual grasses, yellow nutsedge, and multiple broadleaf weed species including Palmer amaranth. *S*-metolachlor does not provide POST control and must be applied to a weed-free soil surface (Anonymous 2004b). Clewis et al. (2007) reported 68% late-season Palmer amaranth control in peanut when *S*-metolachlor was applied at 1.4 kg ai/ha. When *S*-metolachlor was combined with flumioxazin at 72 g ai/ha, Palmer amaranth control increased to 96% (Clewis et al. 2007). Haley and Curtis (2006) reported that 22% of North Carolina sweetpotato growers used *S*-metolachlor in 2005. However, unlike flumioxazin, *S*-metolachlor use has remained stable (B. Little, personal communication).

Despite *S*-metolachlor's reported efficacy in controlling Palmer amaranth in a range of field crops, some North Carolina sweetpotato growers are hesitant to use chloroacetamide herbicides (B. Little, personal communication). Metolachlor at 3.4 kg/ha was reported to be phytotoxic in 'Centennial' sweetpotato (Monks et al. 1981) and

at 4.48 kg/ha reduced the percentage of marketable sweetpotato roots (Glaze and Hall 1986). Porter (1994) reported no loss in vigor or yield caused by metolachlor, but did report that metolachlor at 2.19 kg/ha caused some sweetpotato roots to be shorter and rounder than roots from control plots and plots with lower rates of metolachlor. Likewise, sweetpotatoes treated with dimethenamid-P, a chloroacetamide herbicide, had a greater occurrence of rounder roots compared to control plots (D. W. Monks, unpublished data).

Shorter, rounder sweetpotato roots have been described as a symptom of chloroacetamide (metolachlor) injury (Clark and Moyer 1988). The same symptoms can be explained by drought, excessive fertilizer, weed competition, and other stresses (Clark and Moyer 1988). Metolachlor at 1.12, 2.24, and 3.36 kg/ha showed no evidence of misshapen roots in 'Beauregard', 'Hernandez', 'Jewel', and 'Darby' sweetpotatoes (Porter 1995). Monks et al. (1998) reported metolachlor PRE at 1.1 or 2.2 kg/ha caused no injury or yield reduction in 'Beauregard' or 'Jewel' sweetpotatoes and root length in herbicide treatments did not differ from the cultivated control. Monks et al. (1998) reported sweetpotato root length was the lowest in the weedy control plots.

Flumioxazin and *S*-metolachlor offer different spectra of weed species control yet both are registered to control *Amaranthus* spp (Anonymous 2004a, Anonymous 2004b). The objectives of this research were to develop an effective herbicide program for Palmer amaranth control utilizing flumioxazin and *S*-metolachlor to reduce Palmer amaranth interference during the 2 to 6 WAP critical weed free period, and to evaluate the influence of flumioxazin and *S*-metolachlor on sweetpotato (visual injury, yield, quality,

and root shape).

Materials and Methods

Studies were conducted at the Horticultural Crops Research Station in Clinton, NC in 2007 and 2008. Two fields were transplanted with ‘Beauregard’ sweetpotato slips on 22 June 2007 on an Orangeburg loamy sand (fine-loamy, siliceous, thermic Typic Paleudults) with pH 6.1 and 0.23% humic matter. On 5 June 2008 one field was transplanted with ‘Beauregard’ and ‘Covington’ sweetpotato slips on a Norfolk loamy sand (fine-loamy, siliceous, thermic Typic Paleudults) with pH 5.9 and 0.71% humic matter. Plot size was three rows each 106 cm wide and 5.5 or 7.6 m long in 2007 and 2008, respectively. The first row of each plot was nontreated and served as a border row buffer; the second and third rows were treated. The experimental design was a randomized complete block with four replications.

Flumioxazin¹ was applied PRE 2 d before transplanting at 0, 91 or 109 g ai/ha alone or followed by (fb) *S*-metolachlor² at 0, 0.8, 1.1, or 1.3 kg ai/ha PRE immediately after transplanting or 2 WAP. *S*-metolachlor applications at 2 WAP immediately followed cultivation. Weed-free and weedy checks were included for comparison. Treatments of *S*-metolachlor alone at 0.8 kg/ha (both immediately after transplanting and 2 WAP) and flumioxazin alone at 91 and 109 g/ha PRE 2 d before transplanting were not included for studies conducted in 2007. These treatments were added in 2008 to provide a full complement of herbicide rates and application times. All treatments were applied with a CO₂ pressurized backpack sprayer calibrated to deliver 187 L/ha with DG8002³

nozzle tips at 241 to 290 kPa. All treatments received 0.6 cm irrigation or rainfall 1 d before to 3 d after application. Sethoxydim⁴ at 0.34 kg ai/ha plus crop oil⁵ was applied POST as needed to control goosegrass [*Eleusine indica* (L.) Gaertn.] and large crabgrass [*Digitaria sanguinalis* (L.) Scop.].

Data recorded included Palmer amaranth control and visual crop injury ratings, sweetpotato stand counts, yield by weight and grade, and root length to width ratio. Palmer amaranth control and sweetpotato injury were recorded 12, 32, 77, and 101 d after transplanting (DAP) in 2007, and 12, 28, 64, and 126 DAP in 2008. Injury and control ratings were based on a scale of 0 (no crop injury or no Palmer amaranth control) to 100 percent (crop death or complete Palmer amaranth control). Sweetpotatoes were harvested 112 and 126 DAP in 2007 and 2008, respectively using a tractor-mounted single row chain digger and hand graded into jumbos (> than 8.9 cm in diameter), no. 1 (> than 4.4 cm but < 8.9 cm), and canners (> 2.5 cm but < 4.4 cm) (USDA 2005). Marketable yield was calculated as the sum of jumbo, no. 1, and canner grades. Twenty no. 1 grade roots were randomly chosen from each plot to determine the influence of herbicide treatment on root shape. The length and width of each root was measured using a digital caliper⁶ according to grading standards (USDA 2005); length to width ratio was calculated.

Data were subjected to ANOVA and analyzed by SAS⁷ PROC GLM. The means of the main effects were analyzed using contrast statements. Palmer amaranth control and sweetpotato injury ratings were transformed using the arcsin of the square root of the data. Means were separated using t-tests with LSD and P = 0.05. Weed-free and weedy checks were included in yield analysis. Crop injury and Palmer amaranth control data

from these treatments were not included in data analysis as crop injury and Palmer amaranth control were 0 and 100% and 0 and 0% for weed-free and weedy check plots, respectively.

Results and Discussion

Palmer Amaranth Control.

The effect of treatment on Palmer amaranth control differed from 2007 to 2008. In 2007, no treatment by location interaction was observed. In 2008, no treatment by cultivar interaction was observed. Therefore, data were analyzed separately by year, but combined across both locations in 2007, and both 'Beauregard' and 'Covington' in 2008. In 2007, Palmer amaranth control 12 DAP was 100% for all treatments (Table 1). Control ranged from 30 to 100%, 18 to 100%, and 13 to 100% 32, 77, and 101 DAP, respectively. Treatments containing *S*-metolachlor alone at 1.1 and 1.3 kg/ha applied 2 WAP provided the least control, only 55 and 30% 32 DAP, 44 and 18% 77 DAP, and 35 and 13% 101 DAP, respectively. Treatments with flumioxazin at 91 or 109 g/ha provided greater than 90% Palmer amaranth control 101 DAP regardless of *S*-metolachlor rate and application time. Treatments consisting of *S*-metolachlor alone at 1.1 and 1.3 kg/ha applied immediately after transplanting provided 80 and 93% Palmer amaranth control 101 DAP, respectively.

In 2007, treatments consisting of flumioxazin pre transplant at 91 and 109 g/ha provided greater Palmer amaranth control 101 DAP compared to treatments of flumioxazin at 0 g ai/ha (Table 2). No difference in control was observed between

flumioxazin at 91 and 109 g ai/ha. Palmer amaranth control was not improved when *S*-metolachlor was applied immediately after transplanting following PRE application of flumioxazin. However, when *S*-metolachlor application was delayed until 2 WAP, greater Palmer amaranth control was observed for treatments with flumioxazin fb *S*-metolachlor compared to *S*-metolachlor alone. No differences in control were observed for *S*-metolachlor at 0.8, 1.1, and 1.3 kg ai/ha (data not shown). *S*-metolachlor application time was only significant for controlling Palmer amaranth when *S*-metolachlor was applied alone (flumioxazin = 0 g ai/ha) (Table 3). When applied alone, *S*-metolachlor treatments applied immediately after transplanting provided 63% greater control than those applied 2 WAP. In 2007, flumioxazin at 91 and 109 g/ha provided Palmer control through the first two WAP and allowed for *S*-metolachlor to be applied 2 WAP to a weed free soil surface. However, plots with treatments of *S*-metolachlor alone applied 2 WAP contained Palmer amaranth that emerged in the 2 WAP time period. Palmer amaranth control trends were similar 12, 32, and 77 DAP (data not shown).

In 2008, Palmer amaranth control ranged from 88 to 100%, 37 to 100%, 19 to 97%, and 29 to 100% 12, 28, 64, and 126 DAP, respectively (Table 4). Treatments consisting of *S*-metolachlor applied immediately after transplanting provided excellent Palmer amaranth control regardless of *S*-metolachlor and flumioxazin rate. Treatments of flumioxazin alone at 91 and 109 g/ha provided 97 and 96% Palmer amaranth control 12 DAP, but control quickly declined and was 60 and 59% 126 DAP, respectively. Season long Palmer amaranth control for treatments consisting of *S*-metolachlor applied 2 WAP was varied and ranged from 29 to 79%.

In 2008, flumioxazin at 91 and 109 g/ha provided greater Palmer amaranth control 12 DAP compared to flumioxazin at 0 g/ha (Table 5). Flumioxazin at 109 g/ha provided better Palmer amaranth control than flumioxazin at 0 or 91 g/ha 28 and 64 DAP. Flumioxazin at 109 g/ha provided 9% better Palmer amaranth control than flumioxazin at 91 g/ha 126 DAP. While flumioxazin at 91 g/ha is recommended for control of many *Amaranthus* species, 109 g/ha is recommended for control of Palmer amaranth (Anonymous 2004a). The present research agrees with the labeled recommendation as better control at 109 g/ha was realized in 2008. The addition of flumioxazin did not affect control for treatments receiving *S*-metolachlor immediately after transplanting. However, when *S*-metolachlor application was delayed until 2 WAP, control was greater 12, 28, and 64 DAP for treatments consisting of flumioxazin fb *S*-metolachlor compared to treatments consisting of *S*-metolachlor alone. *S*-metolachlor at 1.3 kg/ha provided better Palmer amaranth control than 0.8 kg/ha 64 DAP (Table 6). No other influence of *S*-metolachlor rate on Palmer amaranth control was observed. The effect of *S*-metolachlor application time was highly significant; treatments consisting of *S*-metolachlor applied immediately after transplanting provided greater Palmer amaranth control compared to treatments of *S*-metolachlor applied 2 WAP. Palmer amaranth escapes from flumioxazin treatments were greater in studies from 2008 than in 2007. These escapes were also missed by cultivation. *S*-metolachlor applied 2 WAP did not control emerged Palmer amaranth. This observation is consistent with the product label (Anonymous 2004b).

The present research suggests that an application of *S*-metolachlor alone at 0.8

kg/ha applied immediately after transplanting has the potential to provide Palmer amaranth control during the 2 to 6 WAP critical weed free period. However, activation of PRE herbicides is typically dependant upon irrigation or rainfall events shortly after application (Anonymous 2004a, 2004b). The application of *S*-metolachlor immediately after transplanting and before Palmer amaranth emergence may be difficult for North Carolina sweetpotato growers who may have hundreds or thousands of ha to spray in a relatively short period of time. The inclusion of flumioxazin PRE 2 to 5 d before transplanting will contribute to Palmer amaranth control prior to the *S*-metolachlor application and allow for greater flexibility in *S*-metolachlor application time. Finally, inclusion of flumioxazin PRE 2 to 5 d before transplanting fb *S*-metolachlor immediately after trasnplanting is likely to reduce the risk of Palmer amaranth establishment in sweetpotato.

Sweetpotato Injury.

Sweetpotato crop injury (stunting and chlorosis relative to the weed free control plot) was analyzed by year, across both locations in 2007 and both cultivars in 2008. In 2007, no sweetpotato injury was observed 12 DAP. Treatment did not influence sweetpotato injury 32 ($p = 0.46$), 77 ($p = 0.09$), and 101 DAP ($p = 0.48$). Sweetpotato stunting injury 32 DAP was less than 1% for all treatments. Chlorosis injury 77 and 101 DAP ranged from 0 to 3% and 1 to 6%, respectively. Injury observed 77 and 101 DAP followed a sethoxydim application used to control grassy weed species. Injury at these times did not correspond with treatment and were likely due to the addition of crop oil included in the sethoxydim application (Anonymous 2005). In 2008, treatment did not

influence sweetpotato injury 12 DAP ($p = 0.56$). Stunting injury 28 and 64 DAP was less than 3% for all treatments. Though injury in some treatments was significant (data not shown), injury in all treatments 28 and 64 DAP was minimal ($< 3\%$) and would likely be considered acceptable injury by North Carolina sweetpotato growers (D. W. Monks, personal communication). No injury was observed 126 DAP. These data are similar to those reported by Kelly et al. (2006).

Sweetpotato Yield.

As with the dependent variables measured, reported, and discussed earlier, sweetpotato yield data were analyzed separately by year and across locations in 2007 and cultivars in 2008. Due to a lack of sweetpotato injury, yield responses to treatment were primarily the result of relative Palmer amaranth control. In 2007, weed-free control plots yielded 9,687; 29,758; 4,882; and 44,249 kg/ha of jumbo, no. 1, canner, and marketable roots, respectively (Table 1). Relative to the weedy control, marketable yield was greater in all treatments with one exception. The exception was marketable yield for plots containing *S*-metolachlor alone 2 WAP at 1.3 kg/ha which was statistically similar to the weedy control. Jumbo, no. 1, and marketable yields were greatest for treatments consisting of flumioxazin at 91 or 109 g/ha compared to those with flumioxazin at 0 g/ha (Table 2). Canner yield was greatest for treatments consisting of flumioxazin at 91 g/ha. The affect of flumioxazin on yield was not significant when *S*-metolachlor was applied immediately after transplanting. However, when *S*-metolachlor application was delayed until 2 WAP, yield of all sweetpotato grades was greater for treatments consisting of flumioxazin fb *S*-metolachlor than those of *S*-metolachlor alone. *S*-metolachlor rate did

not affect yield of any sweetpotato grade (data not shown). For treatments containing flumioxazin at 91 g/ha, there was no affect of *S*-metolachlor application time on yield (Table 3). *S*-metolachlor applied alone (flumioxazin = 0 g/ha) immediately after transplanting resulted in greater yield of jumbo, no. 1, and marketable sweetpotatoes than when applied 2 WAP. This is likely due to the increased level of Palmer amaranth control by these treatments. Flumioxazin at 109 g/ha fb *S*-metolachlor immediately after transplanting resulted in greater jumbo yield but lower canner yield compared to flumioxazin at 109 g/ha fb *S*-metolachlor 2 WAP.

In 2008, weed free control plots yielded 4,854; 17,687; 8,425; and 30,967 kg/ha of jumbo, no. 1, canner, and marketable sweetpotatoes, respectively (Table 4). Most treatments had greater marketable yield than the weedy control. However, marketable yield from treatments of flumioxazin alone at 109 g/ha, *S*-metolachlor alone at 0.8 or 1.1 kg/ha applied 2 WAP, and flumioxazin at 91 g/ha fb *S*-metolachlor at 0.8 kg/ha were statistically similar to the weedy control. Flumioxazin at 109 g/ha had greater no.1 and marketable sweetpotato yield compared to flumioxazin at 0 g/ha (Table 5). The addition of flumioxazin to *S*-metolachlor treatments applied immediately after transplant did not result in additional yield of any grade of sweetpotato. However, if *S*-metolachlor application was delayed until 2 WAP, treatments containing flumioxazin fb *S*-metolachlor had greater yield of all sweetpotato grades compared to treatments of *S*-metolachlor alone. Treatments containing *S*-metolachlor at 1.3 kg/ha had greater jumbo, no. 1, and marketable yield compared to 1.1 kg/ha and greater jumbo yield compared to 0.8 kg/ha (Table 6). The influence of *S*-metolachlor application time on yield was highly

significant. *S*-metolachlor applied alone immediately after transplanting compared to 2 WAP had greater jumbo, no. 1, canner, and marketable yield. Results were similar for treatments containing flumioxazin at 91 and 109 g/ha.

Sweetpotato Root Length to Width Ratio.

Sweetpotato length to width ratio data differed by year, location in 2007, and cultivar in 2008. However, due to a lack of location by treatment interaction in 2007 and cultivar by treatment interaction in 2008, data were analyzed separately by year and across both locations in 2007 and ‘Beauregard’ and ‘Covington’ in 2008. In 2007, treatment did not influence sweetpotato root shape (data not shown); root length to width ratio averaged across both locations and all treatments was 2.5 for ‘Beauregard’. In 2008, root length to width ratio differed slightly by *S*-metolachlor application time. Length to width ratios were 2.1 and 2.2 for treatments consisting of *S*-metolachlor immediately after transplanting and 2 WAP, respectively. Ratios averaged across all treatments were 2.4 and 1.9 for ‘Beauregard’ and ‘Covington’, respectively. These ratios are similar to those reported by Yencho et al. (2008).

Treatments of flumioxazin PRE 2 d before transplanting fb *S*-metolachlor immediately after transplanting and *S*-metolachlor alone immediately after transplanting provided excellent Palmer amaranth control. Flumioxazin fb *S*-metolachlor 2 WAP provided excellent control in 2007 but unacceptable control in 2008. *S*-metolachlor alone 2 WAP did not provide acceptable control in either year. Control was similar for all rates of *S*-metolachlor (0.8, 1.1, and 1.3 kg/ha). In 2008, greater Palmer amaranth control was observed with flumioxazin at 109 g/ha than with 91 g/ha. Sweetpotato crop injury was

minimal and root length to width ratio was similar for all treatments. Sweetpotato yield loss was directly related to Palmer amaranth control. The present research suggests that flumioxazin PRE before transplanting fb S-metolachlor after transplanting provide an effective herbicide program for control of Palmer amaranth in sweetpotato.

Sources of Materials

¹ Valor® SX, Valent U.S.A. Corporation, P.O. Box 8025, Walnut Creek, CA 94596.

² Dual Magnum®, Syngenta Crop Protection, Inc., 410 South Swing Road, Greensboro, NC 27409.

³ Teejet DG 8002, Teejet® Technologies, P.O. Box 7900, Wheaton, IL 60187.

⁴ Poast®, BASF Corporation, 26 Davis Drive, Research Triangle Park, NC 27709.

⁵ Agri-Dex, Helena Chemical Company, 225 Schilling Boulevard, Suite 300, Collierville, TN 38017.

⁶ Mitutoyo Absolute Series-500 digital caliper, code number 500-196-20, Mitutoyo U.S.A., 965 Corporate Boulevard, Aurora, IL 60502.

⁷ SAS, 2004. SAS/STAT® 9.1 User's Guide. SAS Institute Inc., 100 SAS Campus Drive, Cary, NC 27513.

Literature Cited

- Anonymous. 2004a. Valor® SX herbicide label. Walnut Creek, CA: Valent U.S.A. Corporation.
- Anonymous. 2004b. Dual Magnum® herbicide label. Greensboro, NC: Syngenta Crop Protection, Inc.
- Anonymous. 2005. Agri-Dex® adjuvant label. Collierville, TN: Helena Chemical Co.
- Bensch, C. N., M. J. Horak, and D. Peterson. 2003. Interference of redroot pigweed (*Amaranthus retroflexus*), Palmer amaranth (*A. palmeri*), and common waterhemp (*A. rudis*) in soybean. *Weed Sci.* 51:37-43.
- Brill, N. 2005. Effects of Grower Practices and Field Characteristics on Insect Damage to Sweetpotato (*Ipomoea batatas* (L.) Lam.) Roots. M.S. thesis. North Carolina State University, Raleigh, NC.
- Burke, I. C., M. Schroeder, W. E. Thomas, and J. W. Wilcut. 2007. Palmer amaranth interference and seed production in peanut. *Weed Technol.* 21:367-371.
- Clark, C. A. and J. W. Moyer, eds. 1988. Compendium of Sweet Potato Diseases. St. Paul, MN: The American Phytopathological Society. Pp. 57-59.
- Clewis, S. B., W. J. Everman, D. L. Jordan, and J. W. Wilcut. 2007. Weed management in North Carolina peanuts (*Arachis hypogaea*) with S-metolachlor, diclosulam, flumioxazin, and sulfentrazone systems. *Weed Technol.* 21:629-635.
- Glaze, N. C. and M. R. Hall. 1986. The effects of herbicides on weed control and yield of sweet potatoes. *Proc. South. Weed Sci. Soc.* 39:172.
- Glaze, N. C. and M. R. Hall. 1990. Cultivation and herbicides for weed control in sweet

- potato (*Ipomoea batatas*). *Weed Technol.* 4:518-523.
- Guo, P. and K. Al-Khatib. 2003. Temperature effects on germination and growth of redroot pigweed (*Amaranthus retroflexus*), Palmer amaranth (*A. palmeri*), and common waterhemp (*A. rudis*). *Weed Sci.* 51:869-875.
- Haley, J. and J. Curtis. 2006. Sweetpotato grower survey report of results for 2005 crop. Report for USDA CSREES grant: Risk Avoidance and Mitigation Program (RAMP): Development of grower decision management tools to reduce risk and enhance sustainability of Southern sweetpotato pest management systems.
- Hess, F. D. 2000. Light-dependent herbicides: an overview. *Weed Sci.* 48:160-170.
- Holmes, G. J. and J. M. Kemble, eds. 2008. *Vegetable Crop Handbook for the Southeastern United States 2009*. Lincolnshire, IL: Vance Publishing Corp. Pp. 93-94, 269.
- Horak, M. J. and T. M. Loughin. 2000. Growth and analysis of four *Amaranthus* species. *Weed Sci.* 48:347-355.
- Jha, P. and J. K. Norsworthy. 2005. Effect of soybean canopy formation and tillage on temporal emergence of Palmer amaranth. *Proc. South. Weed Sci. Soc.* 58:214.
- Jha, P., J. K. Norsworthy, M. B. Riley, D. G. Bielenberg, and W. Bridges, Jr. 2008. Acclimation of Palmer amaranth (*Amaranthus palmeri*) to shading. *Weed Sci.* 56:729-734.
- Keeley, P. E., C. H. Carter, and R. J. Thullen. 1987. Influence of planting date on growth of Palmer amaranth (*Amaranthus palmeri*). *Weed Sci.* 35:199-204.
- Kelly, S. T., M. W. Shankle, and D. K. Miller. 2006. Efficacy and tolerance of

- flumioxazin on sweetpotato (*Ipomoea batatas*). *Weed Technol.* 20:334-339.
- Klingaman, T. E. and L. R. Oliver. 1994. Palmer amaranth (*Amaranthus palmeri*) interference in soybeans (*Glycine max*). *Weed Sci.* 42:523-527.
- La Bonte, D. R., H. F. Harrison, and C. E. Motsenbocker. 1999. Sweetpotato clone tolerance to weed interference. *Hort Sci.* 34:229-232.
- Massinga, R. A., R. S. Currie, M. J. Horak, and J. Boyer Jr. 2001. Interference of Palmer amaranth in corn. *Weed Sci.* 49:202-208.
- Monks, D. W., D. L. Coffey, T. D. Cordrey, and W. J. McLaurin. 1981. Herbicide evaluation in sweet potatoes. *Proc. South. Weed Sci. Soc.* 34:106.
- Monks, D. W. and L. R. Oliver. 1988. Interactions between soybean (*Glycine max*) cultivars and selected weeds. *Weed Sci.* 36:770-774.
- Monks, D. W., W. E. Mitchem, R. J. Mills, and C. V. Greeson. 1998. Response of nutsedge and sweetpotato to EPTC and metolachlor. *Proc. South. Weed Sci. Soc.* 51:91.
- [NCDA and CS] North Carolina Department of Agriculture & Consumer Services. 2008. North Carolina Agricultural Statistics. Raleigh, NC: N.C. Department of Agriculture.
- Norsworthy, J. K., M. J. Oliveira, P. Jha, M. Malik, J. K. Buckelew, K. M. Jennings, and D. W. Monks. 2008. Palmer amaranth and large crabgrass growth with plasticulture-grown bell pepper. *Weed Technol.* 22:296-302.
- Parker, N. Y., T. J. Monaco, R. B. Leidy, and T. J. Sheets. 1985. Weed control with fluazifop and residues in cucurbit crops (*Cucumis* sp.) and sweet potatoes

- (*Ipomoea batatas*). *Weed Sci.* 33:405-410.
- Porter, W. C. 1993. Postemergence grass control in sweet potatoes (*Ipomoea batatas*).
Weed Technol. 7:812-815.
- Porter, W. C. 1994. Sedge (*Cyperus* spp.) control in sweet potatoes. *Proc. South. Weed
Sci. Soc.* 47:79.
- Porter, W. C. 1995. Response of sweetpotato cultivars to metolachlor. *Hort Sci.*
30:441.
- Seem, J. E., N. G. Creamer, and D. W. Monks. 2003. Critical weed-free period for
'Beauregard' sweetpotato (*Ipomoea batatas*). *Weed Technol.* 17:686-695.
- Sellers, B. A., R. J. Smeda, W. G. Johnson, J. A. Kendig, and M. R. Ellersieck. 2003.
Comparative growth of six *Amaranthus* species in Missouri. *Weed Sci.* 51:329-
333.
- Semidey, N., L. C. Liu, and F. H. Ortiz. 1987. Competition of pigweed (*Amaranth
dubius*) with sweetpotato (*Ipomoea batatas*). *J. Agric. Univ. Puerto Rico.* 71:7-
11.
- Treadwell, D. D., N. G. Creamer, J. R. Schultheis, and G. D. Hoyt. 2007. Cover crop
management affects weeds and yield of organically managed sweetpotato
systems. *Weed Technol.* 21:1039-1048.
- [USDA] U.S. Department of Agriculture. 2005. United States Standards for Grades of
Sweet Potatoes. Washington, DC: U.S. Department of Agriculture.
- [USDA-NASS] U.S. Department of Agriculture- National Agricultural Statistics
Service. 2009. 2007 Census of Agriculture. Washington D.C.: U.S. Department

of Agriculture.

[USDA-NRCS] U.S. Department of Agriculture- Natural Resources Conservation

Service. PLANTS Profile- *Amaranthus palmer* S. Watson, Carelessweed.

Available at [http://plants.usda.gov/java/nameSearch?keywordquery=amaranthus+](http://plants.usda.gov/java/nameSearch?keywordquery=amaranthus+Palmeri&mode=sciname)

Palmeri&mode=sciname. Accessed April 27, 2009.

Vincill (Check the spelling of Vencill), W. K., ed. 2002. Herbicide Handbook. 8th ed.

Champaign, IL: Weed Science Society of America. Pp. 200-202, 299-300.

Webster, T. M. 2006. Weed survey-southern states. Proc. South Weed Sci. Soc.

59:260-277.

Yencho, G. C., K. V. Pecota, J. R. Schultheis, Z. P. VanEsbroeck, G. J. Holmes, B. E.

Little, A. C. Thornton, and V. D. Truong. 2008. 'Covington' sweetpotato. Hort.

Sci. 43:1911-1914.

Table 2.1. Palmer amaranth control and 'Beauregard' sweetpotato yield at Clinton, NC in 2007^a.

| Treatment | | AMAPA control ^{bc} | | | | Sweetpotato yield | | | |
|--------------------------|----------------------------|-----------------------------|-----|-----|-----|-------------------|--------|--------|-------------------------|
| Flumioxazin ^d | S-metolachlor ^e | 12 | 32 | 77 | 101 | Jumbo | No. 1 | Canner | Marketable ^f |
| ----g ai/ha---- | ----kg ai/ha---- | -----%----- | | | | -----kg/ha----- | | | |
| | Weed free | -- | -- | -- | -- | 9,687 | 29,758 | 4,882 | 44,249 |
| | Weedy | -- | -- | -- | -- | 465 | 4,495 | 2,480 | 7,439 |
| 0 | 0.8 PRE ₁ | -- | -- | -- | -- | -- | -- | -- | -- |
| 0 | 1.1 PRE ₁ | 100 | 87 | 88 | 80 | 7,284 | 16,816 | 4,107 | 28,208 |
| 0 | 1.3 PRE ₁ | 100 | 98 | 100 | 93 | 9,299 | 22,086 | 4,960 | 36,345 |
| 91 | 0 | -- | -- | -- | -- | -- | -- | -- | -- |
| 91 | 0.8 PRE ₁ | 100 | 99 | 100 | 95 | 8,214 | 22,086 | 3,565 | 33,865 |
| 91 | 1.1 PRE ₁ | 100 | 100 | 100 | 94 | 8,834 | 24,566 | 4,882 | 38,205 |
| 91 | 1.3 PRE ₁ | 100 | 100 | 100 | 96 | 5,967 | 23,403 | 4,727 | 34,098 |
| 109 | 0 | -- | -- | -- | -- | -- | -- | -- | -- |
| 109 | 0.8 PRE ₁ | 100 | 99 | 100 | 91 | 10,927 | 22,163 | 4,572 | 37,585 |
| 109 | 1.1 PRE ₁ | 100 | 100 | 100 | 97 | 8,679 | 20,846 | 5,115 | 34,640 |
| 109 | 1.3 PRE ₁ | 100 | 100 | 100 | 96 | 10,849 | 21,233 | 4,650 | 36,732 |
| 0 | 0.8 PRE ₂ | -- | -- | -- | -- | -- | -- | -- | -- |
| 0 | 1.1 PRE ₂ | 100 | 55 | 44 | 35 | 1,395 | 13,562 | 4,572 | 19,529 |
| 0 | 1.3 PRE ₂ | 100 | 30 | 18 | 13 | 387 | 6,200 | 3,177 | 9,842 |
| 91 | 0.8 PRE ₂ | 100 | 99 | 100 | 97 | 7,129 | 24,721 | 4,805 | 36,655 |
| 91 | 1.1 PRE ₂ | 100 | 98 | 100 | 97 | 7,672 | 21,698 | 3,720 | 33,013 |
| 91 | 1.3 PRE ₂ | 100 | 99 | 100 | 100 | 8,369 | 19,141 | 5,425 | 32,858 |
| 109 | 0.8 PRE ₂ | 100 | 100 | 100 | 98 | 5,890 | 22,861 | 6,665 | 35,415 |
| 109 | 1.1 PRE ₂ | 100 | 98 | 100 | 95 | 7,517 | 24,566 | 5,580 | 37,662 |
| 109 | 1.3 PRE ₂ | 100 | 99 | 100 | 99 | 8,292 | 20,769 | 5,502 | 34,563 |
| LSD (.05) | | 0 | 15 | 11 | 15 | 4,650 | 6,665 | 1,550 | 7,904 |

^a Data combined across all locations in 2007. ^b AMAPA = *Amaranthus palmeri*; Palmer amaranth. ^c Rating: 0% = no control; 100% = complete control. ^d All flumioxazin treatments applied PRE two days before transplanting. ^e S-metolachlor applied PRE₁ immediately after transplanting or PRE₂ 2 WAP. ^f Marketable is the aggregate of jumbo, no. 1, and canner grades.

Table 2.2. Effect of flumioxazin rate and *S*-metolachlor application time on Palmer amaranth control and sweetpotato yield at Clinton, NC in 2007^a.

| Treatment | Control ^{bcd} | Sweetpotato yield | | | |
|--|------------------------|-------------------|--------|--------|-------------------------|
| | AMAPA | Jumbo | No. 1 | Canner | Marketable ^e |
| | ---%--- | -----kg/ha----- | | | |
| Flumioxazin 0 g ai/ha | 55 | 4,581 | 14,648 | 4,199 | 23,428 |
| Flumioxazin 91 g ai/ha | 97 | 7,677 | 22,579 | 7,505 | 34,761 |
| Flumioxazin 109 g ai/ha | 96 | 8,678 | 22,053 | 5,332 | 36,063 |
| Flumioxazin fb <i>S</i> -metolachlor at transplant | 96 | 8,565 | 22,503 | 4,828 | 35,896 |
| <i>S</i> -metolachlor at transplant | 87 | 8,281 | 19,427 | 4,511 | 32,219 |
| Flumioxazin fb <i>S</i> -metolachlor 2 WAP | 98 | 7,940 | 21,518 | 5,044 | 34,502 |
| <i>S</i> -Metolachlor 2 WAP | 24 | 882 | 9,869 | 3,887 | 14,638 |
| Contrast ^f | | | | | |
| Flumioxazin 0 vs 91 g ai/ha | *** | ** | *** | * | *** |
| Flumioxazin 0 vs 109 g ai/ha | *** | *** | *** | * | *** |
| Flumioxazin 91 vs 109 g ai/ha | NS | NS | NS | * | NS |
| Flumioxazin fb <i>S</i> -metolachlor at transplant vs <i>S</i> -metolachlor at transplant | NS | NS | NS | NS | NS |
| Flumioxazin fb <i>S</i> -metolachlor 2 WAP vs <i>S</i> -metolachlor 2 WAP | *** | *** | *** | * | *** |

^a Data combined across all locations in 2007. ^b Palmer amaranth control 101 DAP. ^c AMAPA = *Amaranthus palmeri*; Palmer amaranth.

^d Rating: 0% = no control; 100% = complete control. ^e Marketable is the aggregate of jumbo, no. 1, and canner grades.

^f Contrast followed by NS, *, **, and *** are not significant or significant at P= 0.05, 0.01 and 0.001, respectively.

Table 2.3. Effect of flumioxazin rate and *S*-metolachlor application time on Palmer amaranth control and sweetpotato yield at Clinton, NC in 2007 (continued)^a.

| Treatment | Control ^{bcd} | | Sweetpotato yield | | |
|--|------------------------|-----------------|-------------------|--------|-------------------------|
| | AMAPA | Jumbo | No. 1 | Canner | Marketable ^e |
| | ---%--- | -----kg/ha----- | | | |
| Flumioxazin 0 g ai/ha fb <i>S</i> -metolachlor at transplant | 87 | 8,281 | 19,427 | 4,511 | 32,219 |
| Flumioxazin 0 g ai/ha fb <i>S</i> -metolachlor 2 WAP | 24 | 882 | 9,869 | 3,887 | 4,879 |
| Flumioxazin 91 g ai/ha fb <i>S</i> -metolachlor at transplant | 95 | 7,649 | 23,340 | 4,379 | 35,368 |
| Flumioxazin 91 g ai/ha fb <i>S</i> -metolachlor 2 WAP | 98 | 7,705 | 21,818 | 4,630 | 34,153 |
| Flumioxazin 109 g ai/ha fb <i>S</i> -metolachlor at transplant | 95 | 10,125 | 21,405 | 4,740 | 37,567 |
| Flumioxazin 109 g ai/ha fb <i>S</i> -metolachlor 2 WAP | 97 | 7,231 | 22,702 | 5,914 | 35,847 |
| Contrast ^f | | | | | |
| <i>S</i> -metolachlor at transplant vs 2 WAP (flumioxazin=0 g ai/ha) | *** | *** | *** | NS | *** |
| <i>S</i> -metolachlor at transplant vs 2 WAP (flumioxazin=91 g ai/ha) | NS | NS | NS | NS | NS |
| <i>S</i> -metolachlor at transplant vs 2 WAP (flumioxazin=109 g ai/ha) | NS | * | NS | * | NS |

^a Data combined across all locations in 2007. ^b Palmer amaranth control 101 DAP. ^c AMAPA = *Amaranthus palmeri*; Palmer amaranth. ^d Rating: 0% = no control; 100% = complete control. ^e Marketable is the aggregate of jumbo, no. 1, and canner grades.

^f Contrast followed by NS, *, **, and *** are not significant or significant at P= 0.05, 0.01 and 0.001, respectively.

Table 2.4. Palmer amaranth control and ‘Beauregard’ and ‘Covington’ sweetpotato yield at Clinton, NC in 2008^a.

| Treatment | | AMAPA control ^{bc} | | | | Sweetpotato yield | | | |
|--------------------------|----------------------------|-----------------------------|-----|----|-----|-------------------|--------|--------|-------------------------|
| Flumioxazin ^d | S-metolachlor ^e | 12 | 28 | 64 | 126 | Jumbo | No. 1 | Canner | Marketable ^f |
| ---g ai/ha--- | ---kg ai/ha--- | -----%----- | | | | -----kg/ha----- | | | |
| Weed free | | -- | -- | -- | -- | 4,854 | 17,687 | 8,425 | 30,967 |
| Weedy | | -- | -- | -- | -- | 56 | 1,730 | 3,738 | 5,524 |
| 0 | 0.8 PRE ₁ | 100 | 100 | 90 | 92 | 6,082 | 18,859 | 12,833 | 37,774 |
| 0 | 1.1 PRE ₁ | 99 | 99 | 95 | 96 | 7,923 | 17,074 | 10,657 | 35,654 |
| 0 | 1.3 PRE ₁ | 93 | 100 | 89 | 95 | 8,202 | 18,468 | 9,485 | 36,156 |
| 91 | 0 | 97 | 50 | 46 | 60 | 2,064 | 11,829 | 7,365 | 21,202 |
| 91 | 0.8 PRE ₁ | 100 | 100 | 95 | 97 | 8,816 | 19,417 | 13,782 | 42,014 |
| 91 | 1.1 PRE ₁ | 100 | 98 | 96 | 96 | 12,275 | 17,520 | 9,653 | 39,504 |
| 91 | 1.3 PRE ₁ | 97 | 100 | 94 | 96 | 10,657 | 21,370 | 11,215 | 43,242 |
| 109 | 0 | 96 | 69 | 38 | 59 | 1,283 | 9,541 | 4,631 | 15,455 |
| 109 | 0.8 PRE ₁ | 100 | 100 | 93 | 100 | 11,717 | 20,923 | 10,657 | 43,242 |
| 109 | 1.1 PRE ₁ | 100 | 94 | 96 | 100 | 7,365 | 21,426 | 11,550 | 40,340 |
| 109 | 1.3 PRE ₁ | 100 | 98 | 97 | 95 | 7,700 | 20,868 | 11,271 | 39,894 |
| 0 | 0.8 PRE ₂ | 88 | 37 | 23 | 51 | 1,451 | 8,760 | 6,751 | 16,962 |
| 0 | 1.1 PRE ₂ | 90 | 38 | 21 | 29 | 2,009 | 6,361 | 3,794 | 12,108 |
| 0 | 1.3 PRE ₂ | 88 | 56 | 51 | 58 | 4,575 | 11,996 | 7,532 | 24,104 |
| 91 | 0.8 PRE ₂ | 95 | 38 | 19 | 38 | 3,013 | 5,022 | 5,077 | 13,112 |
| 91 | 1.1 PRE ₂ | 98 | 68 | 51 | 61 | 1,395 | 9,430 | 6,807 | 17,632 |
| 91 | 1.3 PRE ₂ | 92 | 61 | 40 | 30 | 3,515 | 9,485 | 6,640 | 19,640 |
| 109 | 0.8 PRE ₂ | 96 | 88 | 61 | 54 | 6,528 | 18,971 | 9,095 | 34,538 |
| 109 | 1.1 PRE ₂ | 98 | 56 | 41 | 48 | 2,901 | 11,717 | 7,309 | 21,872 |
| 109 | 1.3 PRE ₂ | 99 | 73 | 81 | 79 | 8,035 | 16,404 | 6,751 | 31,190 |
| LSD (.05) | | 7 | 24 | 24 | 22 | 4,631 | 6,974 | 4,575 | 11,996 |

^a Data combined across ‘Beauregard’ and ‘Covington’ in 2008. ^b AMAPA = *Amaranthus palmeri*; Palmer amaranth. ^c Rating: 0% = no control; 100% = complete control. ^d All flumioxazin treatments applied PRE two days before transplanting. ^e S-metolachlor applied PRE₁ immediately after transplanting or PRE₂ 2 WAP. ^f Marketable is the aggregate of jumbo, no. 1, and canner grades.

Table 2.5. Effect of flumioxazin and *S*-metolachlor on Palmer amaranth control and ‘Beauregard’ and ‘Covington’ sweetpotato yield at Clinton, NC in 2008^a.

| Treatment | AMAPA control (DAP) ^{bc} | | | | Sweetpotato yield | | | |
|--|-----------------------------------|-----|-----|-----|-------------------|--------|--------|-------------------------|
| | 12 | 28 | 64 | 126 | Jumbo | No. 1 | Canner | Marketable ^d |
| | -----%----- | | | | -----kg/ha----- | | | |
| Flumioxazin 0 g ai/ha | 93 | 72 | 61 | 70 | 5,024 | 13,060 | 8,499 | 26,583 |
| Flumioxazin 91 g ai/ha | 97 | 77 | 66 | 70 | 6,602 | 13,695 | 8,864 | 29,161 |
| Flumioxazin 109 g ai/ha | 99 | 85 | 78 | 79 | 7,336 | 18,366 | 9,428 | 35,160 |
| Flumioxazin fb <i>S</i> -metolachlor at transplant | 100 | 99 | 95 | 97 | 9,745 | 20,238 | 11,352 | 41,335 |
| <i>S</i> -metolachlor at transplant | 97 | 100 | 91 | 94 | 7,385 | 18,113 | 10,993 | 36,491 |
| Flumioxazin fb <i>S</i> -metolachlor 2 WAP | 97 | 64 | 49 | 52 | 4,222 | 11,822 | 6,005 | 22,049 |
| <i>S</i> -metolachlor 2 WAP | 88 | 44 | 31 | 46 | 2,663 | 8,006 | 6,939 | 17,608 |
| Contrast ^e | | | | | | | | |
| Flumioxazin 0 vs 91 g ai/ha | ** | NS | NS | NS | NS | NS | NS | NS |
| Flumioxazin 0 vs 109 g ai/ha | *** | *** | *** | NS | NS | * | NS | * |
| Flumioxazin 91 vs 109 g ai/ha | NS | * | * | * | NS | NS | NS | NS |
| Flumioxazin fb <i>S</i> -metolachlor at transplant vs <i>S</i> -metolachlor at transplant | NS | NS | NS | NS | NS | NS | NS | NS |
| Flumioxazin fb <i>S</i> -metolachlor 2 WAP vs <i>S</i> -metolachlor 2 WAP | *** | *** | ** | NS | ** | *** | ** | *** |

^a Data combined across ‘Beauregard’ and ‘Covington’ in 2008. ^b AMAPA = *Amaranthus palmeri*; Palmer amaranth. ^c Rating: 0% = no control; 100% = complete control. ^d Marketable is the aggregate of jumbo, no. 1, and canner grades. ^e Contrast followed by NS, *, **, and *** are not significant or significant at P= 0.05, 0.01 and 0.001, respectively.

Table 2.6. Effect of flumioxazin and *S*-metolachlor on Palmer amaranth control and ‘Beauregard’ and ‘Covington’ sweetpotato yield at Clinton, NC in 2008 (continued)^a.

| Treatment | AMAPA control (DAP) ^{bc} | | | | Sweetpotato yield | | | |
|--|-----------------------------------|-----|-----|-----|-------------------|--------|--------|-------------------------|
| | 12 | 28 | 64 | 126 | Jumbo | No. 1 | Canner | Marketable ^d |
| | -----%----- | | | | -----kg/ha----- | | | |
| <i>S</i> -metolachlor 0.8 kg ai/ha | 96 | 77 | 64 | 72 | 6,250 | 15,306 | 9,694 | 31,250 |
| <i>S</i> -metolachlor 1.1 kg ai/ha | 97 | 75 | 67 | 72 | 5,636 | 13,903 | 8,285 | 27,824 |
| <i>S</i> -metolachlor 1.3 kg ai/ha | 95 | 81 | 75 | 75 | 7,106 | 15,912 | 8,811 | 31,829 |
| Flumioxazin 0 g ai/ha fb <i>S</i> -metolachlor at transplant | 97 | 100 | 91 | 95 | 7,385 | 18,113 | 10,993 | 36,491 |
| Flumioxazin 0 g ai/ha fb <i>S</i> -metolachlor 2 WAP | 88 | 44 | 31 | 46 | 2,663 | 8,006 | 6,005 | 16,674 |
| Flumioxazin 91 g ai/ha fb <i>S</i> -metolachlor at transplant | 99 | 99 | 95 | 96 | 10,568 | 19,421 | 11,550 | 41,539 |
| Flumioxazin 91 g ai/ha fb <i>S</i> -metolachlor 2 WAP | 95 | 55 | 37 | 43 | 2,637 | 7,968 | 6,177 | 16,782 |
| Flumioxazin 109 g ai/ha fb <i>S</i> -metolachlor at transplant | 100 | 98 | 95 | 98 | 8,923 | 21,056 | 11,155 | 41,134 |
| Flumioxazin 109 g ai/ha fb <i>S</i> -metolachlor 2 WAP | 98 | 72 | 61 | 60 | 5,808 | 15,676 | 7,701 | 29,185 |
| Contrast ^e | | | | | | | | |
| <i>S</i> -metolachlor 0.8 vs 1.1 kg ai/ha | NS | NS | NS | NS | NS | NS | NS | NS |
| <i>S</i> -metolachlor 1.1 vs 1.3 kg ai/ha | NS | NS | NS | NS | * | * | NS | ** |
| <i>S</i> -metolachlor 0.8 vs 1.3 kg ai/ha | NS | NS | * | NS | * | NS | NS | NS |
| <i>S</i> -metolachlor at transplant vs 2 WAP (flumioxazin=0 g ai/ha) | *** | *** | *** | *** | *** | *** | *** | *** |
| <i>S</i> -metolachlor at transplant vs 2 WAP (flumioxazin=91 g ai/ha) | NS | *** | *** | *** | * | * | NS | ** |
| <i>S</i> -metolachlor at transplant vs 2 WAP (flumioxazin=109 g ai/ha) | NS | *** | *** | *** | NS | *** | * | ** |

^a Data combined across ‘Beauregard’ and ‘Covington’ in 2008. ^b AMAPA = *Amaranthus palmeri*; Palmer amaranth. ^c Rating: 0% = no control; 100% = complete control. ^d Marketable is the aggregate of jumbo, no. 1, and canner grades. ^e Contrast followed by NS, *, **, and *** are not significant or significant at P= 0.05, 0.01 and 0.001, respectively.

Short Title: Meyers et al.: Glyphosate wick in sweetpotato

Evaluation of Wick-applied Glyphosate for Palmer Amaranth (*Amaranthus palmeri*)

Control in Sweetpotato

Stephen L. Meyers, Katherine M. Jennings, Jonathan R. Schultheis, and David W.

Monks

Studies were conducted in 2007 and 2008 at Clinton, NC to determine the effect of glyphosate applied postemergence via a Dixie wick applicator on Palmer amaranth control and sweetpotato yield and quality. In 2007, treatments consisted of glyphosate wicked sequentially 6 and 8 wk after transplanting (WAP) and glyphosate wicked sequentially 6 and 8 WAP followed by (fb) rotary mowing 9 WAP. In 2008, treatments consisted of glyphosate wicked once 4 or 7 WAP, wicked sequentially 4 and 7 WAP, mowed once 4 WAP, and mowed 4 WAP fb wicking 7 WAP. In 2008, Palmer amaranth control 6 WAP varied by location and ranged from 0 to 61%. Palmer amaranth contacted by the wicking apparatus were controlled, but weeds shorter than the wicking height escaped treatment. Palmer amaranth control 9 WAP was greater than 90% for all treatments wicked 7 WAP. All other treatments were similar to the weedy control. Competition prior to and between glyphosate treatments contributed to large sweetpotato yield losses. Treatments consisting of glyphosate 7 or 8 WAP (in 2007 and 2008, respectively) frequently had greater no. 1 and marketable yields compared to the weedy control. However, jumbo, no. 1, and marketable yields for all glyphosate and mowing treatments were generally less than half the weed-free control. Cracked sweetpotato roots were observed in glyphosate treatments and percent

cracking (by weight) ranged from 0 to 12 for no. 1 roots, and 0 to 9 for marketable roots.

Nomenclature: Palmer amaranth, *Amaranthus palmeri* S. Wats.; sweetpotato, *Ipomoea batatas* L. Lam.; glyphosate.

Key words: wick applicator; root crack; weed; 'Beauregard'; 'Covington'.

Over 40% of sweetpotato [*Ipomoea batatas* (L.) Lam.] grown in the United States (USDA-NASS 2009) is produced in North Carolina. In 2007, more than 17,000 ha of marketable sweetpotato roots were harvested with a gross farm value of \$136 million (NCDA & CS 2008). Production of sweetpotato consists of transplanting vine cuttings (slips) 20 to 25 cm in height into beds 20 to 25 cm tall and 92 to 106 cm wide (Holmes and Kemble 2008). In North Carolina sweetpotato is transplanted from early May to late June and harvested three to four months later (Holmes and Kemble 2008). As a member of the morningglory family, sweetpotato has a vining growth habit (Woolfe 1992). Sweetpotato plants trail along the ground and canopy closure varies by cultivar and planting date (Seem et al. 2003; LaBonte et al. 1999).

Palmer amaranth (*Amaranthus palmeri* S. Watson) is the most common and troublesome weed in North Carolina sweetpotato production (Webster 2006). The upright and branching, annual, herbaceous weed species grows rapidly (Horak and Loughlin 2000; Monks and Oliver 1988) and has the potential to reach heights greater than 2 m (Norsworthy et al. 2008a; Horak and Loughlin 2000; Sellers et al. 2003). Meyers et al. (Chapter 1) reported that season-long Palmer amaranth densities of 0.5 to 6.5/m of crop row reduced marketable sweetpotato yield 36 to 81%, respectively and that yield loss displayed a positive linear relationship with Palmer amaranth light interception.

North Carolina sweetpotato growers control Palmer amaranth through the use of preemergence herbicides, cultivation, mowing, and hand removal (Haley and Curtis 2006). PRE herbicides flumioxazin and S-metolachlor offer over 90% residual Palmer amaranth

control (Meyers et al. Chapter 2), but require rainfall or irrigation for activation, and weed control can be compromised if the soil surface is disturbed after application (Anonymous 2004a, 2004b). While control is greater than 90% for Palmer amaranth in fields, low densities of this weed may escape control (David Monks, personal communication). Even at low densities, Palmer amaranth escapes can compete with the crop and contribute thousands of seeds into the soil seedbank (Burke et al. 2007; Bensch et al. 2003; Massinga et al. 2001).

Postemergence herbicides for Palmer amaranth control in sweetpotato are limited (Holmes and Kemble 2008). Clethodim, fluazifop, and sethoxydim are registered in North Carolina in sweetpotato for control of grasses, but not broadleaf weeds including *Amaranthus* species (Porter 1993; Parker et al. 1985; Glaze and Hall 1990). Glyphosate and carfentrazone-ethyl must be POST-directed to row middles to avoid crop injury (Holmes and Kemble 2008). Carfentrazone most effectively controls actively growing weeds less than 10 cm tall and rosettes less than 7.5 cm across (Anonymous 2008). Norsworthy et al. (2008b) reported that carfentrazone applied to Palmer amaranth at the 6 leaf stage provided only 60 to 84% control 28 d after treatment. Glyphosate, however, provided excellent control of Palmer amaranth plants 60 cm tall (Bond et al. 2006) and plants with nine to 22 leaves (Culpepper and York 2000). However, POST-directed herbicides are difficult to apply due to the vining nature of sweetpotato.

Glyphosate is a non-selective, systemic, 5-enolpyruvylshikimate 3-phosphate inhibitor that acts in the shikimic acid pathway and prevents the production of aromatic amino acids and other essential secondary metabolites (Fuchs et al. 2002; Schonbrunn et al.

2001; Hetherington et al. 1998). Despite the increasing occurrence of glyphosate resistant Palmer amaranth biotypes (Norsworthy et al. 2008b; Steckel et al. 2008; Culpepper et al. 2006), glyphosate remains an effective means of controlling emerged, susceptible biotypes (Norsworthy et al. 2008b; Bond et al. 2006). Because Palmer amaranth grows upright through the sweetpotato canopy, some North Carolina sweetpotato growers have been interested in applying glyphosate to Palmer amaranth via a wicking apparatus (Haley and Curtis 2006). Glyphosate is used for wicking because of its systemic, broad spectrum weed control and low volatility.

Herbicide wicks and wipers are available in many forms but all are intended to provide post-directed herbicide applications, with limited off-target impacts, on the basis of a weed-crop height differential (Dale 1978). Krueger-Mangold et al. (2002) reported wick-applied glyphosate controlled Canada thistle [*Cirsium arvense* (L.) Scop.] in riparian areas in northeastern Montana with limited injury to non-target species. Grekul et al. (2005) reported similar control of Canada thistle in rangeland in Alberta, Canada when using glyphosate applied with a sponge wiper. However, North Carolina sweetpotato growers have expressed concern that wick-applied glyphosate may cause roots to crack, increasing the percentage of roots that are culled (David Monks, personal communication). Furthermore, in agronomic crops some researchers report significant yield losses due to crop-weed competition before and between wick applications (Keely et al. 1984a, 1984b). Glyphosate is registered in sweetpotato for postemergence weed control between rows (Anonymous 2007). In 2005, 19% of North Carolina sweetpotato growers wicked one to four times per growing season

with an average of 1.8 applications. Currently, less than 6% of North Carolina sweetpotato growers use a wicking apparatus for weed control (Allan Thornton, personal communication).

The purpose of this study was to determine the response of Palmer amaranth and sweetpotato to glyphosate applied via a wick applicator.

Materials and Methods

Studies were conducted at the Horticultural Crops Research Station, Clinton, NC in 2007 and 2008. ‘Covington’ sweetpotato slips were transplanted on June 20, 2007 (three fields), and May 30 and June 5, 2008, on an Orangeburg loamy sand (fine-loamy, siliceous, thermic Typic Paleudults) or Norfolk loamy sand (fine-loamy, siliceous, thermic Typic Paleudults) with pH 5.9 to 6.1. ‘Beauregard’ sweetpotato slips were transplanted into one field on June 20, 2007, on an Orangeburg loamy sand with pH 5.8. Humic matter for all fields was less than 1%. Plot size was three rows 106 cm wide and 9.1 m long. The first row of each plot was a nontreated buffer row. The second and third rows of each plot were treated. The experimental design was a randomized complete block with four replications.

Glyphosate treatments were applied using a Dixie wick applicator¹ (Figure 1) consisting of a polyvinyl chloride pipe (PVC) 7.6 cm wide and 2 m long. Two cotton canvas sleeves 45 cm wide were positioned near both ends of the pipe. Beneath each sleeve were seven small holes drilled into the PVC pipe. The pipe was a reservoir for a glyphosate solution that was gravity-fed through the small holes and onto the canvas sleeves. Flow rate

was adjusted with the use of a metering air orifice on one end of the pipe. Sleeves were positioned directly above the planted sweetpotato row and a glyphosate solution (33% Roundup WeatherMax®² v/v) was applied in a single pass in one direction at 4.8 km/h with an output of 323 L/ha. In 2007, the entire unit was tractor-mounted 69 cm above the sweetpotato bed. In 2008, the Dixie wick was mounted to a metal cart 30 cm above the sweetpotato bed. Mowing treatments were applied using a tractor-mounted rotary mower 152 cm wide positioned approximately 30 cm above the sweetpotato bed.

In 2007, treatments consisted of wick-applied glyphosate 6 and 8 wk after transplanting (WAP) or glyphosate 6 and 8 WAP followed by (fb) mowing 9 WAP. In 2007, Palmer amaranth averaged 112 and 104 cm tall 6 and 8 WAP, respectively. In 2008, treatments were modified in an attempt to control Palmer amaranth earlier in the sweetpotato crop cycle. Treatments consisted of a single glyphosate application 4 or 7 WAP, a single mowing 4 WAP, sequential applications of glyphosate both 4 and 7 WAP, and mowing 4 WAP fb glyphosate 7 WAP. In 2008, Palmer amaranth averaged 46 and 120 cm tall 4 and 7 WAP, respectively. Weedy and weed-free control plots were included in both 2007 and 2008.

In 2007, data recorded were limited to sweetpotato yield by weight and grade, and percent root cracking by weight. In 2008, data recorded included Palmer amaranth control, sweetpotato yield by weight and grade, and percent root cracking. Palmer amaranth control ratings were based on a scale of 0 (no control) to 100 percent (complete control).

Sweetpotatoes were harvested 105 to 121 DAP using a tractor-mounted chain sweetpotato

digger and the second row of each plot was hand graded into jumbo (> than 8.9 cm in diameter), no. 1 (> than 4.4 cm but < 8.9 cm), and canner (> 2.5 cm but < 4.4 cm) (USDA 2005). Marketable yield was calculated as the sum of jumbo, no. 1, and canner grades. After each grade was weighed, sweetpotato roots were inspected and those roots with longitudinal cracks or splits containing callus tissue (Figure 2) were weighed by grade. Percentage of cracked roots was calculated as the weight of cracked roots divided by the weight of all storage roots in each grade.

Data were subjected to ANOVA by SAS³ PROC GLM. Palmer amaranth control ratings were transformed using the arcsin of the square root of the data. Means were separated using t-tests with LSD and $P = 0.05$. Weed-free and weedy controls were included in yield analysis. Palmer amaranth control data from these treatments were not included in analysis as control was 100 and 0% for weed-free and weedy control plots, respectively.

Results and Discussion

Palmer Amaranth Control

Due to a location by treatment interaction, data for Palmer amaranth control 6 WAP were analyzed separately by location in 2008. Palmer amaranth control in both field experiments at Clinton ranged from 0 to 11 and 0 to 61%, respectively (Table 1). Treatments consisting of glyphosate 4 WAP had the greatest Palmer amaranth control. Mowing reduced the height of Palmer amaranth plants but was not lethal. Although this treatment gave only 61% control, it may be beneficial as a part of the overall weed

management program to control escape Palmer amaranth. Palmer amaranth control 9 WAP was greater than 90% for all treatments that used glyphosate 7 WAP (Data not shown). Little or no control was obtained with the other treatments as they were similar to the weedy control. The authors observed that during the experiment glyphosate effectively controlled Palmer amaranth plants contacted by the applicator sleeve. However, Palmer amaranth plants below the wicking bar did not contact the glyphosate solution on the Dixie wick sleeve. These shorter weeds escaped herbicide injury and grew rapidly. A similar observation was reported by Keely et al. (1984b) who reported that shorter Johnsongrass plants escaped herbicide injury from a ropewick applicator.

Sweetpotato Yield

Sweetpotato yield data were analyzed separately by year. In 2007, a location by treatment interaction was observed for all grades of sweetpotato. Yield at one of four locations was not influenced by treatment (data not shown). Within the remaining three locations, the weed-free control had the greatest yield of all grades of sweetpotato (Table 2). At two of three locations, glyphosate wicked sequentially 6 and 8 WAP provided greater no. 1 and marketable yield than the weedy control. Sequential glyphosate applications followed by mowing 9 WAP did not improve yield over wicking glyphosate sequentially.

In 2008, a location by treatment interaction was observed for yield of no. 1 sweetpotato. Therefore, no. 1 yield was analyzed separately by location within 2008. All other sweetpotato grades were analyzed across locations. Yield of all sweetpotato grades was greatest in the weed-free control (Table 3). Glyphosate wicked once 7 WAP resulted in

greater canner, marketable, and no. 1 yield (field 2) compared to the weedy control.

Glyphosate wickered sequentially 4 and 7 WAP resulted in greater canner, marketable, and no. 1 yield compared to the weedy control. Mowing 4 WAP fb glyphosate 7 WAP resulted in greater canner, marketable, and no. 1 (field 2) compared to the weedy control.

Sweetpotato Root Cracking

Percentage (by weight and grade) of cracked sweetpotato was analyzed by year. In 2007, no differences were observed in the percentage of cracked roots of any grade (data not shown).

In 2008, a location by treatment interaction for the percentage of cracked canner roots was observed. Therefore, data for percentage of cracked canner roots were separated by location and the percentage of cracked jumbo, no. 1, and marketable roots were analyzed across locations. No cracked roots were observed in weedy or weed free control plots or plots mowed once 4 WAP (Table 4). At one location treatments containing glyphosate 7 WAP had a greater percentage of cracked canner roots than in which glyphosate was not applied (control treatments). At one location mowing 4 WAP fb glyphosate 7 WAP had a greater percentage of cracked canner roots than when glyphosate was not applied. The percentage of cracked roots ranged from 0 to 15, 0 to 12, and 0 to 6% for jumbo, no. 1, and marketable grades, respectively. Percent cracking in jumbo grade sweetpotato roots differed numerically, but was statistically similar for all treatments. Treatments mowed 4 WAP fb glyphosate 7 WAP had a greater percentage of cracked no. 1 and marketable roots (12 and 9%, respectively) compared to plots that had no glyphosate applied. Treatments of

glyphosate applied once 7 WAP had a greater percentage of cracked no. 1 roots (5 %) compared to control plots. Glyphosate wicked sequentially 4 and 7 WAP had a greater percentage of cracked marketable roots compared to the controls.

Glyphosate solution was observed dripping from the wick applicator at the time of application. Occasionally, sweetpotato plants in glyphosate treatments exhibited symptoms consistent with glyphosate exposure (Clark and Moyer 1988). Sweetpotato root cracking was likely due to the random exposure to glyphosate via a dripping wick applicator. However, the authors are aware of no published data reported incidents of sweetpotato root cracking due to glyphosate exposure. Further studies should be conducted to evaluate the correlation between glyphosate exposure and sweetpotato root cracking.

Glyphosate applied via a Dixie wick applicator provided postemergence control of Palmer amaranth contacted by the canvas sleeve. Palmer amaranth below the sleeve escaped the wick applicator and continued to grow and compete with the sweetpotato crop. Sequential applications of glyphosate provided the greatest and most consistent Palmer amaranth control. This result is similar to those reported by others who evaluated single and sequential glyphosate applications to Palmer amaranth (Jha et al. 2008; Price et al. 2008; Culpepper and York 2000). However, due to competition before and between glyphosate applications, jumbo, no. 1, and marketable yields of all glyphosate and mowing treatments were frequently less than half of the weed free control. The reduction in yield is consistent with the report by Seem et al (2003) who reported that the critical weed free period for sweetpotatoes to be 2 to 6 weeks. The percentage of cracked sweetpotato was greatest in

treatments consisting of glyphosate 7 WAP; only treatments consisting of glyphosate contained cracked sweetpotato roots.

Though Palmer amaranth can be controlled by wick-applied glyphosate, sweetpotato yield losses due to competition are too great. At present, a control program consisting of currently registered preemergence herbicides should be followed and future postemergence studies should focus on controlling Palmer amaranth and other weed species below the sweetpotato canopy before competition for light contributes to excessive sweetpotato yield loss.

Sources of Materials

¹ Dixie Wick applicator, Dixie Wick Company, 5807 Highway 11 North, Grifton, NC 28530.

² Roundup WeatherMax®, Monsanto Company, 800 North Lindbergh Boulevard, St. Louis, MO 63167.

³ SAS, 2004. SAS/STAT® 9.1 User's Guide. SAS Institute Inc., 100 SAS Campus Drive, Cary, NC 27513.

Literature Cited

- Anonymous. 2004a. Dual Magnum® herbicide label. Greensboro, NC: Syngenta Crop Protection, Inc.
- Anonymous. 2004b. Valor® SX herbicide label. Walnut Creek, CA: Valent U.S.A. Corporation.
- Anonymous. 2007. Roundup WetherMax® herbicide label. St. Louis, MO: Monsanto Company.
- Anonymous. 2008. Aim® EC herbicide label. Philadelphia, PA: FMC Corporation.
- Bensch, C. N., M. J. Horak, and D. Peterson. 2003. Interference of redroot pigweed (*Amaranthus retroflexus*), Palmer amaranth (*A. palmeri*), and common waterhemp (*A. rudis*) in soybean. *Weed Sci.* 51:37-43.
- Bond, J. A., L. R. Oliver, D. O. Stephenson IV. 2006. Response of Palmer amaranth (*Amaranthus palmeri*) to glyphosate, fomesafen, and pyrithiobac. *Weed Technol.* 20:885-892.
- Burke, I. C., M. Schroeder, W. E. Thomas, and J. W. Wilcut. 2007. Palmer amaranth interference and seed production in peanut. *Weed Technol.* 21:367-371.
- Clark, C. A. and J. W. Moyer, eds. 1988. *Compendium of Sweet Potato Diseases*. St. Paul, MN: The American Phytopathological Society. Pp. 57-60.
- Culpepper, A. S. and A. C. York. 2000. Weed management in ultra narrow row cotton (*Gossypium hirsutum*). *Weed Technol.* 14:19-29.
- Culpepper, A. S., T. L. Grey, W. K. Vencill, J. M. Kichler, T. M. Webster, S. M. Brown,

- A. C. York, J. W. Davis, and W. W. Hanna. 2006. Glyphosate-resistant Palmer amaranth (*Amaranthus palmeri*) confirmed in Georgia. *Weed Sci.* 54:620-626.
- Dale, J. E. 1978. The rope-wick applicator- a new method of applying glyphosate. *Proc. So. Weed Sci. Soc.* 31:332.
- Fuchs, M. A., D. R. Geiger, T. L. Reynolds, and J. E. Bourque. 2002. Pesticide Biochemistry and Physiology. 74:27-39.
- Glaze, N. C. and M. R. Hall. 1990. Cultivation and herbicides for weed control in sweet potato (*Ipomoea batatas*). *Weed Technol.* 4:518-523.
- Grekul, C. W., D. E. Cole, and E. W. Bork. 2005. Canada thistle (*Cirsium arvense*) and pasture forage responses to wiping with various herbicides. *Weed Technol.* 19:298-306.
- Haley, J. and J. Curtis. 2006. Sweetpotato grower survey report of results for 2005 crop. Report for USDA CSREES grant: Risk Avoidance and Mitigation Program (RAMP): Development of grower decision management tools to reduce risk and enhance sustainability of Southern sweetpotato pest management systems.
- Hetherington, P. R., G. Marshall, R. C. Kirkwood, and J. M. Warner. 1998. Absorption and efflux of glyphosate by cell suspensions. *J. Experimental Botany.* 49:527- 533.
- Holmes, G. J. and J. M. Kemble, eds. 2008. Vegetable Crop Handbook for the Southeastern United States 2009. Lincolnshire, IL: Vance Publishing Corp. Pp. 93-94.
- Horak, M. J. and T. M. Loughin. 2000. Growth and analysis of four *Amaranthus* species. *Weed Sci.* 48:347-355.

- Jha, P., J. K. Norsworthy, W. Bridges, Jr., and M. B. Riley. 2008. Influence of glyphosate timing and row width on Palmer amaranth (*Amaranthus palmeri*) and pusley (*Richardia* spp.) demographics in glyphosate-resistant soybean. *Weed Sci.* 56:408-415.
- Keely, P. E., R. J. Thullen, C. H. Carter, and J. H. Miller. 1984a. Control of Johnsongrass (*Sorghum halepense*) in cotton (*Gossypium hirsutum*) with glyphosate. *Weed Sci.* 32:306-309.
- Keely, P. E., C. H. Carter, R. J. Thullen, and J. H. Miller. 1984b. Comparison of ropewick applicators for control of Johnsongrass (*Sorghum halepense*) in cotton (*Gossypium hirsutum*) with glyphosate. *Weed Sci.* 32:431-435.
- Krueger-Mangold, J., R. L. Sheley, and B. D. Roos. 2002. Maintaining plant community diversity in a waterfowl production area by controlling Canada thistle (*Cirsium arvense*) using glyphosate. *Weed Technol.* 16:457-463.
- La Bonte, D. R., H. F. Harrison, and C. E. Motsenbocker. 1999. Sweetpotato clone tolerance to weed interference. *Hort Sci.* 34:229-232.
- Massinga, R. A., R. S. Currie, M. J. Horak, and J. Boyer Jr. 2001. Interference of Palmer amaranth in corn. *Weed Sci.* 49:202-208.
- Monks, D. W. and L. R. Oliver. 1988. Interactions between soybean (*Glycine max*) cultivars and selected weeds. *Weed Sci.* 36:770-774.
- [NCDA and CS] North Carolina Department of Agriculture & Consumer Services. 2008. North Carolina Agricultural Statistics. Raleigh, NC: N.C. Department of Agriculture.

- Norsworthy, J. K., M. J. Oliveira, P. Jha, M. Malik, J. K. Buckelew, K. M. Jennings, and D. W. Monks. 2008a. Palmer amaranth and large crabgrass growth with plasticulture-grown bell pepper. *Weed Technol.* 22:296-302.
- Norsworthy, J. K., G. M. Griffith, R. C. Scott, K. L. Smith, and L. R. Oliver. 2008b. Confirmation and control of glyphosate-resistant Palmer amaranth (*Amaranthus palmeri*) in Arkansas. *Weed Technol.* 22:108-203.
- Parker, N. Y., T. J. Monaco, R. B. Leidy, and T. J. Sheets. 1985. Weed control with fluazifop and residues in cucurbit crops (*Cucumis* sp.) and sweet potatoes (*Ipomoea batatas*). *Weed Sci.* 33:405-410.
- Porter, W. C. 1993. Postemergence grass control in sweet potatoes (*Ipomoea batatas*). *Weed Technol.* 7:812-815.
- Price, A. J., C. H. Koger, J. W. Wilcut, D. Miller, and E. van Santen. 2008. Efficacy of residual and non-residual herbicides used in cotton production systems when applied with glyphosate, glufosinate, or MSMA. *Weed Technol.* 22:459-466.
- Schonbrunn, E., S. Eschenburg, W. A. Shuttleworth, J. V. Schloss, N. Amrhein, J. N. S. Evans, and W. Kabsch. 2001. Interaction of the herbicide glyphosate with its target enzyme 5-enolpuruvylshikimate 3-phosphate synthase in atomic detail. *PNAS.* 98:1376-1380.
- Seem, J. E., N. G. Creamer, and D. W. Monks. 2003. Critical weed-free period for 'Beauregard' sweetpotato (*Ipomoea batatas*). *Weed Technol.* 17:686-695.
- Sellers, B. A., R. J. Smeda, W. G. Johnson, J. A. Kendig, M. R. Ellersieck. 2003.

- Comparative growth of six *Amaranthus* species in Missouri. *Weed Sci.* 51:329-333.
- Steckel, L. E., C. L. Main, A. T. Ellis, and T. C. Mueller. 2008. Palmer amaranth (*Amaranthus palmeri*) in Tennessee has low level glyphosate resistance. *Weed Technol.* 22:119-123.
- [USDA] U.S. Department of Agriculture. 2005. United States Standards for Grades of Sweet Potatoes. Washington, DC: US Department of Agriculture.
- [USDA-NASS] U.S. Department of Agriculture- National Agricultural Statistics Service. 2009. 2007 Census of Agriculture. Washington D.C.: U.S. Department of Agriculture.
- Webster, T. M. 2006. Weed survey-southern states. *Proc. South Weed Sci. Soc.* 59:260-277.
- Woolfe, J. A. 1992. *Sweet Potato: An Untapped Food Resource*. New York, NY: Cambridge University Press.



A.



B.



C.

Figure 3.1. (A) Tractor-mounted Dixie wick applicator. (B) Close up of holes in PVC pipe below canvas sleeve. (C) Side view of wick with air metering orifice.



A.



B.



C.



D.

Figure 3.2. (A) Collection of cracked no. 1 grade sweetpotato roots. (B, C, D) Examples of individual roots with cracking due to glyphosate injury, Clinton, NC, 2008.

Table 3.1. Palmer amaranth control at Clinton, NC in 2008.

| Treatment | Palmer amaranth control ^a | |
|-------------------------------------|--------------------------------------|---------|
| | Field 1 | Field 2 |
| | -----%----- | |
| Glyphosate 4 WAP | 11 | 55 |
| Glyphosate 7 WAP | 0 | 0 |
| Glyphosate 4 WAP + glyphosate 7 WAP | 9 | 61 |
| Mow 4 WAP | 0 | 0 |
| Mow 4 WAP + glyphosate 7 WAP | 0 | 13 |
| LSD (.05) | 9 | 31 |

^a Rating: 0% = no control; 100% = complete control.

Table 3.2. Sweetpotato yield at Clinton, NC in

| Treatment | Sweetpotato yield | | | | | | | | | | | |
|--|-------------------|---------|---------|---------|---------|---------|---------|---------|---------|-------------------------|---------|---------|
| | Jumbo | | | No. 1 | | | Canner | | | Marketable ^a | | |
| | Field 1 | Field 2 | Field 3 | Field 1 | Field 2 | Field 3 | Field 1 | Field 2 | Field 3 | Field 1 | Field 2 | Field 3 |
| | -----kg/ha----- | | | | | | | | | | | |
| Weed-free | 1,093 | 9,949 | 5,555 | 18,185 | 23,007 | 15,775 | 5,750 | 4,726 | 7,865 | 25,028 | 37,682 | 29,196 |
| Weedy | 113 | 314 | 708 | 2,640 | 5,436 | 9,641 | 4,007 | 3,729 | 4,147 | 6,760 | 9,479 | 14,496 |
| Glyphosate 6 WAP + glyphosate 8 WAP | 174 | 2,339 | 1,998 | 6,765 | 11,068 | 9,768 | 4,277 | 4,813 | 4,367 | 11,216 | 18,220 | 16,133 |
| Glyphosate 6 WAP + glyphosate 8 WAP + mow 9 WAP | 0 | 3,315 | -- | 2,971 | 13,137 | -- | 3,890 | 4,683 | -- | 6,860 | 21,135 | -- |
| LSD (.05) | 1,153 | 3,557 | 4,378 | 4,090 | 4,843 | 4,393 | 1,573 | 2,688 | 1,858 | 4,262 | 5,419 | 6,627 |

^a Marketable is the aggregate of jumbo, no. 1, and canner grades.

Table 3.3. Sweetpotato yield at Clinton, NC in 2008.

| Treatment | Sweetpotato yield | | | | |
|-------------------------------------|-------------------|--------|-------------------------|---------|---------|
| | All locations | | | Field 1 | Field 2 |
| | Jumbo | Canner | Marketable ^a | No. 1 | |
| | -----kg/ha----- | | | | |
| Weed-free | 8,629 | 5,401 | 36,798 | 22,232 | 23,305 |
| Weedy | 218 | 1,459 | 2,483 | 958 | 655 |
| Glyphosate 4 WAP | 579 | 2,265 | 5,793 | 1,742 | 4,157 |
| Glyphosate 7 WAP | 923 | 3,062 | 10,305 | 2,282 | 10,360 |
| Glyphosate 4 WAP + glyphosate 7 WAP | 1,738 | 3,515 | 13,760 | 5,305 | 11,708 |
| Mow 4 WAP | 801 | 2,221 | 5,993 | 226 | 5,715 |
| Mow 4 WAP + glyphosate 7 WAP | 1,115 | 3,899 | 12,602 | 2,265 | 12,910 |
| LSD (.05) | 1,787 | 1,040 | 8,788 | 4,164 | 7,562 |

^a Marketable is the aggregate of jumbo, no. 1, and canner grades.

Table 3.4. Percent cracked sweetpotato roots at Clinton, NC in 2008.

| Treatment | Cracked sweetpotato yield ^a | | | | |
|-------------------------------------|--|-------|-------------------------|---------|---------|
| | All locations | | | Field 1 | Field 2 |
| | Jumbo | No. 1 | Marketable ^b | Canner | |
| | -----%----- | | | | |
| Weed-free | 0 | 0 | 0 | 0 | 0 |
| Weedy | 0 | 0 | 0 | 0 | 0 |
| Glyphosate 4 WAP | 6 | 1 | 1 | 0 | 2 |
| Glyphosate 7 WAP | 15 | 5 | 3 | 2 | 5 |
| Glyphosate 4 WAP + glyphosate 7 WAP | 1 | 2 | 5 | 0 | 9 |
| Mow 4 WAP | 0 | 0 | 0 | 0 | 0 |
| Mow 4 WAP + glyphosate 7 WAP | 6 | 12 | 6 | 4 | 9 |
| LSD (.05) | 20 | 4 | 5 | 3 | 5 |

^a Percent cracked roots = cracked root weight/total weight by grade.

^b Marketable is the aggregate of jumbo, no. 1, and canner grades.