INFLUENCE OF PALMER AMARANTH (*Amaranthus*

palmeri) ON GRAIN SORGHUM

(*Sorghum bicolor*)

By

JERRY WAYNE MOORE

Bachelor of Science

Oklahoma State University

Stillwater, Oklahoma

1998

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE
December, 2000

INFLUENCE OF PALMER AMARANTH (*Amaranthus*

palmeri) ON GRAIN SORGHUM

(*Sorghum bicolor*)

Thesis approved:

_____
Thesis Advisor

_____

_____

_____
Dean of the Graduate College

ACKNOWLEDGMENTS

TABLE OF CONTENTS

LIST OF TABLES

a Dale silt loam (fine-silty, mixed, thermic Pachic Haplustolls) with a pH of 7.2 and an organic matter content of 0.5%. In 2000, both noncompetitive and competitive experiments were conducted at Perkins on a Navina loam (fine-loamy, mixed, thermic Udic Argiustolls) with a pH of 5.7 and an organic matter content of 0.4%. Urea was applied before planting to all experiments at rates of 175 kg N/ha in 1999 and 112 kg N/ha in 2000.

Cherokee, a medium maturity, drought tolerant, hybrid grain sorghum, that was treated with fluxofenim was planted on May 17 each year at Chickasha, and on May 16 at Perkins. All experiments received a preemergence treatment of metolachlor at a rate of 1.7 kg ai/ha. Before metolachlor was applied in the competitive experiments, 23-cm diameter paper disks were placed over the intended weed transplanting site to prevent the risk of herbicide injury to transplanted Palmer amaranth plants. This method has been used successfully by others (Pawlak et al. 1990; Smith et al. 1990; Rogers et al. 1996; Rowland et al. 1999; Wood et al. 1999).

Ivyleaf morningglory [*Ipomoea hederacea* (L.) Jacq.] was controlled in all experiments at Chickasha, before the Palmer amaranth were transplanted into the field, with bromoxynil at 0.28 kg ai/ha in 1999 and with bentazon plus crop oil at 1.12 kg ai/ha and 1.2 L/ha in 2000. All experiments were hand-weeded throughout the growing season to prevent competition from unwanted weed species. Irrigation was applied as needed by using a side-roll overhead sprinkler at Perkins and by flooding at Chickasha.

The experimental design for each experiment was a randomized complete block design with four replications, except for the noncompetitive experiment at Chickasha in 2000 which was replicated three times. The

6

LIST OF FIGURES

THESIS FORMAT

This thesis was written in a format so that it could be submitted for publication in <u>Weed Technology</u>, a journal of the Weed Science Society of America.

Influence of Palmer amaranth (*Amaranthus palmeri*)
on Grain Sorghum (*Sorghum bicolor*)

Abstract: Field experiments were conducted near Perkins, OK in 2000 and near Chickasha, OK in 1999 and 2000 to evaluate the noncompetitive and the competitive effects of Palmer amaranth on grain sorghum. The eight weed densities used were 0 (the weed-free check), 1, 2, 4, 6, 9, 12 and 18 plants/15 m of row. Variables in the noncompetitive experiments in 1999 and 2000 were grain moisture before and after cleaning, foreign material, and grain weights before and after cleaning. Effects on grain sorghum seed loss from combine, harvest times, grain sorghum test weights, and grain grades were measured in 2000. Each increase by one weed/15 m of row increased grain moisture before cleaning 0.7% and 0.2% for Chickasha in 1999 and Perkins. Grain moisture after cleaning increased 0.2% at Chickasha in 1999 and at Perkins for each increase by one weed/15 m of row. At Chickasha in 2000, grain moistures before and after cleaning were not affected by Palmer amaranth density. Each weed increase/15 m of row increased foreign material 67, 2, and 3 kg/ha for Chickasha in 1999, Chickasha in 2000, and Perkins, respectively. At Chickasha in 2000, sorghum seed loss from the back of the combine increased 11 kg/ha for each increase by one weed/15 m of row; however, no difference occurred at Perkins. Although sorghum seed loss was significant at Chickasha, no differences were observed for overall grain sorghum yield. No differences were detected in test weights at either location in 2000. Grades improved at Perkins with increasing weed densities; however, no differences occurred at Chickasha in 2000. Grain sorghum in the competitive experiments were exposed to full-season interference from Palmer amaranth. In 1999 and 2000, variables included grain sorghum yield and Palmer amaranth biomass. The number of seed

produced by each panicle, grain sorghum test weights, and grain sorghum grades were determined in 2000. Grain yield decreased by 1.8% to 3.5% for each increase by one weed/15 m of row. Each kg of Palmer amaranth/plot reduced grain yield 5.3% to 9.1%. In 2000, sorghum seed per panicle was reduced by at least 27 for each increase by one weed/15 m of row. Test weights and grain grades decreased as weed density increased at Chickasha in 2000 but not at Perkins.

Nomenclature: Palmer amaranth, *Amaranthus palmeri* S. Wats. #[1] AMAPA; grain sorghum, *Sorghum bicolor* (L.) Moench "Cherokee".

Additional index words: Noncompetitive, competitive, grain moisture, grain yield, foreign material, seed loss, seed produced, test weight, grain grade.

---

[1]Letters following this symbol are a WSSA-approved computer code from *Composite List of Weeds*, Revised 1989. Available only on computer disk from WSSA, 810 East 10th Street, Lawrence, KS 66044-8897.

INTRODUCTION

In nine of 13 southern states, pigweed species are among the 10 most common and most troublesome weeds in grain sorghum (Dowler 1997). Combined with other pigweed species, Palmer amaranth ranks as the most common and fifth most troublesome weed in Oklahoma grain sorghum (Dowler 1997). When compared to common waterhemp (*Amaranthus rudis* Sauer), redroot pigweed (*Amaranthus retroflexus* L.), and tumble pigweed (*Amaranthus albus* L.), Palmer amaranth has a higher growth rate, produces more primary branches, leaf area, dry matter, and plant volume characterizing its ability to be a competitive weed (Horak and Loughin 2000). Besides its aggressive growth, Palmer amaranth roots account for approximately 6 to 13% of the total dry matter (Keeley et al. 1987), and they elongate at approximately the same rate as grain sorghum roots (Wiese 1968). Previous research has shown the ability of Palmer amaranth to interfere with crops such as soybean [*Glycine max* (L.) Merr.] (Monks and Oliver 1988) and cotton (*Gossypium hirsutum* L.) (Keeley and Thullen 1989; Rowland et al. 1999).

Weed seed densities in agricultural soils occur at levels sufficient to produce weed populations that can potentially reduce crop yield; therefore, soil-applied herbicides are usually included in a weed management program as a preventive measure (Vencill and Banks 1994). Grain sorghum yields decreased and weed dry matter increased as tall waterhemp [*Amaranthus tuberculatus* (Moq.) J.D. Sauer] increased in density and/or weed duration (Feltner et al. 1969). In areas where conventional pigweed control methods failed, Palmer amaranth rapidly became the most troublesome weed (Gossett and Toler 1999). In a conservation tillage system for cotton, Palmer amaranth populations doubled in one year when no herbicides were applied (Keeling et al.

4

1991).

Palmer amaranth, a prolific seed producer, has the ability to form viable seeds 9 to 12 weeks after emergence, suggesting that two generations might be produced in one year (Keeley et al. 1987). In weed competition studies, Palmer amaranth caused more than twice the soybean yield loss as did redroot pigweed, and losses comparable to common cocklebur (Xanthium strumarium L.), which is considered to be the most competitive annual weed in North America soybeans (Klingaman and Oliver 1994).

Yield loss information is essential for weed management programs designed to determine levels of economic damage (Klingaman and Oliver 1994). Large weeds influence grain harvesting by reducing the cylinder speed or by clogging grain combines, especially if the weeds have a high moisture content (Burnside et al. 1969). Since weeds influence combine efficiency, farmers may modify their weed control program to obtain late season weed control (Burnside et al. 1969).

Since Palmer amaranth is a significant problem in Oklahoma grain sorghum and late season weed control is particularly important, the objectives of this research were to evaluate the noncompetitive effects of Palmer amaranth on grain sorghum at harvest and to determine the full-season competitive effects of Palmer amaranth on grain sorghum yields.

MATERIALS AND METHODS

A total of six field experiments were conducted at the Agronomy Research Station near Perkins, OK, and the South Central Research Station near Chickasha, OK, in 1999 and 2000. Both noncompetitive and competitive experiments were conducted in 1999 and 2000 at Chickasha on

a Dale silt loam (fine-silty, mixed, thermic Pachic Haplustolls) with a pH of 7.2 and an organic matter content of 0.5%. In 2000, both noncompetitive and competitive experiments were conducted at Perkins on a Navina loam (fine-loamy, mixed, thermic Udic Argiustolls) with a pH of 5.7 and an organic matter content of 0.4%. Urea was applied before planting to all experiments at rates of 175 kg N/ha in 1999 and 112 kg N/ha in 2000.

Cherokee, a medium maturity, drought tolerant, hybrid grain sorghum, that was treated with fluxofenim was planted on May 17 each year at Chickasha, and on May 16 at Perkins. All experiments received a preemergence treatment of metolachlor at a rate of 1.7 kg ai/ha. Before metolachlor was applied in the competitive experiments, 23-cm diameter paper disks were placed over the intended weed transplanting site to prevent the risk of herbicide injury to transplanted Palmer amaranth plants. This method has been used successfully by others (Pawlak et al. 1990; Smith et al. 1990; Rogers et al. 1996; Rowland et al. 1999; Wood et al. 1999).

Ivyleaf morningglory [Ipomoea hederacea (L.) Jacq.] was controlled in all experiments at Chickasha, before the Palmer amaranth were transplanted into the field, with bromoxynil at 0.28 kg ai/ha in 1999 and with bentazon plus crop oil at 1.12 kg ai/ha and 1.2 L/ha in 2000. All experiments were hand-weeded throughout the growing season to prevent competition from unwanted weed species. Irrigation was applied as needed by using a side-roll overhead sprinkler at Perkins and by flooding at Chickasha.

The experimental design for each experiment was a randomized complete block design with four replications, except for the noncompetitive experiment at Chickasha in 2000 which was replicated three times. The

eight weed densities used were 0 (the weed-free check), 1, 2, 4, 6, 9, 12, and 18 plants/15 m of row. Each plot was four rows wide by 17 m long with a row spacing of 0.76 m. Before harvest, 1.0 m of row was removed from each end of the rows to minimize the end-row effect; thus, the harvested row length was 15 m.

The center two rows of each plot were harvested on September 9, 1999 and on August 29, 2000 at Chickasha and on August 25 or 26, 2000 at Perkins using a small commercial type combine[2]. The combine was adjusted to the specifications for sorghum, according to the operators manual. Immediately after harvest, grain from each plot was weighed and its moisture content determined. Each grain sample was then cleaned using a model M-2B Clipper seed cleaner[3] to remove foreign material. Grain weight and moisture content were determined again after cleaning. All grain sorghum moistures were measured with a Harvest Hand DICKEY-john moisture tester[4]. In 2000, test weights were measured for each grain sorghum sample using a GAC2000 DICKEY-john[4]. Grain sorghum samples from each plot were graded by a commercial grain inspection company[5].

Noncompetitive Experiments. The grain sorghum in these experiment remained weed-free for the entire growing season. The Palmer amaranth plants used in these experiments were collected from a field adjacent to

---

[2]Gleaner Baldwin Combines built by ALLIS-CHALMERS MFG. Co., P.O. Box 512, Milwaukee, WI 53201. Model "A".

[3]Clipper Separation Technologies, 805 S. Decker Drive, Bluffton, IN 46714.

[4]DICKEY-john Co., P.O. Box 10, Auburn, IL 62615.

[5]Enid Grain Inspection Co., P.O. Box 229, Enid, OK 73702.

7

these experiments. Each year the Palmer amaranth were measured and cut at 61 cm above the grain sorghum height to simulate the presence of late season weeds. All weed heights were measured from the apex to the desired height below the apex and cut.

At Chickasha in 1999, the Palmer amaranth were placed into a holding apparatus that fit between the two center grain sorghum rows and positioned the Palmer amaranth adjacent to the grain sorghum. The apparatus was composed of three segments. Each segment was built with 10.2 cm (4 inch) PVC pipe, tees and 90° elbows to form a rectangle that fit between the two harvested grain sorghum rows. The overall length of each segment was 5 m, including six tees spaced 0.8 m apart for each grain sorghum row. When the segments were put together, the apparatus was 0.56 m wide and 15 m long. The apparatus was not used in 2000 at either location because of grain sorghum lodging which prevented its use.

Approximately 80% of each Palmer amaranth was harvested and 20% remained in the apparatus; therefore, at both locations in 2000, the Palmer amaranth plants were cut at 80% of the desired height to adjust for the 20% not harvested by the combine. After the Palmer amaranth were cut in 2000, they were manually tossed into the combine header at a rate that resembled the weed spacing of the apparatus. This was done throughout the entire length of the harvest area.

At Chickasha in 1999, the grain sorghum was 122 cm tall at maturity and the weeds were measured and cut at 183 cm tall then placed into the weed holding apparatus. At Perkins the grain sorghum was 99 cm tall at maturity and the weeds were measured and cut at 128 cm tall. At Chickasha in 2000, the grain sorghum was 100 cm tall at maturity and the weeds were measured and cut at 129 cm tall. To insure a nonwilted

8

Palmer amaranth plant at harvest, whole plant samples were cut and placed directly in the sunlight for 4 h. After 4 h, a visual evaluation showed no wilting had occurred. This was more than enough time, since all Palmer amaranth used in these experiments were ran through the combine within 30 min of being cut.

For each location, 20 representative Palmer amaranth plants were cut and collected at the same height that were ran through the combine to determine the amount of weed biomass for each density. Each plant was weighed then dried at 54 C for 10 days, and reweighed to determine percent moisture.

At both locations in 2000, a 0.4 m^2 metal catch pan was placed in each plot to catch the grain that passed over the sieves and came out the back of the combine. This method was used to determine if yield loss was occurring due to an increase in Palmer amaranth biomass during harvest. The sorghum seed that exited the combine was weighed and converted to kg/ha.

The time required to harvest each plot was recorded at both locations in 2000 to determine if harvest times were affected by an increase in Palmer amaranth density. After harvest, the grain samples were immediately transported to the Agronomy farm near Stillwater, OK where all samples were cleaned. From the Perkins sites, it takes approximately 20 minutes to get to Stillwater and from the Chickasha sites, it takes approximately 2 hours to get to Stillwater. This time length could affect the grain moisture, since the grain is in contact with the green foreign material until it is cleaned. Foreign material was calculated as the difference in grain sorghum weights before and after cleaning.

Competitive Experiments. On the same day that the grain sorghum was

9

planted, the Palmer amaranth were planted into peat pellets[6] in a greenhouse and were grown to a 3-to-5 true leaf stage. They were then transplanted to sites approximately 5 cm from one side of grain sorghum rows 2, 3, and 4 that had been covered with 23-cm paper disks as previously described. Earlier research on propagation methods of common cocklebur by Albers-Nelson et al. (2000), showed no differences in direct seeding compared to transplanted peat pellets if done early in the season; therefore, the assumption was made that Palmer amaranth established with peat pellets would behave similarly to those directly seeded.

At grain sorghum maturity for both locations in 2000, one representative Palmer amaranth plant was chosen at random from both rows 2 and 3 to measure the distance of influence on nearby grain sorghum plants. Heights, widths, and primary stem diameters were measured on these representative Palmer amaranth plants. The heights were determined by measuring from the soil surface to the apex of each Palmer amaranth plant. The widths were determined by measuring the widest part of each Palmer amaranth plant. The primary stem diameters for each Palmer amaranth were determined by caliper measurements at the height of the grain sorghum head. Grain sorghum peduncle lengths and head lengths were measured at distances of 0 to 10 cm, 10 to 20 cm, 20 to 30 cm, and 30 to 40 cm from the representative Palmer amaranth plants. Also at both locations in 2000, the number of sorghum panicles for rows 2 and 3 were counted to determine the total number of sorghum panicles harvested per plot. Heights were measured, using the same method as stated earlier, on all Palmer amaranth plants in rows 2 and 3 to determine the

---

[6]Forestry Suppliers, Inc., P.O. Box 8397, Jackson, MS 39284.

effect of weed density on weed height.

To determine the effect of weed biomass on sorghum yield, Palmer amaranth plants were cut, within a day of harvest, at the soil surface from rows 2 and 3 of each plot and weighed. A representative weed sample from each plot was weighed then dried at 54 C for 10 days, and reweighed to determine percent moisture. Total plot weed fresh weights were adjusted to total plot weed dry weights using the respective percent moisture values. Dry weed weights were then compared to the grain sorghum yield as percent yield loss. Also at both locations in 2000, weight of 1000 seed and the mean number of seed per panicle were determined.

Data were subjected to analysis of variance. Grain moisture, grain yield, Palmer amaranth weights, percent loss of grain yield, mean number of seed per panicle, and foreign material were tested for goodness-of-fit to linear regression models. Grain sorghum peduncle lengths, grain sorghum head lengths, test weights, grades, and harvest times were compared using trend analyses. The regression models and the trend analyses were analyzed using PROC GLM (SAS 1988).

RESULTS AND DISCUSSION

Noncompetitive Experiments. When compared to the weed-free check, grain moisture showed a positive linear response to an increase in Palmer amaranth density in two of three experiments. Each increase by one weed/15 m of row, increased grain moisture before cleaning 0.7 and 0.2% for Chickasha in 1999 and Perkins (Figure 1A). Grain moisture after cleaning increased 0.2% at Chickasha in 1999 and at Perkins for each increase by one weed/15 m of row (Figure 1B). At Chickasha in 2000, grain moisture before and after cleaning were not affected by Palmer

11

amaranth. Knowing the effects Palmer amaranth on grain sorghum moisture is extremely important because producers can adjust their storage or marketing decisions according to Palmer amaranth populations at grain sorghum harvest.

Foreign material increased 67, 2, and 3 kg/ha for each increase by one weed/15 m of row for Chickasha in 1999, Chickasha in 2000, and Perkins, respectively (Figure 2). The amount of foreign material at both locations in 2000, are closely related because the size of Palmer amaranth at harvest were similar. The Palmer amaranth dry weights at harvest were 0.6, 0.2, and 0.2 kg/plant for Chickasha in 1999, Chickasha in 2000, and Perkins, respectively.

At Chickasha in 2000, seed lost from the back of the combine increased 11 kg/ha for each increase by one weed/15 m of row (Figure 3). Palmer amaranth had no affect on the amount of seed lost from the back of the combine at Perkins in 2000. Although seed loss appeared great at Chickasha, no differences were observed for the overall grain sorghum yields.

In 2000, grain sorghum grades at Perkins and harvest times at both locations showed an increasing linear trend at the 0.05 probability level (Table 1). Although harvest times showed an increasing linear trend, there was a difference of approximately 4.0 s at Chickasha and 1.5 s at Perkins between the weed-free check and the highest weed density; therefore, Palmer amaranth, up to a density of 18 plants/15 m of row, did not extensively affect combine performance. No differences were detected for grain sorghum test weights at either location in 2000 and for grain sorghum grades at Chickasha in 2000. Grain sorghum grades were better at Perkins for the higher weed densities, which could be a result of Palmer amaranth buffering the grain sorghum as it passed

12

through the combine. Since the moisture of the grain sorghum was low, the combine could have caused more broken or split seeds in the lower weed density plots, therefore, reducing the grade.

Competitive Experiments. In all experiments grain sorghum yields, when compared to the weed-free check, showed a negative linear response to an increase in Palmer amaranth density. Each increase by one weed/15 m of row, decreased grain sorghum yields 97, 190, and 92 kg/ha for Chickasha in 1999, Chickasha in 2000, and Perkins, respectively (Figure 4A). Although full-season competition from Palmer amaranth had a negative affect on grain sorghum yields, no differences were detected for grain sorghum peduncle lengths or grain sorghum head lengths at either location in 2000 (data not shown).

The environmental conditions of Oklahoma can be extremely variable from year to year and from location to location; therefore, expressing yield reduction as a percentage of the weed-free check is desirable (Rowland et al. 1999; Wood et al. 1999). The percentage of grain yield reduced was estimated at 1.8, 3.5, and 2.7% for each increase by one weed/15 m of row at Chickasha in 1999, Chickasha in 2000, and Perkins respectively (Figure 4B).

Palmer amaranth dry weights showed a positive linear response to an increase in Palmer amaranth densities. Weed weights increased 0.4, 0.6, and 0.3 kg/plot for each increase by one weed/15 m of row at Chickasha in 1999, Chickasha in 2000, and Perkins, respectively (Figure 5). Grain yield reduction, as a percentage of the weed-free check, showed a positive linear response to an increase in Palmer amaranth weights. Each increase by 1 kg of Palmer amaranth/plot, reduced grain yield 5.3, 5.9, and 9.1% at Chickasha in 1999, Chickasha in 2000, and Perkins, respectively (Figure 6).

13

In 2000, for each increase by one weed/15 m of row, the mean number of seed produced by each panicle decreased by 27 at Perkins and by 50 at Chickasha (Figure 7). A similar experiment reported that redroot pigweed reduced sorghum seed per head by as much as 55 seed (Knezevic et al. 1997). Heinrich et al. (1983) reported that the number of seed per head is a yield component that is significantly related to the crop yield. This indicates that grain sorghum yields decrease because the grain sorghum plant does not produce as many seed per panicle. Also in 2000 at Chickasha, test weights and grades showed a negative linear trend (Table 2). Although differences were detected at the 0.05 probability level, from a practical standpoint the test weight for the highest weed density was still above 734 kg/m^3, which is classified on the grading scale as U.S. No. 1 (USDA 1995).

These experiments indicate that Palmer amaranth is a dominating weed in grain sorghum. If allowed to compete all season, one Palmer amaranth plant/m of row can reduce seed production per panicle by a range of 24% to 37%. The potential seed number per head is determined during the boot stage which is shortly before sorghum flowering (Vanderlip 1993). Another indicator of yield reduction was that grain yields decreased steadily as Palmer amaranth biomass increased.

Since Palmer amaranth biomass is usually large, one Palmer amaranth/m of grain sorghum row can increase grain moisture by at least 3% when Palmer amaranth is harvested with the grain sorghum. Although harvest times showed an increasing linear trend, Palmer amaranth did not extensively affect combine performance; however, at one location, Palmer amaranth increased seed loss from the back of the combine, but effects on grain yield could not be detected. Grain sorghum test weights decreased at Chickasha in 2000, however no other difference were

14

detected for any other experiment. Grain sorghum grades decreased at Chickasha in 2000 as a result of full-season competition; however, when Palmer amaranth was harvested with the grain sorghum at Perkins, grades increased suggesting that the Palmer amaranth could have buffered the grain sorghum seed as it passed through the combine.

Palmer amaranth is not only a common weed but a troublesome weed in Oklahoma grain sorghum. The results of these experiments indicate that Palmer amaranth is very competitive with grain sorghum; therefore, based on the variables evaluated, Palmer amaranth control during the growing season is essential to minimize grain sorghum losses.

LITERATURE CITED

Albers-Nelson, M. R., D. S. Murray, L. M. Verhalen, and C. L. Goad. 2000. Establishment Techniques for Common Cocklebur (*Xanthium strumarium*). Weed Technol. 14:463-470.

Burnside, O. C., G. A. Wicks, D. D. Warnes, B. R. Somerhalder, and S. A. Weeks. 1969. Effect of weeds on harvesting efficiency in corn, sorghum, and soybeans. Weed Sci. 17:438-441.

Dowler, C. C. 1997. Weed survey-Southern States. Proc. South. Weed Sci. Soc. 50:227-246.

Feltner, K. C., H. R. Hurst, and L. E. Anderson. 1969. Tall waterhemp competition in grain sorghum. Weed Sci. 17:214-216.

Gossett, B. J. and J. E. Toler. 1999. Differential control of Palmer amaranth (*Amaranthus palmeri*) and smooth pigweed (*Amaranthus hybridus*) by postemergence herbicides in soybean (*Glycine Max*). Weed Technol. 13:165-168.

Heinrich, G. M., C. A. Francis, and J. D. Eastin. 1983. Stability of grain sorghum yield components across diverse environments. Crop Sci. 23:209-212.

Horak, M. J. and T. M. Loughin. 2000. Growth analysis of four *Amaranthus* species. Weed Sci. 48:347-355.

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.

Keeley, P. E. and R. J. Thullen. 1989. Growth and competition of black nightshade (*Solanum nigrum*) and Palmer amaranth (*Amaranthus palmeri*) with cotton (*Gossypium hirsutum*). Weed Sci. 37:326-334.

Keeling, J. W., K. T. Siders, and J. R. Abernathy. 1991. Palmer

amaranth (*Amaranthus palmeri*) control in a conservation tillage

system for cotton (*Gossypium hirsutum*). Weed Technol. 5:137-141.

Klingaman, T. E. and L. R. Oliver. 1994. Palmer amaranth (*Amaranthus

palmeri*) interference in soybeans (*Glycine max*). Weed Sci.

42:523-527.

Knezevic, S. Z., M. J. Horak, and R. L. Vanderlip. 1997. Relative time

of redroot pigweed (*Amaranthus retroflexus* L.) emergence is

critical in pigweed-sorghum [*Sorghum bicolor* (L.) Moench]

competition. Weed Sci. 45:502-508.

Monks, D. W. and L. R. Oliver. 1988. Interactions between soybean

(*Glycine max*) cultivars and selected weeds. Weed Sci. 36:770-774.

Pawlak, J. A., D. S. Murray, and B. S. Smith. 1990. Influence of

capsule age on germination of nondormant jimsonweed (*Datura

stramonium*) seed. Weed Technol. 4:31-34.

Rogers, J. B., D. S. Murray, L. M. Verhalen, and P. L. Claypool. 1996.

Ivyleaf morningglory (*Ipomoea hederacea*) interference with cotton

(*Gossypium hirsutum*). Weed Technol. 10:107-114.

Rowland, M. W., D. S. Murray, and L. M. Verhalen. 1999. Full-season

Palmer amaranth (*Amaranthus palmeri*) interference with cotton

(*Gossypium hirsutum*). Weed Sci. 47:305-309.

[SAS] Statistical Analysis Systems. 1988. SAS/STAT User's Guide.

Release 6.03 ed. Cary, NC: Statistical Analysis Systems

Institute. 1028p.

Smith, B. S., D. S. Murray, and D. L. Weeks. 1990. Velvetleaf

(*Abutilon theophrasti*) interference with cotton (*Gossypium

hirsutum*). Weed Technol. 4:799-803.

U. S. Department of Agriculture. 1997. Grain Inspection Handbook-Book
    II. Grain Grading Procedures [Online]. Available at
    http://www.usda.gov/gipsa/strulreg/handbooks/grbook2/handbook.htm
    (verified 26 Sept. 2000).

Vanderlip, R. L. 1993. How a sorghum plant develops. Revised version.
    Kansas State Univ. Coop. Ext. Serv., Manhattan, KS.

Vencill, W. K. and P. A. Banks. 1994. Effects of tillage systems and
    weed management on weed populations in grain sorghum (*Sorghum
    bicolor*). Weed Sci. 42:541-547.

Wiese, A. F. 1968. Rate of weed root elongation. Weed Sci. 16:11-13.

Wood, M. L., D. S. Murray, R. B. Westerman, L. M. Verhalen, and P. L.
    Claypool. 1999. Full-season interference of *Ipomoea hederacea*
    with *Gossypium hirsutum*. Weed Sci. 47:693-696.

Table 1. Noncompetitive effects of Palmer amaranth on grain sorghum test weights, grades, and harvest times in 2000.

Weed density	Test weight		Grade		Harvest times	
	Chickasha	Perkins	Chickasha	Perkins	Chickasha	Perkins
#/15 m of row	——— kg/m^3 ———				——— s/plot ———	
0	790	784	2.00	2.25	20.9	23.0
1	786	784	1.67	3.00	24.1	21.6
2	793	784	1.67	2.75	24.4	23.3
4	791	786	1.67	2.75	24.8	21.7
6	789	785	2.00	2.50	24.7	23.2
9	790	788	2.00	2.25	24.5	23.9
12	791	784	2.00	1.75	24.4	23.7
18	790	790	1.67	1.50	24.9	24.4
Linear	NS	NS	NS	*	*	*

* Significant at the 0.05 probability level.

[NS] Not significant at the 0.05 probability level.

Table 2. Effect of full-season interference from Palmer amaranth on grain sorghum test weights and grades in 2000.

Weed density	Test weight		Grade	
	Chickasha	Perkins	Chickasha	Perkins
#/15 m of row	——— kg/m^3 ———			
0	781	787	1.75	2.25
1	782	785	2.00	1.75
2	782	789	2.00	1.75
4	781	792	2.00	1.75
6	781	788	2.25	1.75
9	777	790	2.25	2.50
12	779	787	2.50	1.75
18	776	787	2.75	2.00
Linear	*	NS	*	NS

* Significant at the 0.05 probability level.

[NS] Not significant at the 0.05 probability level.

Figure 1. Effect of Palmer amaranth on grain moisture content before (A) and after (B) cleaning the grain sorghum from the 1999 and 2000 noncompetitive experiments.
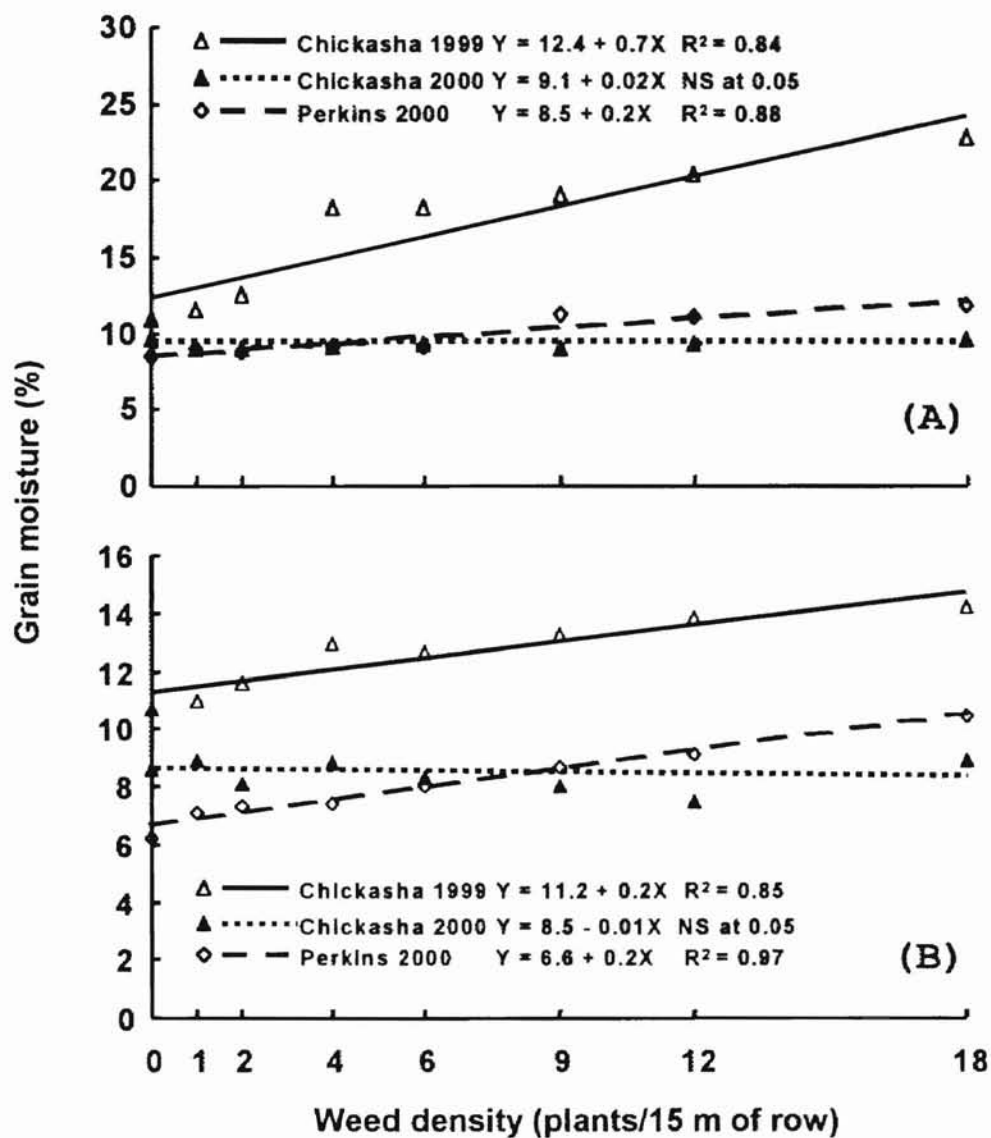
Figure 2. Relationship between foreign material and Palmer amaranth density for the noncompetitive, machine harvested experiments in 1999 and 2000.
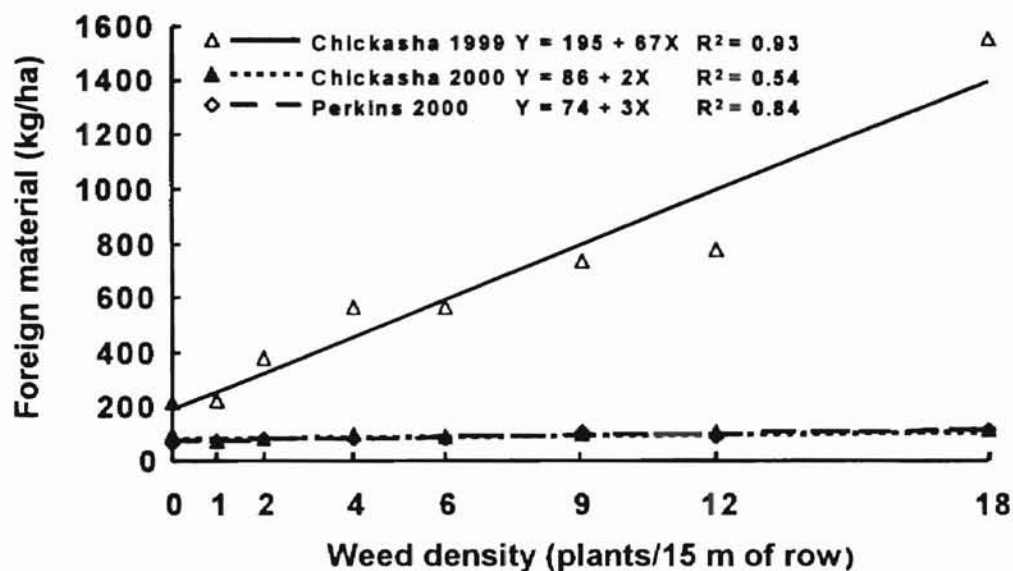
Figure 3. Noncompetitive effect of Palmer amaranth on the amount of grain sorghum seed passed out the back of the combine in 2000.
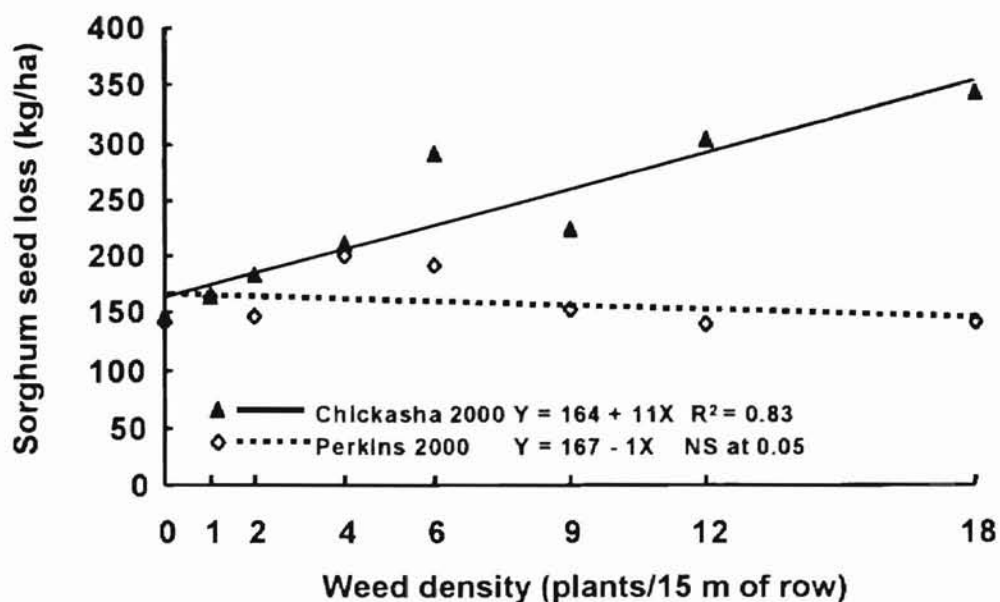
Figure 4. Grain yield (A) and grain yield (% of the weed-free check) (B) response to full-season interference from Palmer amaranth in 1999 and 2000
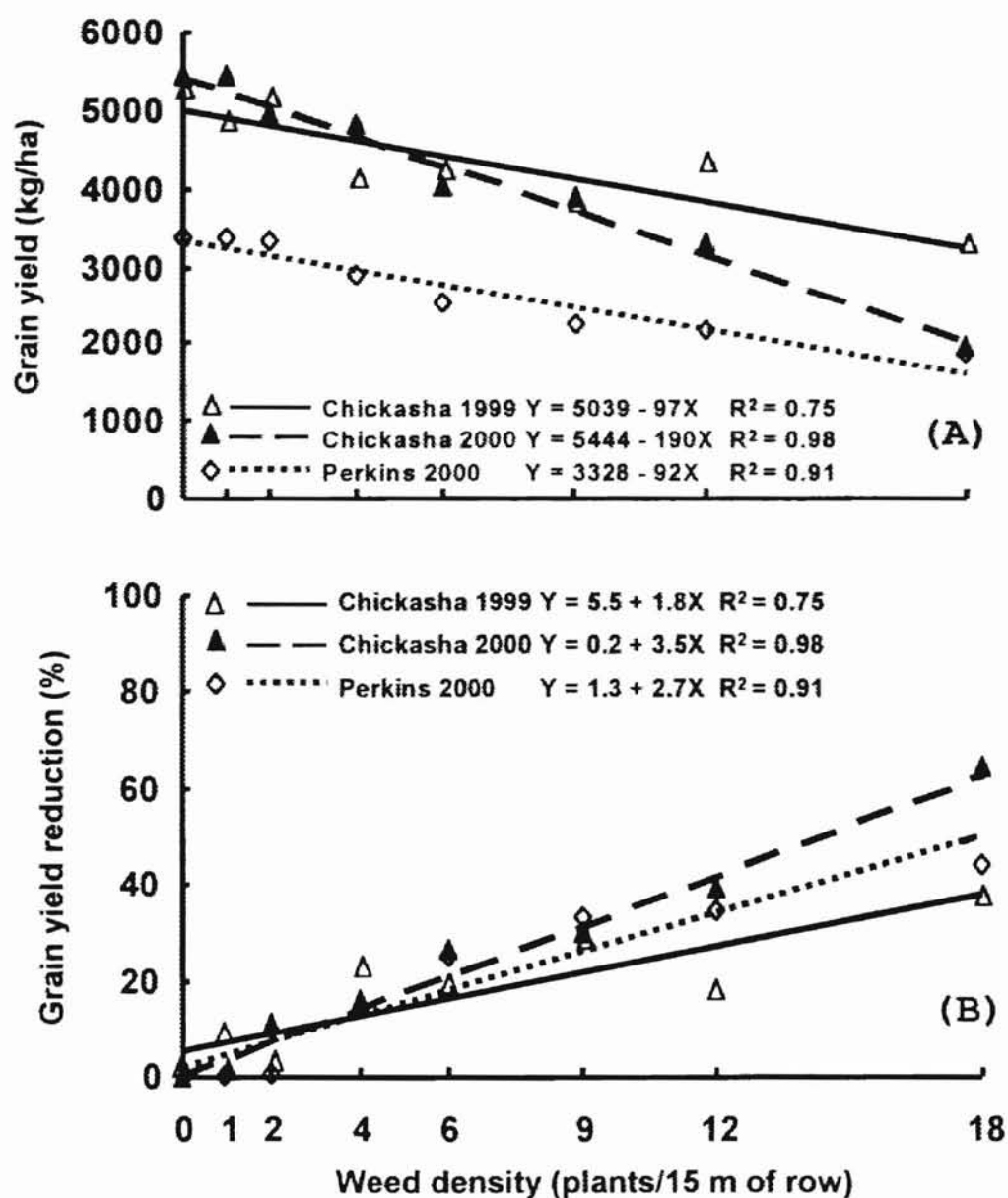
Figure 5. Relationship between Palmer amaranth density and Palmer amaranth dry biomass in 1999 and 2000.
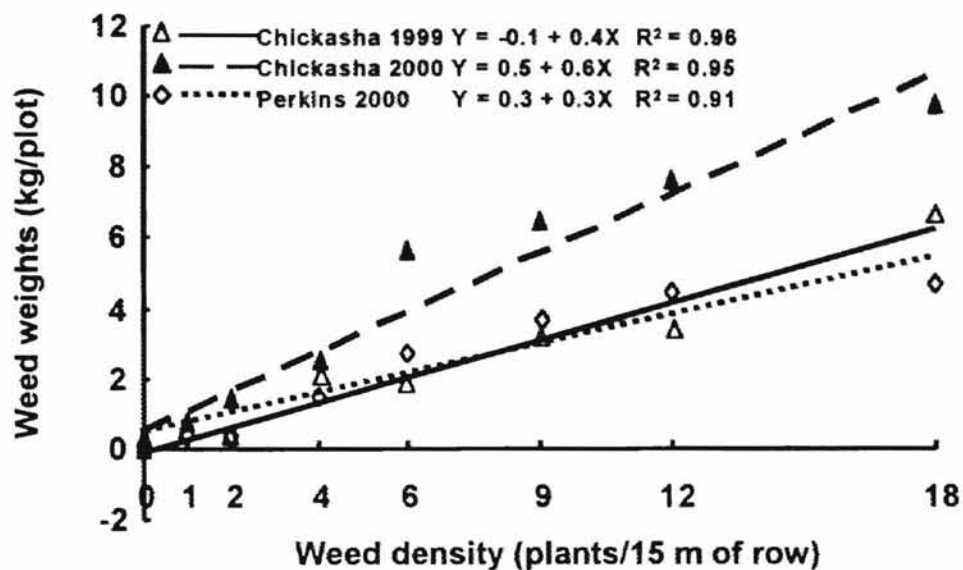
Figure 6. Relationship between Palmer amaranth biomass and grain sorghum yields (% of the weed-free check) in 1999 and 2000.
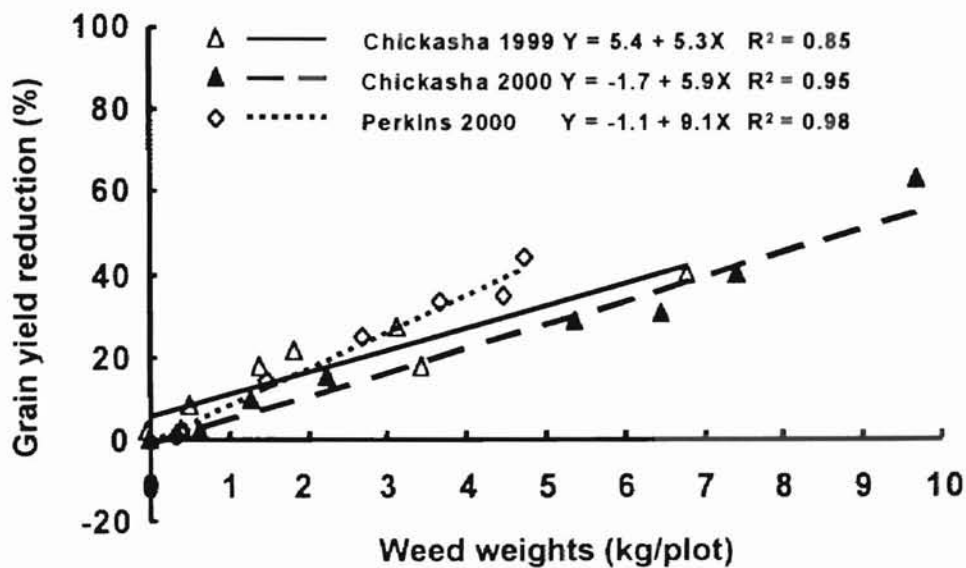
Figure 7. Effect of full-season interference from Palmer amaranth on the number of seed produced per grain sorghum panicle in 2000.

Chickasha 2000 Y = 2023 - 50X R^2 = 0.80
Perkins 2000   Y = 1684 - 27X R^2 = 0.72

Weed density (plants/15 m of row)

No. of seed/panicle
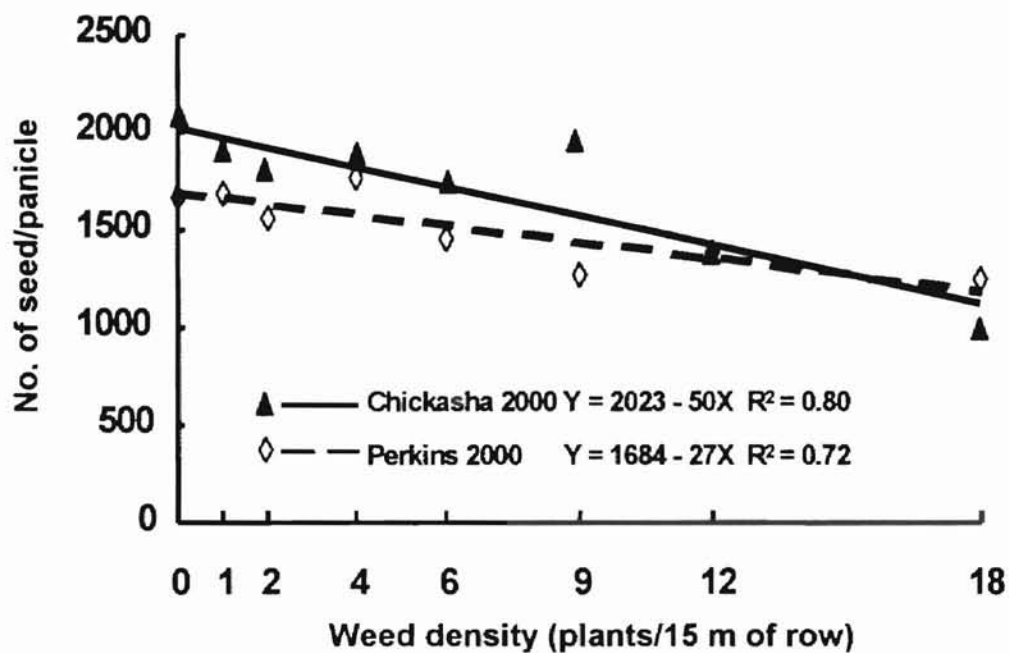
APPENDIX

Appendix Table 3. Grain moistures before cleaning for the noncompetition experiment at Perkins in 1998.

Weed density	Replication				Mean
#/10 m of row	I	II	III	IV	%/plot
0	9.9	9.9	10.9	11.3	10.5
0	10.1	10.0	9.5	12.7	10.6
1	9.6	9.4	12.1	9.6	10.2
2	9.0	10.1	8.4	9.2	9.2
4	9.5	14.1	14.5	15.6	13.4
6	16.4	18.4	15.0	10.2	15.0
12	19.0	19.1	18.2	18.5	18.7

Appendix Table 4. Grain moistures before cleaning for the noncompetition experiment at Chickasha in 1999.

Weed density	Replication				Mean
#/15 m of row	I	II	III	IV	%/plot
0	11.3	10.9	10.8	10.7	10.9
1	11.4	12.3	10.7	11.7	11.5
2	12.6	12.9	13.1	11.8	12.6
4	16.0	16.5	24.0	16.8	18.3
6	19.6	21.9	13.3	17.8	18.2
9	17.2	15.7	23.0	20.0	19.0
12	17.9	23.5	19.3	20.9	20.4
18	22.6	20.1	22.2	26.6	22.9

Appendix Table 5. Grain moistures before cleaning for the noncompetition experiment at Perkins in 2000.

| Weed density | Replication | | | | Mean |
	I	II	III	IV	
#/15 m of row	———————————————— %/plot ————————————————				
0	7.7	9.2	8.7	8.6	8.6
1	8.2	8.7	10.2	8.6	8.9
2	8.6	9.7	9.8	6.9	8.8
4	8.0	9.5	10.0	9.2	9.2
6	8.2	9.4	9.2	9.6	9.1
9	12.1	12.1	10.3	10.8	11.3
12	11.7	11.2	10.3	11.1	11.1
18	11.9	10.5	12.9	12.2	11.9

Appendix Table 6. Grain moistures before cleaning for the noncompetition experiment at Chickasha in 2000.

| Weed density | Replication | | | | Mean |
	I	II	III	IV[a]	
#/15 m of row	———————————————— %/plot ————————————————				
0	9.5	9.7	9.5	----	9.6
1	8.8	8.6	9.3	----	8.9
2	8.7	8.6	9.4	----	8.9
4	8.9	9.1	9.3	----	9.1
6	9.0	8.9	10.0	----	9.3
9	9.7	9.0	8.0	----	8.9
12	8.8	9.5	9.6	----	9.3
18	10.5	8.8	9.8	----	9.7

[a] Rep four was not harvested due to extensive bird damage.

Appendix Table 7. Grain moistures after cleaning for the noncompetition experiment at Perkins in 1998.

Weed density	Replication				Mean
	I	II	III	IV	
#/10 m of row			%/plot		
0	6.0	6.8	7.7	5.4	6.5
0	8.0	5.7	7.2	7.4	7.1
1	8.6	8.0	8.3	7.7	8.2
2	7.2	6.8	7.2	6.7	7.0
4	7.5	9.8	11.4	9.6	9.6
6	12.5	13.7	10.2	6.8	10.8
12	14.0	14.8	15.7	13.6	14.5

Appendix Table 8. Grain moistures after cleaning for the noncompetition experiment at Chickasha in 1999.

Weed density	Replication				Mean
	I	II	III	IV	
#/15 m of row			%/plot		
0	11.3	10.3	10.8	10.4	10.7
1	11.4	11.7	10.0	10.7	11.0
2	11.2	11.4	11.9	11.8	11.6
4	11.9	13.9	13.2	12.6	12.9
6	12.3	14.0	11.5	12.4	12.6
9	13.0	13.6	13.7	12.6	13.2
12	12.3	13.7	14.2	14.9	13.8
18	13.8	13.2	14.3	15.4	14.2

Appendix Table 9. Grain moistures after cleaning for the noncompetition experiment at Perkins in 2000.

| Weed density | Replication | | | | Mean |
	I	II	III	IV	
#/15 m of row			%/plot		
0	6.5	4.2	5.3	8.7	6.2
1	7.1	8.8	5.3	7.1	7.1
2	7.3	5.8	8.1	8.1	7.3
4	6.7	7.9	8.7	6.1	7.4
6	6.7	8.0	9.2	8.1	8.0
9	8.7	9.6	8.7	7.9	8.7
12	8.9	8.1	9.5	9.8	9.1
18	10.5	10.4	11.0	10.0	10.5

Appendix Table 10. Grain moistures after cleaning for the noncompetition experiment at Chickasha in 2000.

| Weed density | Replication | | | | Mean |
	I	II	III	IV[a]	
#/15 m of row			%/plot		
0	9.0	8.4	8.5	----	8.6
1	9.3	8.1	9.2	----	8.9
2	7.8	8.4	8.1	----	8.1
4	9.2	8.0	9.2	----	8.8
6	7.8	8.7	8.5	----	8.3
9	8.6	8.0	7.5	----	8.0
12	6.4	8.7	7.5	----	7.5
18	9.1	8.6	9.0	----	8.9

[a] Rep four was not harvested due to extensive bird damage.

Appendix Table 11. Grain sorghum yields before cleaning for the noncompetition experiment at Perkins in 1998.

Weed density	Replication				
	I	II	III	IV	Mean
#/10 m of row	———————————		kg/ha	———————————	
0	960	960	960	1107	997
0	1329	1255	1033	1107	1181
1	1255	1255	1033	1107	1163
2	886	960	738	1181	941
4	1403	1181	1107	1255	1237
6	1329	1476	1181	1181	1292
12	1550	1550	1255	1624	1495

Appendix Table 12. Grain sorghum yields before cleaning for the noncompetition experiment at Chickasha in 1999.

Weed density	Replication				
	I	II	III	IV	Mean
#/15 m of row	———————————		kg/ha	———————————	
0	6459	5179	4933	4602	5293
1	5524	4860	5020	4146	4888
2	4762	3974	4860	4614	4553
4	5709	5587	5561	4478	5334
6	5390	5524	5106	4429	5112
9	5315	5364	4970	4331	4995
12	5844	5106	4872	4073	4974
18	8526	5659	5512	6016	6428

Appendix Table 13. Grain sorghum yields before cleaning for the noncompetition experiment at Perkins in 2000.

Weed density	Replication				Mean
#/15 m of row	I	II	III	IV	kg/ha
0	3815	2472	2695	2350	2833
1	2941	3236	3138	2781	3024
2	2093	2669	2350	3520	2658
4	2843	3138	3346	2768	3024
6	3002	3384	3248	2683	3079
9	3520	3728	2718	3679	3411
12	3150	2252	2620	3199	2805
18	3900	2843	3642	2350	3184

Appendix Table 14. Grain sorghum yields before cleaning for the noncompetition experiment at Chickasha in 2000.

Weed density	Replication				Mean
#/15 m of row	I	II	III	IV[a]	kg/ha
0	6693	5856	5167	----	5906
1	5315	5807	5327	----	5483
2	5303	5856	5118	----	5426
4	5364	5512	5364	----	5413
6	5549	6091	4626	----	5422
9	6030	5807	5217	----	5684
12	5474	5390	5413	----	5426
18	5315	5376	5474	----	5388

[a] Rep four was not harvested due to extensive bird damage.

Appendix Table 15. Grain sorghum yields after cleaning for the noncompetition experiment at Perkins in 1998.

Weed density	Replication				Mean
	I	II	III	IV	
#/10 m of row	——————————— kg/ha ———————————				
0	960	960	960	1107	997
0	1255	1181	960	1033	1107
1	1255	1181	1033	1107	1144
2	886	886	738	1181	923
4	1329	1107	1033	1181	1163
6	1181	1329	1107	1181	1200
12	1403	1403	1107	1476	1347

Appendix Table 16. Grain sorghum yields after cleaning for the noncompetition experiment at Chickasha in 1999.

Weed density	Replication				Mean
	I	II	III	IV	
#/15 m of row	——————————— kg/ha ———————————				
0	6128	5008	4724	4441	5075
1	5291	4626	4785	3937	4660
2	4406	3581	4516	4159	4166
4	5254	4959	4835	4012	4765
6	4835	4823	4577	3949	4546
9	4652	4455	4159	3752	4255
12	5242	4195	4061	3274	4193
18	5500	4713	4589	4675	4869

Appendix Table 17. Grain sorghum yields after cleaning for the noncompetition experiment at Perkins in 2000.

Weed density	Replication				Mean
	I	II	III	IV	
#/15 m of row	—————————————————— kg/ha ——————————————————				
0	3728	2411	2646	2276	2765
1	2866	3150	3063	2707	2946
2	2030	2498	2301	3457	2571
4	2756	3051	3260	2707	2943
6	2915	3285	3175	2596	2993
9	3421	3630	3620	3543	3304
12	3063	2191	2510	3077	2710
18	3789	2768	3457	2240	3063

Appendix Table 18. Grain sorghum yields after cleaning for the noncompetition experiment at Chickasha in 2000.

Weed density	Replication				Mean
	I	II	III	IV[a]	
#/15 m of row	—————————————————— kg/ha ——————————————————				
0	6571	5770	5069	----	5803
1	5266	5720	5242	----	5409
2	5217	5783	5031	----	5344
4	5266	5413	5266	----	5315
6	5463	5980	4553	----	5332
9	5906	5709	5130	----	5581
12	5364	5278	5315	----	5319
18	5167	5266	5390	----	5274

[a] Rep four was not harvested due to extensive bird damage.

Appendix Table 19. Foreign material for the noncompetition experiment at Perkins in 1998.

	Replication				
Weed density	I	II	III	IV	Mean
#/10 m of row	————————————————— kg/ha —————————————				
0	0	0	0	0	0
0	74	74	73	74	74
1	0	74	0	0	19
2	0	74	0	0	19
4	74	74	74	74	74
6	148	147	74	0	92
12	147	147	148	148	148

Appendix Table 20. Foreign material for the noncompetition experiment at Chickasha in 1999.

	Replication				
Weed density	I	II	III	IV	Mean
#/15 m of row	———————————————— kg/ha —————————————				
0	331	171	209	161	218
1	232	234	234	209	227
2	356	394	344	455	387
4	455	628	726	467	569
6	555	701	530	480	567
9	663	909	811	579	741
12	602	911	811	799	781
18	3026	947	923	1341	1559

Appendix Table 21. Foreign material for the noncompetition experiment at Perkins in 2000.

Weed density	Replication				Mean
	I	II	III	IV	
#/15 m of row	——————————— kg/ha ———————————				
0	87	61	49	75	68
1	75	87	75	75	78
2	63	171	49	63	87
4	87	87	87	61	80
6	87	98	73	87	86
9	98	98	98	136	108
12	87	61	110	122	95
18	110	75	185	110	120

Appendix Table 22. Foreign material for the noncompetition experiment at Chickasha in 2000.

Weed density	Replication				Mean
	I	II	III	IV[a]	
#/15 m of row	——————————— kg/ha ———————————				
0	122	87	98	----	102
1	49	87	85	----	73
2	87	73	87	----	82
4	98	98	98	----	98
6	87	110	73	----	90
9	124	98	87	----	103
12	110	112	98	----	107
18	148	110	85	----	114

[a] Rep four was not harvested due to extensive bird damage.

Appendix Table 23. Catch pan weights for the noncompetition experiment at Perkins in 2000.

| Weed density | Replication | | | | Mean |
	I	II	III	IV	
#/15 m of row			g/pan[a]		
0	4.24	4.02	7.44	5.25	5.24
1	5.74	5.25	6.40	6.72	6.03
2	5.53	6.06	5.29	4.81	5.42
4	8.36	5.96	8.07	6.98	7.34
6	6.05	6.83	5.77	9.69	7.09
9	3.19	5.04	5.58	8.62	5.61
12	5.58	4.35	4.93	5.72	5.14
18	6.68	5.51	3.96	4.74	5.22

[a] Weights were adjusted to 12% moisture.

Appendix Table 24. Catch pan weights for the noncompetition experiment at Chickasha in 2000.

| Weed density | Replication | | | | Mean |
	I	II	III	IV[a]	
#/15 m of row			g/pan[b]		
0	5.42	5.27	5.58	----	5.42
1	5.01	7.02	5.98	----	6.00
2	3.98	10.15	6.15	----	6.76
4	9.14	6.40	7.83	----	7.79
6	12.95	7.94	11.34	----	10.74
9	9.11	7.19	8.52	----	8.27
12	9.61	12.47	11.62	----	11.23
18	14.60	14.93	8.59	----	12.70

[a] Rep four was not harvested due to extensive bird damage.

[b] Weights were adjusted to 12% moisture.

Appendix Table 25. Harvest times for the noncompetition experiment at Perkins in 2000.

| Weed density | Replication | | | | Mean |
	I	II	III	IV	
#/15 m of row			s/plot		
0	24.8	23.3	22.6	21.3	23.0
1	20.6	21.5	22.8	21.6	21.6
2	23.1	23.0	23.8	23.4	23.3
4	22.2	20.3	22.0	22.3	21.7
6	22.9	22.9	24.5	22.6	23.2
9	22.8	23.8	24.4	24.4	23.9
12	23.0	24.0	24.6	23.1	23.7
18	23.7	24.8	25.1	24.0	24.4

Appendix Table 26. Harvest times for the noncompetition experiment at Chickasha in 2000.

| Weed density | Replication | | | | Mean |
	I	II	III	IV[a]	
#/15 m of row			s/plot		
0	20.8	21.7	20.1	----	20.9
1	24.6	23.6	24.2	----	24.1
2	24.8	24.3	24.0	----	24.4
4	25.5	25.1	23.9	----	24.8
6	25.3	24.8	24.1	----	24.7
9	24.9	24.5	24.2	----	24.5
12	25.3	23.9	24.1	----	24.4
18	25.8	24.1	24.8	----	24.9

[a] Rep four was not harvested due to extensive bird damage.

Appendix Table 27. Grain sorghum test weights for the noncompetition experiment at Perkins in 2000.

Weed density	Replication				Mean
	I	II	III	IV	
#/15 m of row				kg/m^3	
0	789	782	782	782	784
1	790	785	782	780	784
2	781	781	779	793	783
4	784	782	789	788	786
6	788	786	786	781	785
9	792	792	779	788	787
12	784	785	784	781	783
18	798	790	793	777	790

Appendix Table 28. Grain sorghum test weights for the noncompetition experiment at Chickasha in 2000.

Weed density	Replication				Mean
	I	II	III	IV[a]	
#/15 m of row				kg/m^3	
0	792	789	790	----	790
1	782	793	784	----	786
2	794	793	792	----	793
4	792	792	789	----	791
6	789	793	786	----	789
9	788	790	793	----	790
12	789	793	792	----	791
18	788	794	788	----	790

[a] Rep four was not harvested due to extensive bird damage.

Appendix Table 29. Grain sorghum grades for the noncompetition experiment at Perkins in 2000.

Weed density	Replication				Mean
	I	II	III	IV	
#/15 m of row					
0	3	1	2	3	2
1	3	3	3	3	3
2	3	3	3	2	3
4	2	3	3	3	3
6	3	2	2	3	3
9	2	2	2	3	2
12	1	2	2	2	2
18	2	1	1	2	2

Appendix Table 30. Grain sorghum grades for the noncompetition experiment at Chickasha in 2000.

Weed density	Replication				Mean
	I	II	III	IV[a]	
#/15 m of row					
0	2	2	2	----	2
1	2	2	1	----	2
2	2	2	1	----	2
4	1	2	2	----	2
6	2	2	2	----	2
9	2	2	2	----	2
12	2	2	2	----	2
18	1	2	2	----	2

[a] Rep four was not harvested due to extensive bird damage.

Appendix Table 31. Grain moistures after cleaning for the competition experiment at Chickasha in 1999.

Weed density	Replication				Mean
	I	II	III	IV	
#/15 m of row	————————————————— %/plot —————————————————				
0	11.5	11.3	11.9	11.2	11.5
1	11.2	11.7	11.6	11.7	11.6
2	10.7	11.1	11.7	11.6	11.3
4	11.0	11.4	10.7	11.3	11.1
6	10.9	11.8	10.6	11.5	11.2
9	10.4	11.4	11.0	11.6	11.1
12	11.0	11.4	10.9	11.1	11.1
18	10.9	11.8	10.6	11.3	11.2

Appendix Table 32. Grain moistures after cleaning for the competition experiment at Perkins in 2000.

Weed density	Replication				Mean
	I	II	III	IV	
#/15 m of row	————————————————— %/plot —————————————————				
0	10.1	10.7	10.9	10.3	10.5
1	9.9	10.9	10.8	10.5	10.5
2	10.2	11.1	11.6	10.5	10.9
4	10.0	11.0	10.9	10.7	10.7
6	9.7	10.5	10.5	12.0	10.7
9	10.2	10.6	9.9	10.7	10.4
12	9.9	10.9	10.3	9.8	10.2
18	10.5	10.4	10.6	10.7	10.6

Appendix Table 33. Grain moistures after cleaning for the competition experiment at Chickasha in 2000.

Weed density	Replication				Mean
	I	II	III	IV	
#/15 m of row			%/plot		
0	9.8	10.2	9.6	9.0	9.7
1	9.8	9.6	9.9	10.1	9.9
2	9.5	10.3	9.7	9.1	9.7
4	9.7	10.2	10.0	9.9	10.0
6	9.6	9.8	10.2	9.8	9.9
9	9.8	9.6	10.0	8.9	9.6
12	9.3	9.8	9.5	9.6	9.6
18	9.4	9.8	9.9	9.2	9.6

Appendix Table 34. Grain sorghum yields for the competition experiment at Chickasha in 1999.

Weed density	Replication				Mean
	I	II	III	IV	
#/15 m of row			kg/ha[a]		
0	4812	5320	5300	5872	5326
1	4258	4432	4849	5864	4851
2	5056	5220	4987	5476	5185
4	3944	4670	3721	4278	4153
6	3338	3824	4012	5852	4257
9	3834	2552	3982	5080	3862
12	4767	4224	3949	4585	4381
18	3538	3514	2711	3249	3253

[a] Grain sorghum weights were adjusted to 12% moisture.

Appendix Table 35. Grain sorghum yields for the competition experiment at Perkins in 2000.

| Weed density | Replication | | | | Mean |
	I	II	III	IV	
#/15 m of row	——————————— kg/ha[a] ———————————				
0	3306	3721	3077	3368	3368
1	2469	4311	2981	3742	3376
2	2499	3480	4054	3344	3344
4	3032	2875	2766	2891	2891
6	2575	2815	2214	2535	2535
9	2085	2626	2015	2242	2242
12	2255	3165	1555	1778	2188
18	1890	2567	1188	1882	1882

[a] Grain sorghum weights were adjusted to 12% moisture.

Appendix Table 36. Grain sorghum yields for the competition experiment at Chickasha in 2000.

| Weed density | Replication | | | | Mean |
	I	II	III	IV	
#/15 m of row	——————————— kg/ha[a] ———————————				
0	5902	6918	5371	3613	5451
1	5296	6307	4775	5379	5439
2	4656	5996	5959	3050	4915
4	4078	5864	5222	3616	4695
6	4437	4982	3917	2774	4027
9	3608	5486	3700	2712	3877
12	3678	4086	2429	3122	3329
18	3269	1677	1084	1726	1939

[a] Grain sorghum weights were adjusted to 12% moisture.

Appendix Table 37. Peduncle lengths measured at 0 to 10 cm from the representative Palmer amaranth for the competition experiment at Perkins in 2000.

Weed density	Replication				Mean
#/15 m of row	I	II	III	IV	cm
0	3.5	6.0	8.4	6.7	6.2
1	4.3	6.0	5.2	5.2	5.2
2	9.0	11.3	3.3	2.0	6.4
4	4.0	4.5	8.0	7.3	6.0
6	8.8	9.0	10.5	7.0	8.8
9	8.5	8.8	10.5	9.5	9.3
12	8.5	3.3	9.2	6.0	6.7
18	7.0	4.8	6.5	9.0	6.8

Appendix Table 38. Peduncle lengths measured at 0 to 10 cm from the representative Palmer amaranth for the competition experiment at Chickasha in 2000.

Weed density	Replication				Mean
#/15 m of row	I	II	III	IV	cm
0	4.3	11.0	8.6	6.8	7.7
1	6.0	7.0	7.7	10.0	7.7
2	1.0	5.0	8.0	11.0	6.3
4	7.5	10.5	7.0	12.0	9.3
6	8.3	6.6	8.0	6.0	7.2
9	3.5	8.5	11.0	8.0	7.8
12	15.0	9.0	13.8	14.0	13.0
18	9.3	10.8	6.7	0.0	6.7

Appendix Table 39. Peduncle lengths measured at 10 to 20 cm from the representative Palmer amaranth for the competition experiment at Perkins in 2000.

Weed density	Replication				Mean
#/15 m of row	I	II	III	IV	cm
0	5.0	6.6	10.7	4.4	6.7
1	9.5	11.8	8.0	5.0	8.6
2	4.5	6.3	9.5	4.4	6.2
4	8.3	2.0	8.0	9.0	6.8
6	3.5	11.0	5.0	4.0	5.9
9	6.0	6.7	10.0	6.5	7.3
12	4.2	7.8	11.5	5.0	7.1
18	3.3	6.0	9.5	11.0	7.5

Appendix Table 40. Peduncle lengths measured at 10 to 20 cm from the representative Palmer amaranth for the competition experiment at Chickasha in 2000.

Weed density	Replication				Mean
#/15 m of row	I	II	III	IV	cm
0	4.0	7.0	10.5	6.0	6.9
1	13.0	9.7	8.8	7.3	9.7
2	6.3	11.7	8.0	6.0	8.0
4	4.3	8.5	7.0	22.0	10.5
6	1.7	17.0	0.0	9.7	7.1
9	11.0	7.3	6.0	10.5	8.7
12	6.3	9.3	10.5	10.0	9.0
18	2.6	11.3	10.0	9.0	8.2

Appendix Table 41. Peduncle lengths measured at 20 to 30 cm from the representative Palmer amaranth for the competition experiment at Perkins in 2000.

Weed density	Replication				Mean
#/15 m of row	I	II	III	IV	cm
0	7.0	8.3	12.0	4.7	8.0
1	6.0	8.6	4.0	6.0	6.2
2	3.0	2.3	8.6	1.5	3.9
4	7.4	0.0	7.8	6.7	5.5
6	8.7	9.5	8.0	6.5	8.2
9	6.0	11.5	6.0	6.5	7.5
12	6.7	7.0	11.7	8.0	8.4
18	10.3	9.3	13.5	3.0	9.0

Appendix Table 42. Peduncle lengths measured at 20 to 30 cm from the representative Palmer amaranth for the competition experiment at Chickasha in 2000.

Weed density	Replication				Mean
#/15 m of row	I	II	III	IV	cm
0	4.3	12.5	8.0	14.0	9.7
1	15.6	10.0	4.5	9.6	9.9
2	0.4	6.8	11.0	9.5	6.9
4	5.8	19.3	11.0	8.5	11.2
6	3.5	1.5	6.0	10.0	5.3
9	2.5	4.0	8.0	10.8	6.3
12	6.3	10.5	11.3	3.3	7.9
18	2.0	8.6	8.2	6.7	6.4

Appendix Table 43. Peduncle lengths measured at 30 to 40 cm from the representative Palmer amaranth for the competition experiment at Perkins in 2000.

Weed density	Replication				
	I	II	III	IV	Mean
#/15 m of row				cm	
0	6.0	7.3	10.0	9.7	8.3
1	5.7	9.3	10.3	0.0	6.3
2	5.0	4.3	6.0	5.7	5.3
4	14.0	7.5	5.0	5.8	8.1
6	9.3	11.0	2.0	10.0	8.1
9	4.0	11.8	9.6	6.0	7.9
12	5.3	4.4	12.8	9.6	8.0
18	5.5	7.3	4.3	9.3	6.6

Appendix Table 44. Peduncle lengths measured at 30 to 40 cm from the representative Palmer amaranth for the competition experiment at Chickasha in 2000.

Weed density	Replication				
	I	II	III	IV	Mean
#/15 m of row				cm	
0	3.3	11.5	8.8	4.0	6.9
1	8.0	6.0	10.3	11.8	9.0
2	3.8	8.0	9.0	8.0	7.2
4	7.0	5.6	9.0	7.0	7.2
6	6.0	1.3	11.0	7.7	6.5
9	13.0	5.0	10.0	5.0	8.3
12	3.4	11.0	6.0	8.0	7.1
18	4.0	11.8	13.5	7.3	9.2

Appendix Table 45. Grain sorghum head lengths measured at 0 to 10 cm from the representative Palmer amaranth for the competition experiment at Perkins in 2000.

Weed density	Replication				Mean
	I	II	III	IV	
#/15 m of row				cm	
0	24	26	26	25	25
1	25	25	24	23	24
2	25	23	26	23	24
4	27	23	24	24	25
6	23	22	26	25	24
9	26	23	27	27	26
12	26	21	24	26	24
18	25	25	24	26	25

Appendix Table 46. Grain sorghum head lengths measured at 0 to 10 cm from the representative Palmer amaranth for the competition experiment at Chickasha in 2000.

Weed density	Replication				Mean
	I	II	III	IV	
#/15 m of row				cm	
0	21	24	22	23	23
1	18	25	21	21	21
2	24	26	20	19	22
4	20	24	20	24	22
6	22	23	23	24	23
9	19	20	19	18	19
12	20	22	17	24	21
18	17	21	20	23	20

Appendix Table 47. Grain sorghum head lengths measured at 10 to 20 cm from the representative Palmer amaranth for the competition experiment at Perkins in 2000.

Weed density	Replication				Mean
	I	II	III	IV	
#/15 m of row			cm		
0	26	24	23	24	24
1	24	24	23	25	24
2	27	26	25	22	25
4	25	26	26	26	26
6	25	27	26	24	26
9	25	26	25	25	25
12	26	22	24	26	25
18	25	26	27	24	26

Appendix Table 48. Grain sorghum head lengths measured at 10 to 20 cm from the representative Palmer amaranth for the competition experiment at Chickasha in 2000.

Weed density	Replication				Mean
	I	II	III	IV	
#/15 m of row			cm		
0	18	26	22	22	22
1	21	23	22	25	23
2	17	21	22	19	20
4	22	21	25	19	22
6	22	19	16	21	20
9	21	22	20	25	22
12	22	23	20	18	21
18	19	22	23	20	21

Appendix Table 49. Grain sorghum head lengths measured at 20 to 30 cm from the representative Palmer amaranth for the competition experiment at Perkins in 2000.

Weed density	Replication				Mean
	I	II	III	IV	
#/15 m of row	cm				
0	25	25	22	24	24
1	23	23	24	27	24
2	27	25	25	24	25
4	26	28	25	23	26
6	22	24	25	25	24
9	27	20	24	25	24
12	23	22	25	26	24
18	24	24	25	24	24

Appendix Table 50. Grain sorghum head lengths measured at 20 to 30 cm from the representative Palmer amaranth for the competition experiment at Chickasha in 2000.

Weed density	Replication				Mean
	I	II	III	IV	
#/15 m of row	cm				
0	21	26	21	20	22
1	18	23	23	23	22
2	22	23	21	23	22
4	20	19	21	24	21
6	21	24	19	21	21
9	20	20	21	22	21
12	19	21	22	25	22
18	20	22	21	20	21

Appendix Table 51. Grain sorghum head lengths measured at 30 to 40 cm from the representative Palmer amaranth for the competition experiment at Perkins in 2000.

| Weed density | Replication | | | | Mean |
	I	II	III	IV	
#/15 m of row			cm		
0	28	26	24	24	26
1	26	22	21	28	24
2	26	23	27	24	25
4	25	26	27	25	26
6	24	22	27	25	25
9	23	25	23	25	24
12	24	25	24	23	24
18	25	23	26	24	25

Appendix Table 52. Grain sorghum head lengths measured at 30 to 40 cm from the representative Palmer amaranth for the competition experiment at Chickasha in 2000.

| Weed density | Replication | | | | Mean |
	I	II	III	IV	
#/15 m of row			cm		
0	21	22	23	24	23
1	21	22	18	23	21
2	21	22	21	23	22
4	22	22	24	24	23
6	23	26	22	19	23
9	18	20	23	25	22
12	22	25	24	24	24
18	19	22	21	23	21

Appendix Table 53. Palmer amaranth dry weights for the competition experiment at Chickasha in 1999.

| Weed density | Replication | | | | Mean |
	I	II	III	IV	
#/15 m of row			kg/plot		
0	0.00	0.00	0.00	0.00	0.00
1	0.57	0.69	0.41	0.27	0.49
2	0.38	0.50	0.27	0.27	0.36
4	1.64	3.02	1.89	0.88	1.86
6	1.70	1.13	2.57	1.80	1.80
9	1.95	4.91	4.59	1.28	3.18
12	1.58	4.66	3.58	3.78	3.40
18	3.78	7.31	8.64	7.43	6.79

Appendix Table 54. Palmer amaranth dry weights for the competition experiment at Perkins in 2000.

| Weed density | Replication | | | | Mean |
	I	II	III	IV	
#/15 m of row			kg/plot		
0	0.00	0.00	0.00	0.00	0.00
1	0.23	0.16	0.58	0.32	0.32
2	0.23	0.61	0.47	0.25	0.39
4	1.57	1.36	1.52	1.38	1.46
6	2.92	2.79	2.07	2.99	2.69
9	3.56	2.61	4.59	3.89	3.66
12	4.73	4.40	5.28	3.41	4.45
18	3.28	5.08	6.49	4.09	4.74

Appendix Table 55. Palmer amaranth dry weights for the competition experiment at Chickasha in 2000.

Weed density	Replication				Mean
	I	II	III	IV	
#/15 m of row			kg/plot		
0	0.00	0.00	0.00	0.00	0.00
1	0.37	0.64	0.69	1.03	0.68
2	0.96	1.66	0.72	1.84	1.29
4	2.56	1.95	2.15	2.64	2.33
6	3.69	5.49	5.93	6.67	5.45
9	5.95	4.46	9.83	5.48	6.43
12	8.47	6.92	7.94	6.64	7.49
18	9.28	9.04	9.48	11.23	9.76

Appendix Table 56. Palmer amaranth heights for the competition experiment at Perkins in 2000.

Weed density	Replication				Mean
	I	II	III	IV	
#/15 m of row			cm		
0	0	0	0	0	0
1	174	183	216	166	185
2	153	204	192	164	178
4	185	190	176	173	181
6	199	197	197	198	198
9	197	192	199	196	196
12	178	171	198	165	178
18	167	173	190	177	177

Appendix Table 57. Palmer amaranth heights for the competition experiment at Chickasha in 2000.

Weed density	Replication				Mean
	I	II	III	IV	
#/15 m of row			cm		
0	0	0	0	0	0
1	133	177	193	181	171
2	131	173	153	183	160
4	141	166	159	168	159
6	166	181	175	183	176
9	158	164	197	156	169
12	162	170	175	183	173
18	149	187	183	169	172

Appendix Table 58. Number of sorghum heads harvested for the competition experiment at Perkins in 2000.

Weed density	Replication				Mean
	I	II	III	IV	
#/15 m of row			heads/plot		
0	211	245	213	215	221
1	206	243	205	224	220
2	219	233	232	203	222
4	247	207	218	227	225
6	228	229	207	228	223
9	208	233	218	235	224
12	210	219	217	216	216
18	200	214	209	204	207

Appendix Table 59. Number of sorghum heads harvested for the competition experiment at Chickasha in 2000.

Weed density	Replication				Mean
	I	II	III	IV	
#/15 m of row			heads/plot		
0	299	296	292	257	286
1	298	309	269	325	300
2	303	324	295	224	287
4	237	297	287	247	267
6	291	267	230	234	256
9	240	312	174	226	238
12	253	311	252	259	269
18	245	247	181	210	221

Appendix Table 60. Seed weight of 1000 seed for the competition experiment at Perkins in 2000.

Weed density	Replication				Mean
	I	II	III	IV	
#/15 m of row			g^a		
0	19.08	21.07	20.40	17.01	19.39
1	19.64	21.15	20.85	21.01	20.66
2	16.25	19.60	21.22	19.94	19.25
4	19.31	20.01	15.38	18.06	18.19
6	19.08	18.95	21.80	21.97	20.45
9	16.64	19.45	21.43	19.50	19.26
12	17.18	15.26	19.31	18.26	17.50
18	20.21	16.76	19.36	21.24	19.39

[a] Seed weights were adjusted to 12% moisture.

Appendix Table 61. Seed weight of 1000 seed for the competition experiment at Chickasha in 2000.

Weed density	Replication				Mean
#/15 m of row	I	II	III	IV	g[a]
0	24.70	22.69	19.71	17.36	21.12
1	24.45	22.45	23.13	19.51	22.38
2	22.36	23.34	22.29	18.92	21.73
4	22.74	23.94	21.54	18.59	21.70
6	22.22	21.20	20.95	19.67	21.01
9	19.54	22.63	19.16	17.67	19.75
12	21.75	24.29	19.50	18.95	21.12
18	21.52	19.81	19.00	17.70	19.51

[a] Seed weights were adjusted to 12% moisture.

Appendix Table 62. Seed produced by each panicle for the competition experiment at Perkins in 2000.

Weed density	Replication				Mean
#/15 m of row	I	II	III	IV	seed/panicle
0	1894	1662	1633	1455	1661
1	1407	1934	1608	1834	1696
2	1619	1757	1899	1005	1570
4	1466	1601	1903	2113	1771
6	1366	1496	1132	1869	1466
9	1389	1336	995	1363	1271
12	1441	2185	856	1040	1380
18	1078	1651	677	1556	1240

Appendix Table 63. Seed produced by each panicle for the competition experiment at Chickasha in 2000.

Weed density	Replication				Mean
	I	II	III	IV	
#/15 m of row	seed/panicle				
0	1843	2375	2152	1868	2059
1	1677	2097	1770	1956	1875
2	1585	1828	2090	1659	1791
4	1745	1902	1948	1816	1853
6	1582	2030	1875	1390	1719
9	1775	1792	2560	1566	1923
12	1542	1247	1140	1467	1349
18	1430	790	727	1071	1005

Appendix Table 64. Grain sorghum test weights for the competition experiment at Perkins in 2000.

Weed density	Replication				Mean
	I	II	III	IV	
#/15 m of row	kg/m^3				
0	786	790	786	784	787
1	784	789	782	784	785
2	786	793	793	785	789
4	794	788	790	794	792
6	786	788	788	789	788
9	782	794	790	792	790
12	785	782	792	788	787
18	782	790	788	789	787

Appendix Table 65. Grain sorghum test weights for the competition experiment at Chickasha in 2000.

| Weed density | Replication | | | | Mean |
	I	II	III	IV	
#/15 m of row			kg/m^3		
0	785	790	782	767	781
1	782	786	784	775	782
2	784	785	782	775	782
4	781	785	784	772	781
6	784	786	784	771	781
9	780	786	776	766	777
12	784	781	779	773	779
18	784	779	768	771	775

Appendix Table 66. Grain sorghum grades for the competition experiment at Perkins in 2000.

| Weed density | Replication | | | | Mean |
	I	II	III	IV	
#/15 m of row					
0	2	2	2	3	2
1	2	2	2	1	2
2	2	1	2	2	2
4	1	2	2	2	2
6	1	2	2	2	2
9	3	2	2	3	3
12	1	2	2	2	2
18	2	2	2	2	2

Appendix Table 67. Grain sorghum grades for the competition experiment at Chickasha in 2000.

Weed density	Replication				Mean
	I	II	III	IV	
#/15 m of row					
0	2	1	2	2	2
1	1	2	2	3	2
2	2	2	2	2	2
4	2	2	2	2	2
6	2	2	2	3	2
9	2	2	3	2	2
12	2	2	3	3	3
18	2	3	3	3	3

VITA

Jerry Wayne Moore

Candidate for the Degree of

Master of Science

Thesis: INFLUENCE OF PALMER AMARANTH (*Amaranthus palmeri*) ON GRAIN SORGHUM (*Sorghum bicolor*)

Major Field: Plant and Soil Sciences

Biographical:

   Personal Data: Born in Frederick, Oklahoma, on April 15, 1974, the son of H. Wayne and Glenda F. Moore. Married Robyn L. Farris on March 13, 1999, a daughter Kelsey L. Farris was born August 25, 1995.

   Education: Graduated from Frederick High School, Frederick, Oklahoma, in May, 1992; received Bachelor of Science degree in Plant and Soil Sciences from Oklahoma State University, Stillwater, Oklahoma in December, 1998. Completed the requirements for the Master of Science degree in Plant and Soil Sciences at Oklahoma State University, Stillwater, Oklahoma, in December, 2000.

   Experience: Employed as a farm laborer before starting my undergraduate work. Employed by Oklahoma State University as an undergraduate and as a Graduate Research Assistant in the Plant and Soil Sciences Department, Oklahoma State University, Stillwater, Oklahoma, May 1996 to the present.

   Professional Memberships: Southern Weed Science Society, Weed Science Society of America, International Weed Science Society.