WEED MANAGEMENT INTENSITY AND NITROGEN

EFFECTS ON WEED DYNAMICS AND COTTON

(*GOSSYPIUM HIRSUTUM*) IN

MULTIPLE-YEAR STUDIES

By

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## Weed Management Intensity and Nitrogen Effects on Weed Dynamics and Cotton (*Gossypium hirsutum*) in Multiple-Year Studies

**Abstract.** Cotton studies were initiated in 1991 at Chickasha, OK, a dryland location, and at Altus, OK, an irrigated site. These studies measured weed population shifts and cotton yield resulting from the use of different weed control practices, determined significance of nitrogen source/placement, and decided the most profitable or cost effective weed management practices for continuous cotton production. A weed infestation of devil's-claw, johnsongrass, large crabgrass, morningglory, Palmer amaranth, silverleaf nightshade, and Texas panicum was established in 1990 at both sites, prior to the first year of cotton production in 1991. Three weed management intensities (WMI1, WMI2, and WMI3) were used with four nitrogen variables (source/placement); however, only two variables are presented (0N and AN) because statistical analyses showed that nitrogen source/placement was not significant. The WMI1 did not receive herbicides; WMI2 received trifluralin, prometryn, and one application of fluazifop-P-butyl in 1991 only; and WMI3 received

trifluralin, prometryn, and fluazifop-P-butyl, hand hoeing, and mepiquat chloride as required. Johnsongrass counts were generally highest in WMI1 at both sites. Johnsongrass was greatly reduced in WMI2 at Chickasha, but not at Altus. Johnsongrass was controlled in WMI3 plots at both sites. Nitrogen increased johnsongrass counts and biomass in WMI2 at the Altus site. Devil's-claw counts were generally consistent within all three weed management intensities each year at the Chickasha site. Devil's-claw counts in WMI1 at Chickasha were slightly suppressed by johnsongrass. Devil's-claw counts were highest in WMI2 at Chickasha, which corresponded with decreases in johnsongrass counts in WMI2. Devil's-claw in WMI3 at Chickasha emerged each year from an initial year of seed propagation. Devil's-claw biomass in WMI1 at Chickasha was decreased by the high densities of johnsongrass. Palmer amaranth was controlled by trifluralin and prometryn in WMI2 and WMI3 at both sites. Palmer amaranth normally increased in counts and biomass after the addition of nitrogen each year at both sites. Morningglory were generally consistent within all treatments each year at the Altus site. The highest morningglory counts were in WMI1 at both sites. Morningglory were constant in WMI3 at the Altus site. Morningglory biomass was very low at the Chickasha site. High counts of morningglory did not produce high biomass at the Altus site. All morningglory biomass and WMI2 counts were normally increased by nitrogen at Altus. Silverleaf nightshade counts were constant in WMI2 at the Altus site. Nitrogen increased the silverleaf nightshade counts from WMI2 each year, but it did not increase the biomass. Cotton biomass was lowest in WMI1 at both sites. Cotton biomass was not significantly different between WMI2 and WMI3 at the Chickasha site. Cotton biomass at the Altus site was generally higher in WMI3 than in WMI2. Generally, the addition of nitrogen did not add to the biomass of cotton at either site. The highest yielding weed management intensity at both sites was WMI3. Nitrogen normally increased yields at Chickasha but seldom increased yields at Altus. Therefore, the most profitable treatment at Chickasha was WMI3 AN, but at Altus the most profitable treatment was WMI3 0N. **Nomenclature:** Fluazifop-P-butyl, butyl (R)-2-[4-[[5-(trifluoromethyl)-2-pyridinyl]oxy]phenoxy]propanoate; mepiquat chloride, N,N-dimethylpiperidinium chloride; prometryn, 2, 4-bis(isopropylamino)-6-(methylthio)-s-triazine; trifluralin, α,α,α-trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine; devil's-claw, *Proboscidea louisianica* (Mill.) Thellung #[1] PROLO; johnsongrass, *Sorghum halepense* (L.) Pers. # SORHA; large crabgrass, *Digitaria sanguinalis* (L.) Scop. # DIGSA; morningglory, *Ipomoea* spp. # IPOZZ; Palmer amaranth, *Amaranthus palmeri* S.Wats. # AMAPA; silverleaf nightshade, *Solanum elaeagnifolium* Cav. # SOLEL; Texas panicum, *Panicum texanum* Buckl. # PANTE; cotton, *Gossypium hirsutum* L., 'Paymaster HS-26.' **Additional index words:** Variable treatment costs, economic analyses, lint yield, fiber quality, lint grades, weed counts, plant biomass, hoe times, AMAPA, DIGSA, IPOZZ, PANTE, PROLO, SOLEL, SORHA.

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[1]Letters following this symbol are a WSSA-approved computer code from Composite List of Weeds, Revised 1989. Available from WSSA, 1508 West University Ave., Champaign, IL 61821-3133.

## INTRODUCTION

Most of the cotton produced in Oklahoma is grown in rotation with grain sorghum [*Sorghum bicolor* (L.) Moench] or winter wheat (*Triticum aestivum* L.)[2]. Different cultural practices, crop competition, and associated herbicide use, which is varied with crop rotation, control different weed species (Cousens and Mortimer 1995; Hauser et al. 1974; Haas and Streibig 1982). At the end of 4 yr, the johnsongrass stand in a cultivated corn (*Zea mays* L.)-cotton-cotton-corn rotation was less than 10% (6 plants/$m^2$) of that in cultivated continuous corn (67 plants/$m^2$) (Dale and Chandler 1979).

Monoculture cotton is grown on approximately 25,000 ha in Oklahoma, this is in contrast to the 122,000 ha grown in rotation[2]. Monoculture crops increase specific weed species from repetitive use of the same cultural practices, herbicides, and crop competition (Dowler et al. 1974; Keeley et al. 1979).

Dowler et al. (1974) grew corn, cotton, peanut (*Arachis hypogaea* L.), and soybean [*Glycine max* (L.) Merr.]

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[2]Banks, J. C. 1996. Personal communication. Cotton Research and Extension Center, Altus, OK 73521.

each continuously and each in rotation with each other and each with the use of cultivation and herbicides for 4 yr with a diverse population of large crabgrass, Florida pusley (*Richardia scabra* L.), Florida beggarweed [*Desmodium tortuosum* (Sw.) DC.], yellow nutsedge (*Cyperus esculentus* L.), sicklepod [*Senna obtusifolia* (L.) Irwin and Barneby], pigweed species, common cocklebur (*Xanthium strumarium L.*), and common lambsquarters (*Chenopodium album* L.). The total weed count for the continuous cropping sequences was greater than three times that of the total weed count for the rotation cropping sequences.

Keeley et al. (1979) decreased viable yellow nutsedge tubers in soil by 96, 97, and 98% in cotton when grown in rotation for 3 yr with cropping systems of barley (*Hordeum vulgare* L.)-corn, alfalfa (*Medicago sativa* L.), and barley-fallow, respectively. This is compared to a 91% reduction of viable yellow nutsedge tubers in soil after 3 yr of continuous cotton. These small differences between cropping systems were significantly different.

Herbicides should be used in rotation sequences or in conjunction with other herbicides. The repeated use of a single herbicide increases tolerant weed species that cause serious weed control problems (Baker 1982; Frans 1969). Cyanazine [2-[[4-chloro-6-(ethylamino)-1,3,5-triazin-2-yl]amino]-2-methylpropanenitrile], diuron [N'-(3,4-dichlorophenyl)-N,N-dimethylurea], and norflurazon [4-chloro-5-(methylamino)-2-(3-(trifluoromethyl)phenyl)-3(2H)-pyridazinone] did not effectively control annual grasses, prickly sida (*Sida spinosa* L.), and pitted morningglory (*Ipomoea lacunosa* L.), respectively, in cotton after 3 yr of continual application (Baker 1982). Therefore, the repetitive isolated use of these herbicides will favor an increase in these weed species. Likewise, the long-term continual use of trifluralin has contributed to the increase of broadleaf weeds (Frans 1969).

The Cotton Production Guide for Oklahoma cotton producers by Banks (1992) gives a detailed explanation of cotton fertility management. Normally, nitrogen is the first limiting nutrient to cotton production. Both insufficient or excessive soil nitrogen causes unwanted effects on cotton lint yields. Inadequate nitrogen results in a stunted and woody plant with fewer branches that have smaller leaves which turn yellow at maturity and senescence earlier than usual. Inadequate nitrogen also causes a decline of boll numbers and size. These fewer and smaller bolls open earlier or shed prematurely, thus reducing lint yield, fiber length, and micronaire. Excessive amounts of nitrogen increases the vegetative growth of cotton making stripper harvest difficult. This also makes the plant a more likely target of disease, late-season insects, freeze damage, and lowers micronaire of the lint. Therefore, the optimum nitrogen rate for cotton production in Oklahoma is 67 kg N/ha per bale of cotton lint.

Oklahoma cotton producers need to know the best nitrogen source to apply and the best application method. Buchanan and McLaughlin (1975) reported that nitrogen applied at 0, 67, and 100 kg N/ha to cotton did not affect the cotton-weed competition relationship. Even though Buchanan and McLaughlin's (1975) study included several annual grasses, which are sensitive to nitrogen application, and cotton is not a strong competitor in the early growing season, the addition of nitrogen did not favor the weed species in the cotton-weed competition relationship.

A winter wheat production experiment by Campbell et al. (1991) tested for differences between two nitrogen sources (urea and ammonium nitrate), three nitrogen placements (seed-placed, banded at 5-cm depth midway between seed rows, and broadcasted), and four application times (at seeding, on cool unfrozen soil, on frozen snow-covered soil, and in early spring). The nitrogen source "rarely" made a difference on yield or grain protein and the application method of nitrogen "rarely" made a difference on yield or grain protein when applied at seeding time.

Oklahoma cotton producers frequently question if an extensive weed control program is profitable if it involves intensive herbicide use or other methods of control including hand hoeing. Menges (1987) grew cotton in rotation with cantaloupe (*Cucumis melo* L. var. *reticulatus*), bell pepper (*Capsicum annuum* L. var. *grossum*), onion (*Allium cepa* L.), and cabbage (*Brassica oleracea* var. *capitata* L.) and reduced cotton production costs from $457 to $395/ha and $758 to $54/ha in 1981 and 1984, respectively, by using herbicides supplemented with handweeding instead of handweeding alone.

Hauser et al. (1974) decreased weed control costs in cotton in rotation with corn and peanut from $313/ha to $68/ha, by using intensive herbicides with cultivation rather than hoe-labor alone. The intensive herbicide weed control system used four different herbicides in several combinations and application methods and times. Therefore, the profitability of this type of intensive herbicide treatment will depend on current herbicide prices and commodity price.

The objectives of this study, one dryland and one irrigated, were to measure weed population shifts and cotton yields from the use of different weed control practices, determine significance of nitrogen source/placement, and determine the most profitable or cost effective weed management practices for continuous cotton production.

## MATERIALS AND METHODS

A dryland experiment near Chickasha, OK was conducted on a Reinach silt loam soil (a coarse-silty, mixed, thermic Pachic Haplustoll) with a pH of 6.6, 1.1% organic matter, 36% sand, 44% silt, and 20% clay. Based on soil tests, 0-46-0 fertilizer was broadcast at 67 kg $P_2O_5$/ha and incorporated on April 21, 1993. A furrow-irrigated experiment near Altus, OK was conducted on a Tillman-Hollister clay loam soil (a fine, mixed, thermic Pachic Paleustoll) with a pH of 7.5, 0.9% organic matter, 15% sand, 48% silt, and 37% clay. Based on soil tests, 18-46-0 fertilizer was broadcast at 112 kg $P_2O_5$/ha on April 2, 1991 and incorporated on April 5, 1991.

The experimental design was a randomized complete block with four replications and with a three by four factorial arrangement of treatments utilizing three weed management intensities and four nitrogen source/placements (Table 1). Plot size was twelve rows by 30 m with 1 m between rows. Of necessity, treatments were reapplied to the same plots every year.

**Weed establishment.** In 1990, a uniform weed infestation was established without cotton on all rows of each plot at both sites. Devil's-claw and silverleaf nightshade were transplanted into the field as seedlings in peat pellets[3]. Devil's-claw density was 3/30 m of row at Chickasha and 2/30 m at Altus. Silverleaf nightshade density was 3/30 m of row at both sites. Johnsongrass, large crabgrass, morningglory species largely of ivyleaf [*Ipomoea hederacea* (L.) Jacq. # IPOHE] and of pitted morningglory (# IPOLA), pigweed species (predominantly Palmer amaranth and referred to as such

[3]Jiffy-7 Peat Pellets, Forestry Supply, P. O. Box 8397, Jackson, MS 39284-8397.

herein), and Texas panicum were planted at 22 seed/m of row at both sites. The weed species were allowed to mature to ensure seed production, were shredded, and tilled into the soil to establish a uniform weed infestation.

Before weed establishment, the test sites did contain Palmer amaranth and large crabgrass, but they were generally free of the others.

**General procedures.** The application of paraquat dichloride (1,1′-dimethyl-4,4′-bipyridinium dichloride), with a non-ionic surfactant[4], over the entire experimental area at both sites was required in some years to facilitate cotton planting and/or emergence because of high densities of early emerging weeds or late in the season as a harvest aid (Tables 2 and 3). Furrow irrigation was applied as needed throughout the growing season in the Altus experiment. Because hail destroyed the cotton too late in 1995 to replant at Altus, plant biomass, hoe times, and yield and fiber data were not collected that year; however, weed counts and the first visual rating were taken.

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[4]Latron AG-98 spray adjuvant, 80% alkylaryl polyoxyethylene glycols, Rohm and Haas Company, Independence Mall West, Philadelphia, PA 19105.

**Weed management intensity.** Three weed management intensities were used, i.e., no herbicide (paraquat dichloride was applied but was not part of the factorial arrangement of treatments) (WMI1)[5], trifluralin PPI followed by prometryn PRE as a 34-cm band over the row (followed in 1991 only by one POST application of fluazifop-P-butyl) (WMI2)[5], and trifluralin and prometryn applied the same as in WMI2 plus fluazifop-P-butyl POST broadcast and/or spot applied and hand hoeing (as needed to maintain those plots in a weed-free condition) plus mepiquat chloride (in some years to regulate cotton growth) (WMI3)[5] (Tables 2 and 3). All fluazifop-P-butyl applications were made using a non-ionic surfactant[4] or crop oil concentrate[6]. The number of hand hoeings required varied with growing season.

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[5]Abbreviations: WMI1, weed management intensity 1; WMI2, weed management intensity 2; WMI3, weed management intensity 3; 0N, no nitrogen; AN, ammonium nitrate.

[6]Majestic Crop Oil Concentrate, paraffinic petroleum oil, Estes Incorporated, P. O. Box 8287, Wichita Falls, TX 76307.

**Nitrogen source/placement.** Nitrogen fertilization was based on lint yield goals of 840 kg/ha for the Chickasha experiment and of 1120 kg/ha for the Altus experiment. Plots received no nitrogen or one of the three nitrogen source/placements, i.e., ammonium nitrate broadcast, urea ammonium nitrate injected, or urea ammonium nitrate plus a nitrification inhibitor injected (Tables 2 and 3). Injections were applied 15-cm to the side of the cotton row.

**Weed counts and plant biomass.** Weed counts were taken each year for the seven weed species planted (Table 4). Counts for WMI2 and WMI3 treatments were taken from the three middles between the four center rows of each plot. However, counts for WMI1 treatments were taken on two 1.5 m lengths from the top of the two center rows of each plot and then converted to the equivalent area of the WMI2 and WMI3 counts. Johnsongrass culms were counted at waist level; all other weed species were counted as whole plants. Generally, these counts were made after the first cultivation and after the first application of fluazifop-P-butyl each year.

Plant biomass was not determined in 1991 in either experiment (Table 4). In 1992 through 1995 at Chickasha and 1992 through 1994 at Altus, a 1.5 m length was used to measure plant biomass from each of rows 3 and 10 in each 12-row plot. Plants were separated by species, dried for 7 d at 41 C, and weighed in grams.

**Visual ratings.** Twice each year, visual ratings of percentage weed control were taken from the three middles of the four center rows in each plot; visual ratings of crop injury were made on the four rows (Table 4). Devil's-claw, johnsongrass, morningglory, and Palmer amaranth were rated; large crabgrass, silverleaf nightshade and Texas panicum were not because of their limited numbers. All ratings were made on a 0 to 100 scale (in increments of five) and were averaged over the four replications. These data are not discussed but are presented in the Appendix (Appendix Tables 1 and 2).

**Hoe times.** The times required to hoe the three middles of the center four rows in each WMI3 plot were recorded (Table 4). Those hoe times were then converted to $/ha using the current minimum wage ($4.25/hr). After hoe times were taken, the remaining rows of the WMI3 plots were also maintained weed-free in an effort to insure that no weeds produced seed.

**Harvest.** Ethephon [(2-chloroethyl)phosphonic acid] and tribufos (S,S,S-tributyl phosphorotrithioate) were applied in some years before harvest to hasten boll opening for a quicker and easier harvest (Tables 2 and 3). Generally, cotton was mechanically harvested from the four center rows of each WMI2 and WMI3 plot in all experiments (with one exception) and the WMI1 plots at Chickasha in 1991 through 1993 and at Altus in 1991 and 1992 (Table 4). The exception was at Altus in 1993 where all treatments were hand harvested. Because of excessive johnsongrass infestations, the WMI1 plots were hand harvested in 1994 and 1995 at Chickasha, and in 1994 at Altus. Fiber samples from each plot were collected after ginning each year and sent to the USDA classing office in Altus, OK or Lubbock, TX in 1992 through 1995. Fiber samples are not discussed but were used in the economic analyses.

During the course of this study, the methods used by the USDA to measure leaf trash in cotton changed. The former leaf trash ratings were converted to approximate the leaf grades of the current method (Appendix Table 3).

Due to the lack of proper equipment, the machine-harvested cotton could not be cleaned during ginning. Thus, it contained more trash than normal in the lint...resulting in lower leaf trash ratings from 1991 through 1994 and lower leaf grades in 1995. An additional adjustment was made for those ratings and grades to approximate more closely a commercial situation.

The market value of the lint for each treatment was calculated in dollars/kilogram after using corresponding fiber qualities and grades on the base loan rate schedule for 1995-96 to assign value after adding a constant factor of 2120 points[7] to each value (Cotton Division 1994; Plains Cotton Coop. Assoc. 1995).

**Economic analyses.** The average annual variable costs associated with each treatment (herbicides, surfactants nitrogen, growth regulators, application and/or incorporation, and hand hoeing) were used to determine the profitability of each treatment. Fixed costs such as planting seed, paraquat, harvest aids, tillage, cultivation, or other inputs made to the entire experimental area were not considered in these analyses. The application and incorporation costs for chemicals and nitrogen were taken

[7]Kenrad, J. 1996. Personal communication. Plains Cotton Coop. Assoc., Lubbock, TX 79408.

from a recent publication by Jobes and Kletke (1995).

**Statistical analyses.** Data from the Chickasha and Altus experiments were not pooled because of the large differences expected between dryland vs. irrigated production and because the test locations were about 175 km apart. Data were analyzed using PROC GLM in SAS[8] to test for nitrogen source/placement by weed management intensity by year interactions. The "protected" Least Significant Difference (LSD) multiple comparison test was used to compare treatments for variables with significant differences as detected by ANOVA.

## RESULTS AND DISCUSSION

There were few instances of significant nitrogen source/placement by weed management intensity interactions. If all three nitrogen sources were pooled and averaged for comparison with no nitrogen (0N)[5] a biased or unequal weighting would have resulted for comparing to the 0N treatment; therefore, ammonium nitrate (AN)[5] was chosen as

[8]SAS, Version 6.08, SAS Institute Inc., Box 8000, Cary, NC 27513.

the one nitrogen source treatment to contrast with the 0N treatment. Therefore, only the data for the 0N and AN per weed management intensity are presented, hence only six treatments (two by three factorial) are discussed.

The significant ($P < 0.05$) nitrogen source/placement by weed management intensity interactions of the Chickasha site were cotton biomass from WMI3 and WMI1 in 1995, johnsongrass biomass from WMI1 in 1995 and WMI3 in 1994, Palmer amaranth counts from WMI1 in 1995, and yields from WMI1 and WMI2 in 1993 and 1991, respectively. The interactions detected at the Altus site were johnsongrass counts from WMI3 in 1991, Palmer amaranth counts from WMI3 in 1992, silverleaf nightshade counts from WMI1 and WMI3 in 1991 and 1995, respectively, cotton biomass from WMI1 in 1992, and yield from WMI1 in 1992. With few exceptions, nitrogen source/placement by weed management intensity interactions were not significant; therefore, analysis using only AN (other nitrogen source/placement combinations ignored) were considered representative. Based on work by Boman et al. (1995) concurrent to our experiment, there was no scientific premise to expect differences from urea ammonium nitrate (with and without a nitrification inhibitor) injected and ammonium nitrate broadcast.

**Weed counts and plant biomass.**

*Chickasha site.* Johnsongrass counts were highest from WMI1 plots (Table 5). The single application of fluazifop-P-butyl to WMI2 plots in 1991 reduced the johnsongrass counts. Because of no fluazifop-P-butyl input to WMI3 in 1992, one to three applications of fluazifop-P-butyl were required each year thereafter to control johnsongrass in those plots. There was no consistent pattern of johnsongrass counts relative to nitrogen application or the lack of nitrogen application. By the end of this 5-yr study, there was a very obvious treatment difference in johnsongrass counts. Johnsongrass was almost eliminated from WMI3 plots and WMI2 plots have four or five fold fewer culms than WMI1 plots.

The biomass shows a similar response; however, each year after 1993 WMI1 plots showed an increase in biomass as a result of the addition of nitrogen. This is probably a predictable response where nitrogen would not effect the counts, but would contribute to the increased growth and biomass of plants. The soil at this particular site is inherently fertile and the response to nitrogen was not detectable until the third through fifth year.

The devil's-claw counts were generally consistent within all three weed management intensities each year. Devil's-claw counts in WMI1 were slightly suppressed by johnsongrass. Devil's-claw counts were highest from WMI2; which corresponded well with decreases of johnsongrass counts in WMI2. Even though no weed species were allowed to produce seed in WMI3 after the weed infestation establishment, the soil seed bank of devil's-claw that was propagated in WMI3 during 1990 remained constant and produced an average of 68 plants each year.

Devil's-claw biomass was lowest in WMI1, reflecting the high density of johnsongrass in this weed management intensity. Devil's-claw biomass was highest with WMI2 and consistent in WMI3 after 1992. Nitrogen did not consistently affect counts or biomass.

Palmer amaranth counts and biomass in WMI1 increased each year from the addition of nitrogen, after 1991. Palmer amaranth was effectively controlled by trifluralin and prometryn with WMI2 and WMI3.

Morningglory counts were highest in WMI1. Morningglory counts remained constant in most treatments and years, but the numbers were generally low. Morningglory biomass was very low.

Silverleaf nightshade, Texas panicum, and large crabgrass counts and biomass were inconsistent and will not be discussed (Appendix Table 4).

Cotton counts were not taken. Cotton biomass was lowest in WMI1. Cotton biomass was not significantly different between WMI2 and WMI3. Generally, nitrogen did not add to the biomass of cotton.

*Altus site.* Because fluazifop-P-butyl was not applied and due to the extensive hail damage in 1995, count data for 1995 will not be discussed (Appendix Table 5).

Johnsongrass counts were high in WMI1 because no herbicides were applied (Table 6). Johnsongrass counts were reasonably high and continually increased over the course of the experiment with WMI2 because the addition of fluazifop-P-butyl in 1991 did not reduce johnsongrass in subsequent years. Lower johnsongrass biomass from WMI1 corresponded with higher johnsongrass counts from WMI1; this may be due to intraspecific competition. The addition of nitrogen increased johnsongrass counts and biomass in WMI2, but rarely in WMI1 or WMI3.

Devil's-claw counts were low and inconsistent in WMI1. Devil's-claw counts were consistent in WMI2 and WMI3, with the highest counts in 1993. Devil's-claw biomass was low after 1992. This, in part, was due to the counts being taken over an area of three row middles 30 m long and the biomass was collected on only 3 m of row.

Palmer amaranth counts were highest in WMI1. Palmer amaranth was controlled by trifluralin and prometryn with WMI2 and WMI3. Palmer amaranth counts and biomass in WMI1 generally increased when nitrogen was added each year.

Morningglory were generally consistent within all treatments each year. The highest morningglory counts were in WMI1. Morningglory were constant in WMI3, regardless of the additional weed control input of hand hoeing.

Morningglory biomass was not consistent with the counts; high counts did not produce high biomass. The addition of nitrogen normally increased biomass in all weed management intensities and WMI2 counts.

Silverleaf nightshade had constant counts in WMI2. Silverleaf nightshade counts from WMI2 were increased each year by the addition of nitrogen. Silverleaf nightshade biomass was sporadic and rare until 1994.

Texas panicum and large crabgrass counts and biomass were inconsistent and not significant; therefore, these data are not discussed (Appendix Table 6).

Cotton counts were not taken. Cotton biomass was lowest in WMI1. Cotton biomass was generally higher in WMI3 than in WMI2. Cotton biomass was highest in 1992 and lowest in 1994. Cotton biomass rarely increased with the addition of nitrogen.

**Hoe times.**

*Chickasha site.* Hoeing times ranged from 5 h/ha to 11 h/ha (Table 7). Although the DAP ranged from 39 to 60 there was not a close association with changes in hoe times. The variation from year to year was probably affected more by the time period since the last cultivation and/or rain than any other variable. These hoe times are not correlated to any particular weed species, although the highest weed population was devil's-claw and this species may have contributed to the hoe times (Table 5).

*Altus site.* Hoeing times ranged from 4 h/ha to 14 h/ha (Table 7). Even though the DAP ranged from 40 to 69 there was not a close association with changes in hoe times. The extremely low hoeing time in 1992 corresponded with a decrease in Palmer amaranth, morningglory, and silverleaf nightshade populations in WMI3.

**Lint Yield.**

*Chickasha site.* Because of the high weed infestation, yields from WMI1 plots were low (Table 8). Because of less weed control, the yields from WMI2 were lower each year than the yields from WMI3, with one exception in 1992. Providing nitrogen increased WMI3 yields every year, but it did not always increase WMI1 or WMI2 yields. The addition of nitrogen is not beneficial if weeds are not controlled. The highest yielding treatment each year was WMI3 with AN. The extra use of weed control inputs beyond those of WMI2 increased yields.

*Altus site.* Because of high weed densities, yields from WMI1 were lower than WMI2 or WMI3 (Table 8). Even though WMI2 and WMI3 yields were not significantly different, with the exception of one treatment each year after 1991, WMI3 yields were generally higher and produced the maximum yields each year. Yields rarely increased as a result of the addition of nitrogen regardless of weed management intensity; rather, nitrogen increased counts and/or biomass of johnsongrass, morningglory, and silverleaf nightshade in WMI2 (Table 6). The counts of morningglory and silverleaf nightshade from WMI2 in 1994 were equivalent to 31 and 9 plants/10 m row, respectively. Rogers et al. (1996) and Green et al. (1987) reported that these density levels of ivyleaf morningglory and silverleaf nightshade decreased cotton lint yield approximately 60% and 10%, respectively. The highest yielding weed management intensity was WMI3. The extra weed control inputs in WMI3, fluazifop-P-butyl and hand hoeing, effectively raised the yield above WMI2. However, the addition of nitrogen to WMI3 did not effectively raise the yield each year.

Because some treatments were hand harvested in certain years at both sites, less foreign material was in the cotton lint causing lower leaf trash ratings and leaf grades than if the cotton had been mechanically harvested (Appendix Table 3).

**Economic analyses.**

*Chickasha site.* The additional inputs of WMI3, fluazifop-P-butyl, mepiquat chloride, and hand hoeing, were the three highest average annual treatment variable costs (Table 9).

Each successive weed management intensity increased the average yield and the difference between the gross income and treatment variable costs (Table 10). However, the addition of nitrogen did not always increase the average yield and it decreased the difference between the gross income and treatment variable costs in WMI1 and WMI2. The most profitable treatment was WMI3 with AN. Intensive weed control involving herbicides and hand hoeing was profitable and the addition of nitrogen is not cost effective unless weeds are controlled.

*Altus site.* Hand hoeing was the highest average annual treatment variable costs followed by fluazifop-P-butyl, ammonium nitrate, and mepiquat chloride (Table 9). Each weed management intensity increased the average yield and the difference between the gross income and treatment variable costs (Table 10). However, the use of nitrogen decreased the difference between the gross income and treatment variable costs in all weed management intensities. The most profitable treatment was WMI3 with 0N. Intense weed control programs which involve numerous herbicide applications and hand hoeing can maximize profits, but the benefit of nitrogen depends on the control of weeds.

These are the results of our objectives. Some weed species were consistent after intensive herbicide use with hand hoeing. Yields were increased with each additional weed management intensity. Nitrogen/source placement was not significant and the addition of nitrogen is not beneficial unless weeds are controlled, because the additional costs are greater than the increase in yields. The best control of all weed species will require intensive herbicide use supplemented with hand hoeing. Intensive herbicide use with hand hoeing was profitable.

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*Table 1.* Factorial arrangement of treatments for both experiments[a].

| No. | Weed management intensity | Nitrogen source/placement[b] |
|---|---|---|
| 1. | None (WMI1) | None (0N) |
| 2. | WMI1 | Ammonium nitrate (AN) |
| 3. | WMI1 | Urea ammonium nitrate (UAN) |
| 4. | WMI1 | UAN + nitrification inhibitor (NI) |
| 5. | Trifluralin fb[c] prometryn[d] (WMI2) | 0N |
| 6. | WMI2 | AN |
| 7. | WMI2 | UAN |
| 8. | WMI2 | UAN + NI |
| 9. | Trifluralin fb prometryn fb fluazifop-P-butyl fb hand hoeing fb mepiquat chloride[e] (WMI3) | 0N |
| 10. | WMI3 | AN |
| 11. | WMI3 | UAN |
| 12. | WMI3 | UAN + NI |

[a]Factorial remaining after initial statistical analyses included treatment numbers 1,2,5,6,9, and 10.

[b]Ammonium nitrate was broadcast and urea ammonium nitrate (with and without a nitrification inhibitor) was injected. The nitrification inhibitor was DCD (dicyandiamide).

[c]Abbreviation: fb, followed by.

[d]This treatment was followed by one application of fluazifop-P-butyl in 1991.

[e]Fluazifop-P-butyl, hand hoeing, and mepiquat chloride were applied as required.

*Table 2.* Dates of chemical application, fertilization, and planting in the dryland experiment near Chickasha[a].

| Operation[b] | Rate | Year | | | | |
|---|---|---|---|---|---|---|
| | | 1991 | 1992 | 1993 | 1994 | 1995 |
| | kg/ha | mo/d | | | | |
| Paraquat dichloride + NIS | 0.6 - 1 + 0.5 - 1%[c] | 6/10 | 6/12 | — | 5/20 | 5/5, 5/19 |
| Trifluralin PPI | 1.1 | 5/17 | 5/5 | 6/2 | 4/21 | 5/5 |
| AN | 45 | — | 5/5 | 6/2 | 5/19 | 5/18 |
| | 67 | 5/17 | — | — | — | — |
| UAN, UAN + NI | 45 | — | 5/15 | 6/2 | 5/19 | 5/18 |
| | 67 | 5/21 | — | — | — | — |
| Planting | 20 | 6/19[d] | 6/13[e] | 6/2 | 5/19 | 5/19 |
| Prometryn PRE | 2.2 | 5/21[d] | 5/15[e] | 6/2 | 5/20 | 5/19 |
| Fluazifop-P-butyl + NIS POST | 0.21 + 0.5% | 7/2, 7/16 | — | — | 6/20 | — |
| | 2% + 0.5%[f] | — | — | 7/20 | 7/26, 9/10 | 6/29, 7/27 |
| Ethephon | 1.3 - 2.5[c] | 10/24 | 10/28 | — | 10/12 | 10/18 |
| Mepiquat chloride | 0.009 - 0.05[c] | — | 8/13 | 7/20, 8/30 | — | — |
| Tribufos | 0.84 - 2.5[c] | 10/24 | — | — | 10/12 | 10/18 |
| Paraquat dichloride + NIS | 0.4 + 0.5%[g] | — | — | — | 11/15 | — |

[a]Dashes indicate no application.

[b]Abbreviations: NIS, non-ionic surfactant; AN, ammonium nitrate; UAN, urea ammonium nitrate; UAN + NI, urea ammonium nitrate plus nitrification inhibitor.

[c]Rate varied from year to year.

[d]Previous plantings on 5/17 and 5/21 failed; prometryn applied after second planting only.

[e]A previous planting on 5/15 failed; prometryn applied after first planting only.

[f]Spot treatment.

[g]Applied as a harvest aid.

*Table 3*. Dates of chemical application, fertilization, and planting in the irrigated experiment near, Altus[a].

| Operation[b] | Rate | Year | | | | |
|---|---|---|---|---|---|---|
| | | 1991 | 1992 | 1993 | 1994 | 1995[c] |
| | kg/ha | mo/d | | | | |
| Paraquat dichloride + NIS | 0.7 - 1 + 0.5%[d] | — | — | — | — | 4/24 |
| Trifluralin PPI | 1.1 | 5/20 | 6/16 | 6/3 | 4/26 | 5/4 |
| AN, UAN, UAN + NI | 45 | — | 6/17 | 6/3 | 5/18 | 5/16 |
| | 90 | 5/20 | — | — | — | — |
| Planting | 20 | 5/30 | 6/17 | 6/3 | 5/19 | 5/17 |
| Prometryn PRE | 2.2 | 5/30 | 6/17 | 6/3 | 5/19 | 5/17 |
| Fluazifop-P-butyl + NIS or COC POST | 0.21 - 0.42 + 0.5 or 1%[d] | 6/14, 7/16 | — | — | 6/20 | — |
| | 2% + 0.5%[e] | — | — | 7/23 | 7/12, 8/9, 9/10 | — |
| Ethephon | 1.7 | 10/23 | — | — | — | — |
| Mepiquat chloride | 0.01 | — | — | 7/23 | — | — |
| Tribufos | 0.84 | 10/23 | — | — | — | — |
| Paraquat dichloride + NIS | 0.7 + 0.125%[f] | — | — | — | 11/4 | — |

[a]Dashes indicate no application.

[b]Abbreviations: NIS, non-ionic surfactant; AN, ammonium nitrate; UAN, urea ammonium nitrate; UAN + NI, urea ammonium nitrate plus nitrification inhibitor; COC, crop oil concentrate.

[c]Fluazifop-P-butyl, plant growth regulators, or harvest aids were not applied because hail destroyed the crop too late in the season to replant.

[d]Rate varied from year to year.

[e]Spot treatment.

[f]Applied as a harvest aid.

*Table 4*. Dates of data collection for both experiments[a].

| | Chickasha | | | | | Altus | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Year | | | | | | | | | |
| Data collected | 1991 | 1992 | 1993 | 1994 | 1995 | 1991 | 1992 | 1993 | 1994 | 1995 |
| | mo/d | | | | | | | | | |
| Weed counts | 7/30 | 7/21 | 7/20 | 6/27 | 7/12 | 7/31 | 8/24 | 7/31 | 6/28 | 8/16 |
| Plant biomass | — | 8/12 | 7/20 | 6/27 | 7/12 | — | 8/25 | 7/31 | 6/27 | — |
| Visual ratings (1st) | 7/11 | 7/21 | 7/13 | 6/27 | 7/12 | 7/17 | 7/14 | 7/21 | 6/28 | 8/16 |
| Visual ratings (2nd) | 7/30 | 8/12 | 9/7 | 9/10 | 9/29 | 7/31 | 8/25 | 9/7 | 9/10 | — |
| Hoe times | 7/30 | 8/12 | 7/20 | 6/27 | 7/12 | 7/31 | 8/25 | 7/31 | 6/28 | — |
| Harvest | 12/17 | 1/28[b] | 11/23 | 12/21 | 11/9 | 2/17[b] | 2/4[b] | 12/7 | 12/19 | — |

[a]Dashes indicate no data. At Altus in 1995, hail destroyed the crop too late in the season to replant.

[b]Experiments were harvested the following year.

*Table 5.* Weed counts and plant biomass of four weed species and plant biomass of cotton in the dryland experiment near Chickasha[a].

| Weed management intensity[b] | Nitrogen source/ placement[c] | Weed counts | | | | | Plant biomass | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Year | | | | | | | | |
| | | 1991 | 1992 | 1993 | 1994 | 1995 | 1992 | 1993 | 1994 | 1995 |
| | | no./90 $m^2$ | | | | | g/3 $m^2$ | | | |
| | | SORHA[d] | | | | | | | | |
| WMI1 | ON | 174 | 2280 | 4568 | 990 | 2190 | 879 | 319 | 171 | 224 |
| | AN | 59 | 2655 | 3735 | 2018 | 2678 | 529 | 883 | 317 | 494 |
| WMI2 | ON | 1 | 3 | 83 | 90 | 631 | 0 | 15 | 31 | 118 |
| | AN | 2 | 4 | 148 | 98 | 230 | 0 | 0 | 25 | 87 |
| WMI3 | ON | 0 | 14 | 123 | 25 | 2 | 0 | 0 | 0 | 0 |
| | AN | 0 | 2 | 37 | 19 | 3 | 0 | 0 | 17 | 0 |
| LSD (0.05) | | 87 | 1091 | 1109 | 939 | 948 | 222 | 269 | 79 | 120 |
| | | PROLO | | | | | | | | |
| WMI1 | ON | 31 | 53 | 30 | 68 | 68 | 1 | 5 | 1 | 1 |
| | AN | 28 | 90 | 30 | 38 | 38 | 34 | 12 | 8 | 3 |
| WMI2 | ON | 51 | 137 | 88 | 146 | 199 | 135 | 65 | 25 | 49 |
| | AN | 48 | 131 | 69 | 153 | 328 | 143 | 49 | 57 | 85 |
| WMI3 | ON | 43 | 85 | 54 | 73 | 65 | 0 | 33 | 26 | 45 |
| | AN | 59 | 76 | 60 | 83 | 77 | 0 | 28 | 23 | 64 |
| LSD (0.05) | | NS | NS | 43 | 63 | 115 | 102 | NS | 35 | 48 |
| | | AMAPA | | | | | | | | |
| WMI1 | ON | 49 | 608 | 285 | 743 | 473 | 16 | 16 | 0 | 5 |
| | AN | 49 | 975 | 3068 | 1988 | 2273 | 392 | 116 | 21 | 109 |
| WMI2 | ON | 0 | 1 | 0 | 1 | 20 | 0 | 0 | 0 | 7 |
| | AN | 0 | 1 | 0 | 1 | 19 | 0 | 0 | 0 | 0 |
| WMI3 | ON | 0 | 5 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| | AN | 0 | 3 | 1 | 4 | 25 | 0 | 0 | 0 | 5 |
| LSD (0.05) | | 46 | 551 | 1256 | 1168 | 154 | 268 | 93 | 10 | 39 |
| | | IPOZZ | | | | | | | | |
| WMI1 | ON | 14 | 45 | 0 | 8 | 23 | 15 | 1 | 0 | 0 |
| | AN | 7 | 128 | 45 | 45 | 68 | 14 | 2 | 0 | 2 |
| WMI2 | ON | 2 | 2 | 2 | 2 | 11 | 0 | 0 | 0 | 0 |
| | AN | 2 | 8 | 5 | 8 | 14 | 1 | 0 | 0 | 3 |
| WMI3 | ON | 9 | 16 | 2 | 2 | 1 | 0 | 0 | 0 | 0 |
| | AN | 3 | 5 | 2 | 1 | 2 | 0 | 0 | 0 | 0 |
| LSD (0.05) | | NS | NS | NS | NS | 34 | NS | NS | NS | NS |
| | | COTTON | | | | | | | | |
| WMI1 | ON | — | — | — | — | — | 51 | 28 | 6 | 13 |
| | AN | — | — | — | — | — | 166 | 13 | 4 | 4 |
| WMI2 | ON | — | — | — | — | — | 488 | 196 | 40 | 67 |
| | AN | — | — | — | — | — | 573 | 229 | 27 | 71 |
| WMI3 | ON | — | — | — | — | — | 563 | 194 | 54 | 100 |
| | AN | — | — | — | — | — | 598 | 209 | 43 | 99 |
| LSD (0.05) | | — | — | — | — | — | 120 | 45 | 15 | 42 |

[a]Dashes indicate no data. Plant biomass was not determined in 1991. Large crabgrass, silverleaf nightshade, and Texas panicum displayed few or no significant differences at Chickasha.

[b]Weed management intensity treatments: WMI1, no herbicide application; WMI2, trifluralin PPI and prometryn PRE (and fluazifop-P-butyl POST applied once in 1991); and WMI3, trifluralin PPI and prometryn PRE with fluazifop-P-butyl POST, hand hoeing, and mepiquat chloride as required.

[c]Nitrogen source/placement treatments: 0N, no nitrogen was applied; AN, ammonium nitrate broadcast.

[d]Computer code designations for weeds: SORHA, johnsongrass; PROLO, devil's-claw; AMAPA, Palmer amaranth; and IPOZZ, ivyleaf and pitted morningglory.

*Table 6*. Weed counts and plant biomass of five weed species and plant biomass of cotton in the irrigated experiment near Altus[a].

| Weed management intensity[b] | Nitrogen source/ placement[c] | Weed counts | | | | Plant biomass | | |
|---|---|---|---|---|---|---|---|---|
| | | Year | | | | | | |
| | | 1991 | 1992 | 1993 | 1994 | 1992 | 1993 | 1994 |
| | | no./90 $m^2$ | | | | g/3 $m^2$ | | |
| | | SORHA[d] | | | | | | |
| WMI1 | ON | 96 | 1050 | 1553 | 3135 | 238 | 492 | 115 |
| | AN | 65 | 1155 | 2318 | 2618 | 189 | 463 | 129 |
| WMI2 | ON | 3 | 64 | 304 | 447 | 22 | 84 | 16 |
| | AN | 6 | 2073 | 1422 | 644 | 233 | 116 | 161 |
| WMI3 | ON | 6 | 0 | 31 | 3 | 0 | 3 | 0 |
| | AN | 4 | 0 | 9 | 1 | 0 | 0 | 0 |
| LSD (0.05) | | 45 | 1092 | 1427 | 1878 | 174 | 290 | 110 |
| | | PROLO | | | | | | |
| WMI1 | ON | 7 | 0 | 0 | 0 | 0 | 0 | 0 |
| | AN | 12 | 0 | 8 | 0 | 0 | 0 | 0 |
| WMI2 | ON | 7 | 8 | 22 | 18 | 49 | 6 | 2 |
| | AN | 11 | 10 | 24 | 4 | 39 | 0 | 6 |
| WMI3 | ON | 8 | 8 | 31 | 30 | 39 | 0 | 10 |
| | AN | 7 | 7 | 13 | 11 | 0 | 0 | 0 |
| LSD (0.05) | | NS | 5 | 15 | 17 | NS | NS | NS |
| | | AMAPA | | | | | | |
| WMI1 | ON | 648 | 1958 | 548 | 540 | 518 | 271 | 16 |
| | AN | 672 | 1890 | 555 | 915 | 848 | 367 | 45 |
| WMI2 | ON | 9 | 1 | 2 | 1 | 0 | 0 | 0 |
| | AN | 1 | 2 | 1 | 0 | 0 | 0 | 0 |
| WMI3 | ON | 33 | 0 | 0 | 0 | 0 | 0 | 0 |
| | AN | 38 | 1 | 1 | 0 | 0 | 0 | 0 |
| LSD (0.05) | | 366 | 778 | 261 | 635 | 268 | 231 | NS |
| | | IPOZZ | | | | | | |
| WMI1 | ON | 8 | 83 | 45 | 435 | 2 | 13 | 6 |
| | AN | 6 | 38 | 30 | 323 | 8 | 7 | 7 |
| WMI2 | ON | 10 | 10 | 27 | 121 | 6 | 14 | 5 |
| | AN | 17 | 11 | 35 | 276 | 0 | 60 | 7 |
| WMI3 | ON | 16 | 7 | 24 | 77 | 0 | 6 | 1 |
| | AN | 12 | 7 | 23 | 111 | 0 | 11 | 10 |
| LSD (0.05) | | NS | 43 | NS | NS | NS | NS | NS |
| | | SOLEL | | | | | | |
| WMI1 | ON | 5 | 0 | 8 | 15 | 0 | 0 | 0 |
| | AN | 3 | 0 | 0 | 30 | 0 | 0 | 0 |
| WMI2 | ON | 3 | 2 | 12 | 46 | 0 | 0 | 20 |
| | AN | 10 | 17 | 47 | 83 | 9 | 0 | 13 |
| WMI3 | ON | 5 | 3 | 6 | 30 | 0 | 0 | 11 |
| | AN | 4 | 0 | 0 | 0 | 0 | 0 | 1 |
| LSD (0.05) | | NS | 8 | 25 | NS | NS | NS | NS |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | COTTON | | | | | | |
| WMI1 | ON | — | — | — | — | 78 | 98 | 22 |
| | AN | — | — | — | — | 54 | 200 | 25 |
| WMI2 | ON | — | — | — | — | 639 | 366 | 74 |
| | AN | — | — | — | — | 393 | 242 | 47 |
| WMI3 | ON | — | — | — | — | 665 | 355 | 85 |
| | AN | — | — | — | — | 724 | 434 | 61 |
| LSD (0.05) | | — | — | — | — | 245 | 186 | 39 |

[a]Dashes indicate no data. Plant biomass was not determined in 1991. Hail destroyed the crop too late in 1995 to replant. Large crabgrass and Texas panicum displayed no significant differences at Altus.

[b]Weed management intensity treatments: WMI1, no herbicide application; WMI2, trifluralin PPI and prometryn PRE (and fluazifop-P-butyl POST applied once in 1991); WMI3, trifluralin PPI and prometryn PRE with fluazifop-P-butyl, hand hoeing, and mepiquat chloride as required.

[c]Nitrogen source/placement treatments: ON, no nitrogen was applied; AN, ammonium nitrate broadcast.

[d]Computer code designations for weeds: SORHA, johnsongrass; PROLO, devil's-claw; AMAPA, Palmer amaranth; IPOZZ, ivyleaf and pitted morningglory; and SOLEL, silverleaf nightshade.

*Table* 7. Hoe times and estimated costs from the highest weed management intensity treatment (WMI3) for both experiments[a].

| Year | Chickasha | | Altus | |
|---|---|---|---|---|
| | h/ha[b] | $/ha[b] | h/ha | $/ha |
| 1991 | 11 | 47 | 12 | 52 |
| 1992 | 8 | 34 | 4 | 17 |
| 1993 | 5 | 21 | 13 | 55 |
| 1994 | 9 | 38 | 14 | 60 |
| 1995 | 11 | 47 | — | — |
| Mean | 9 | 38 | 11 | 47 |

[a]Dashes indicate no data. Hail destroyed the crop at Altus too late in 1995 to replant.

[b]The time required to hoe 90 $m^2$ was converted into time/ha, then multiplied by the current minimum wage ($4.25/hr).

*Table 8.* Cotton lint yields for both experiments.

| Weed management intensity[b] | Nitrogen source/ placement[c] | Chickasha | | | | | | Altus[a] | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Year | | | | | | | | | | |
| | | 1991 | 1992 | 1993 | 1994 | 1995 | Mean | 1991 | 1992 | 1993 | 1994 | Mean |
| | | kg/ha | | | | | | | | | | |
| WMI1 | ON | 114 | 45 | 2 | 1 | 1 | 33 | 250 | 73 | 123 | 21 | 117 |
| | AN | 76 | 67 | 8 | 1 | 0 | 30 | 168 | 71 | 152 | 14 | 101 |
| WMI2 | ON | 438 | 616 | 313 | 81 | 59 | 301 | 397 | 674 | 630 | 416 | 529 |
| | AN | 458 | 710 | 272 | 53 | 69 | 312 | 379 | 637 | 281 | 87 | 346 |
| WMI3 | ON | 521 | 614 | 425 | 367 | 209 | 427 | 475 | 798 | 694 | 655 | 656 |
| | AN | 558 | 886 | 539 | 417 | 244 | 529 | 398 | 620 | 852 | 757 | 657 |
| LSD (0.05) | | 132 | 103 | 86 | 52 | 48 | — | 158 | 119 | 307 | 387 | — |

[a]Hail destroyed the crop at Altus too late in 1995 to replant...therefore, no yield.

[b]Weed management intensity treatments: WMI1, no herbicide application; WMI2, trifluralin PPI and prometryn PRE (and fluazifop-P-butyl POST applied once in 1991); and WMI3, trifluralin PPI and prometryn PRE with fluazifop-P-butyl, hand hoeing, and mepiquat chloride as required.

[c]Nitrogen source/placement treatments: ON, no nitrogen was applied; AN, ammonium nitrate broadcast.

*Table 9.* Average annual variable costs associated with weed management intensity and nitrogen source/placement treatments.

| Treatment variable costs | Chickasha[a] | Altus[b] |
|---|---|---|
| | $/ha | $/ha |
| Trifluralin PPI | 19 | 18 |
| Ammonium nitrate | 30 | 32 |
| Urea ammonium nitrate (UAN) | 23 | 23 |
| UAN + nitrification inhibitor | 30 | 29 |
| Prometryn PRE | 14 | 14 |
| Fluazifop-P-butyl POST | 57 | 44 |
| Non-ionic surfactant or crop oil concentrate | 5 | 5 |
| Mepiquat chloride | 31 | 31 |
| Herbicide application[c] | 6 | 6 |
| Nitrogen application[c] | 6 | 6 |
| Mepiquat chloride application[c] | 6 | 6 |
| Incorporation of trifluralin[c] | 11 | 11 |
| Hand hoeing | 38 | 47 |

[a]Average costs from 1991-1995.

[b]Average costs from 1991-1995. Hail destroyed the crop at Altus too late in 1995 to replant.

[c]Taken from Jobes and Kletke (1995).

*Table 10.* Average lint yield, gross income, annual treatment variable costs, and their differences for both experiments.

| Weed management intensity[c] | Nitrogen source/ placement[d] | Chickasha[a] Lint yield | Chickasha[a] Gross income | Chickasha[a] Treatment variable costs | Chickasha[a] Their difference[e] | Altus[b] Lint yield | Altus[b] Gross income | Altus[b] Treatment variable costs | Altus[b] Their difference |
|---|---|---|---|---|---|---|---|---|---|
| | | kg/ha | $/ha | | | kg/ha | $/ha | | |
| WMI1 | ON | 33 | 48 | 0 | 48 | 117 | 163 | 0 | 163 |
| | AN | 30 | 42 | 36 | 6 | 101 | 145 | 38 | 107 |
| WMI2 | ON | 301 | 421 | 56 | 365 | 529 | 778 | 55 | 723 |
| | AN | 312 | 437 | 92 | 345 | 346 | 491 | 93 | 398 |
| WMI3 | ON | 427 | 602 | 199 | 403 | 656 | 971 | 194 | 777 |
| | AN | 529 | 741 | 235 | 506 | 657 | 979 | 232 | 747 |

[a]Cotton lint prices for the Chickasha experiment were $1.45/kg for WMI1 (ON); $1.40/kg for WMI1 (AN), WMI2 (ON), WMI2 (AN), and WMI3 (AN); and $1.41/kg for WMI3 (ON). Lint was priced according to grade and quality.

[b]Cotton lint prices for the Altus experiment were $1.39/kg for WMI1 (ON); $1.44/kg for WMI1 (AN); $1.47/kg for WMI2 (ON); $1.42/kg for WMI2 (AN); $1.48/kg for WMI3 (ON); $1.49/kg for WMI3 (AN). Lint was priced according to grade and quality.

[c]Weed management intensity treatments: WMI1, no herbicide application; WMI2, trifluralin PPI and prometryn PRE (and fluazifop-P-butyl POST applied once in 1991); and WMI3, trifluralin PPI and prometryn PRE with fluazifop-P-butyl, hand hoeing, and mepiquat chloride as required.

[d]Nitrogen source/placement treatments: ON, no nitrogen was applied; AN, ammonium nitrate broadcast.

[e]Gross income minus treatment variable costs.

APPENDIX

*Appendix Table 1.* First and second visual ratings of four weed species and cotton in the dryland experiment near Chickasha[a].

| Weed management intensity[b] | Nitrogen source/ placement[c] | First rating 1991 | 1992 | 1993 | 1994 | 1995 | Second rating 1991 | 1992 | 1993 | 1994 | 1995 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | % control | | | | | | | | | |
| | | SORHA[d] | | | | | | | | | |
| WMI1 | ON | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | AN | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| WMI2 | ON | 60 | 79 | 96 | 81 | 40 | 93 | 99 | 91 | 38 | 38 |
| | AN | 46 | 79 | 97 | 88 | 70 | 90 | 99 | 93 | 51 | 58 |
| WMI3 | ON | 94 | 78 | 97 | 94 | 99 | 99 | 100 | 100 | 100 | 100 |
| | AN | 95 | 79 | 99 | 93 | 98 | 99 | 100 | 100 | 100 | 100 |
| LSD (0.05) | | 19 | 1 | 4 | 11 | 17 | 4 | 2 | 4 | 19 | 26 |
| | | PROLO | | | | | | | | | |
| WMI1 | ON | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | AN | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| WMI2 | ON | 18 | 49 | 15 | 26 | 58 | 24 | 7 | 10 | 25 | 60 |
| | AN | 26 | 44 | 18 | 24 | 10 | 25 | 10 | 5 | 6 | 35 |
| WMI3 | ON | 36 | 62 | 18 | 50 | 85 | 33 | 100 | 100 | 100 | 100 |
| | AN | 28 | 68 | 38 | 43 | 73 | 15 | 100 | 100 | 100 | 100 |
| LSD (0.05) | | 16 | 17 | 20 | 24 | 21 | NS | 9 | 10 | 8 | 31 |
| | | AMAPA | | | | | | | | | |
| WMI1 | ON | — | — | 0 | 0 | 0 | — | 0 | 0 | 0 | 0 |
| | AN | — | — | 0 | 0 | 0 | — | 0 | 0 | 0 | 0 |
| WMI2 | ON | — | — | 100 | 99 | 96 | — | 50 | 100 | 95 | 93 |
| | AN | — | — | 100 | 100 | 99 | — | 50 | 100 | 94 | 78 |
| WMI3 | ON | — | — | 100 | 100 | 100 | — | 50 | 100 | 100 | 100 |
| | AN | — | — | 100 | 99 | 91 | — | 50 | 100 | 100 | 100 |
| LSD (0.05) | | — | — | 1 | 2 | 5 | — | 45 | 1 | 4 | 14 |
| | | IPOZZ | | | | | | | | | |
| WMI1 | ON | — | 0 | — | — | — | — | 0 | — | — | — |
| | AN | — | 0 | — | — | — | — | 0 | — | — | — |
| WMI2 | ON | — | 100 | — | — | — | — | 100 | — | — | — |
| | AN | — | 96 | — | — | — | — | 98 | — | — | — |
| WMI3 | ON | — | 98 | — | — | — | — | 100 | — | — | — |
| | AN | — | 99 | — | — | — | — | 100 | — | — | — |
| LSD (0.05) | | — | 4 | — | — | — | — | 2 | — | — | — |
| | | % injury | | | | | | | | | |
| | | COTTON | | | | | | | | | |
| WMI1 | ON | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | AN | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| WMI2 | ON | 5 | 0 | 0 | 0 | 3 | 9 | 0 | 0 | 0 | 0 |
| | AN | 1 | 0 | 0 | 0 | 1 | 6 | 0 | 0 | 0 | 0 |
| WMI3 | ON | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 |
| | AN | 4 | 0 | 0 | 0 | 3 | 4 | 0 | 0 | 0 | 0 |
| LSD (0.05) | | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |

[a]Dashes indicate no data. Large crabgrass, silverleaf nightshade, and Texas panicum were not rated because of limited numbers.

[b]Weed management intensity treatments: WMI1, no herbicide application; WMI2, trifluralin PPI and prometryn PRE (and fluazifop-P-butyl POST applied once in 1991); and WMI3, trifluralin PPI and prometryn PRE with fluazifop-P-butyl, hand hoeing, and mepiquat chloride as required.

[c]Nitrogen source/placement treatments: 0N, no nitrogen was applied; AN, ammonium nitrate broadcast.

[d]Computer code designations for weeds: SORHA, johnsongrass; PROLO, devil's-claw; AMAPA, Palmer amaranth; and IPOZZ, ivyleaf and pitted morningglory.

*Appendix Table 2.* First and second visual ratings of four weed species and cotton in the irrigated experiment near, Altus[a].

| Weed management intensity[b] | Nitrogen source/ placement[c] | First Rating | | | | | Second Rating | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Year | | | | | | | | |
| | | 1991 | 1992 | 1993 | 1994 | 1995 | 1991 | 1992 | 1993 | 1994 |
| | | % control | | | | | | | | |
| | | SORHA[d] | | | | | | | | |
| WMI1 | ON | 0 | 0 | 0 | 0 | 43 | 0 | 0 | 0 | 0 |
| | AN | 0 | 0 | 0 | 0 | 43 | 0 | 0 | 0 | 0 |
| WMI2 | ON | 70 | 99 | 79 | 76 | 60 | 95 | 93 | 74 | 25 |
| | AN | 43 | 73 | 49 | 38 | 50 | 89 | 40 | 34 | 15 |
| WMI3 | ON | 96 | 99 | 96 | 98 | 60 | 95 | 100 | 100 | 100 |
| | AN | 95 | 100 | 99 | 98 | 15 | 98 | 100 | 100 | 100 |
| LSD (0.05) | | 23 | 12 | 19 | 23 | NS | 4 | 25 | 29 | 21 |
| | | PROLO | | | | | | | | |
| WMI1 | ON | 0 | — | — | 0 | 23 | 0 | — | — | 0 |
| | AN | 0 | — | — | 0 | 65 | 0 | — | — | 0 |
| WMI2 | ON | 18 | — | — | 60 | 68 | 21 | — | — | 89 |
| | AN | 40 | — | — | 70 | 80 | 30 | — | — | 40 |
| WMI3 | ON | 6 | — | — | 41 | 50 | 9 | — | — | 100 |
| | AN | 10 | — | — | 68 | 20 | 23 | — | — | 100 |
| LSD (0.05) | | 26 | NS | NS | 25 | NS | NS | NS | NS | 30 |
| | | AMAPA | | | | | | | | |
| WMI1 | ON | 0 | — | 0 | 0 | 43 | 0 | 0 | 0 | 0 |
| | AN | 0 | — | 0 | 0 | 75 | 0 | 0 | 0 | 0 |
| WMI2 | ON | 91 | — | 100 | 100 | 43 | 95 | 99 | 99 | 100 |
| | AN | 98 | — | 100 | 100 | 95 | 99 | 100 | 98 | 50 |
| WMI3 | ON | 91 | — | 100 | 99 | 48 | 93 | 100 | 100 | 100 |
| | AN | 89 | — | 100 | 100 | 18 | 89 | 99 | 100 | 100 |
| LSD (0.05) | | 7 | NS | 1 | 2 | NS | 8 | 2 | 2 | 36 |
| | | IPOZZ | | | | | | | | |
| WMI1 | ON | — | — | 0 | 0 | 28 | — | — | 0 | 0 |
| | AN | — | — | 0 | 0 | 60 | — | — | 0 | 0 |
| WMI2 | ON | — | — | 38 | 66 | 50 | — | — | 24 | 33 |
| | AN | — | — | 31 | 19 | 38 | — | — | 0 | 3 |
| WMI3 | ON | — | — | 24 | 64 | 43 | — | — | 100 | 100 |
| | AN | — | — | 48 | 75 | 0 | — | — | 100 | 100 |
| LSD (0.05) | | NS | NS | 31 | 32 | NS | NS | NS | 14 | 12 |
| | | % injury | | | | | | | | |
| | | COTTON | | | | | | | | |
| WMI1 | ON | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | AN | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| WMI2 | ON | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | AN | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| WMI3 | ON | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | AN | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LSD (0.05) | | NS | NS | NS | NS | NS | NS | NS | NS | NS |

[a]Dashes indicate no data. Large crabgrass, silverleaf nightshade, and Texas panicum were not rated because of limited numbers. Second ratings were not

collected in 1995 because hail had destroyed the crop too late in the season to replant.

[b]Weed management intensity treatments: WMI1, no herbicide application; WMI2, trifluralin PPI and prometryn PRE (and fluazifop-P-butyl POST applied once in 1991); and WMI3, trifluralin PPI and prometryn PRE with fluazifop-P-butyl, hand hoeing, and mepiquat chloride as required.

[c]Nitrogen source/placement treatments: 0N, no nitrogen was applied; AN, ammonium nitrate broadcast.

[d]Computer code designations for weeds: SORHA, johnsongrass; PROLO, devil's-claw; AMAPA, Palmer amaranth; and IPOZZ, ivyleaf and pitted morningglory.

*Appendix Table 3.* Average leaf trash ratings converted to approximate leaf grades for both experiments[a].

| | | Chickasha | | | | | | Altus | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Year | | | | | | | | | | | | | |
| Weed management intensity[b] | Nitrogen source/ placement[c] | 1993 | 1994[d] | 1995[d] | 1993 | 1994 | 1995 | 1991 | 1992 | 1993[d] | 1994[d] | 1991 | 1992 | 1993 | 1994 |
| | | Average leaf trash rating | | Unad-justed leaf grade | Leaf grade[f] | | | Average leaf trash rating | | | | Leaf grade[f] | | | |
| WMI1 | ON | 33 | 17 | 8 | 3 | 3 | 5 | 37 | 44 | 42 | 22 | 5 | 4 | 6 | 4 |
| | AN | 42 | — | 8 | 4 | — | 5 | 38 | 38 | 38 | 17 | 5 | 4 | 5 | 3 |
| WMI2 | ON | 41 | 24 | 8 | 4 | 5 | 5 | 41 | 32 | 29 | 22 | 6 | 3 | 4 | 4 |
| | AN | 50 | 18 | 8 | 5 | 4 | 5 | 22 | 47 | 50 | 27 | 3 | 5 | 7 | 5 |
| WMI3 | ON | 45 | 32 | 8 | 4 | 6 | 5 | 35 | 31 | 23 | 19 | 5 | 3 | 3 | 4 |
| | AN | 47 | 26 | 7 | 4 | 5 | 4 | 33 | 33 | 22 | 18 | 5 | 3 | 3 | 4 |

[a]Dashes indicate no data. Fiber qualities and/or cotton grades were unavailable for 1991 or 1992 at Chickasha. Hail destroyed the crop at Altus in 1995 too late in the season to replant. Leaf trash ratings (formly estimated by the USDA) were converted to leaf grades (the current trait estimated). An additional adjustment was made for the inability to clean the cotton during ginning which resulted in lower ratings and grades.

[b]Weed management intensity treatments: WMI1, no herbicide application; WMI2, trifluralin PPI and prometryn PRE (and fluazifop-P-butyl POST applied once in 1991); and WMI3, trifluralin PPI and prometryn PRE with fluazifop-P-butyl, hand hoeing, and mepiquat chloride as required.

[c]Nitrogen source/placement treatments: ON, no nitrogen was applied; AN, ammonium nitrate broadcast.

[d]WMI1 treatments were hand harvested in 1994 and 1995 at Chickasha and in 1994 at Altus. All treatments at Altus in 1993 were hand harvested. Hand harvest results in cleaner cotton, causing a higher leaf grade than if it had been mechanically harvested. Leaf grades for 1995 at Chickasha were made using the new method; therefore, these ratings were adjusted for the

lack of cleaning during ginning only.

[f]Leaf trash ratings for Chickasha were divided by 11 in 1993 and 5 in 1994. Its leaf grades in 1995 were divided by 1.7. Leaf trash ratings for Altus were divided by 7 in 1991 and 1993; 10 in 1992, and 5 in 1994.

*Appendix Table 4.* Weed counts and plant biomass of three weed species in the dryland experiment near Chickasha[a].

| Weed management intensity[b] | Nitrogen source/ placement[c] | Weed counts | | | | | Plant biomass | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Year | | | | | | | | |
| | | 1991 | 1992 | 1993 | 1994 | 1995 | 1992 | 1993 | 1994 | 1995 |
| | | no./90 $m^2$ | | | | | g/3 $m^2$ | | | |
| | | SOLEL[d] | | | | | | | | |
| WMI1 | 0N | 1 | 0 | 0 | 15 | 8 | 0 | 0 | 2 | 23 |
| | AN | 2 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 0 |
| WMI2 | 0N | 5 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 6 |
| | AN | 4 | 1 | 2 | 3 | 10 | 0 | 0 | 0 | 28 |
| WMI3 | 0N | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| | AN | 4 | 0 | 1 | 3 | 3 | 0 | 0 | 0 | 0 |
| LSD (0.05) | | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| | | PANTE | | | | | | | | |
| WMI1 | 0N | 2 | 113 | 0 | 0 | 30 | 15 | 0 | 0 | 0 |
| | AN | 6 | 90 | 75 | 0 | 8 | 124 | 0 | 0 | 0 |
| WMI2 | 0N | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| | AN | 0 | 5 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| WMI3 | 0N | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| | AN | 0 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 0 |
| LSD (0.05) | | NS | NS | 47 | NS | NS | 83 | NS | NS | NS |
| | | DIGSA | | | | | | | | |
| WMI1 | 0N | 0 | 83 | 0 | 0 | 0 | — | — | — | — |
| | AN | 5 | 0 | 0 | 0 | 0 | — | — | — | — |
| WMI2 | 0N | 0 | 0 | 0 | 0 | 0 | — | — | — | — |
| | AN | 0 | 0 | 0 | 0 | 1 | — | — | — | — |
| WMI3 | 0N | 0 | 0 | 0 | 0 | 0 | — | — | — | — |
| | AN | 0 | 2 | 0 | 0 | 1 | — | — | — | — |
| LSD (0.05) | | NS | NS | NS | NS | NS | — | — | — | — |

[a]Dashes indicate no data. Plant biomass was not determined in 1991. Other weeds reported in Table 5.

[b]Weed management intensity treatments: WMI1, no herbicide application; WMI2, trifluralin PPI and prometryn PRE (and fluazifop-P-butyl POST applied once in 1991); and WMI3, trifluralin PPI and prometryn PRE with fluazifop-P-butyl, hand hoeing, and mepiquat chloride as required.

[c]Nitrogen source/placement treatments: 0N, no nitrogen was applied; AN, ammonium nitrate broadcast.

*Appendix Table 5.* Weed counts of seven weed species in the irrigated experiment near Altus in 1995[a].

| Weed management intensity[b] | Nitrogen source/ placement[c] | Weed species | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | SORHA[d] | PROLO | AMAPA | IPOZZ | SOLEL | PANTE | DIGSA |
| | | no./90 m$^2$ | | | | | | |
| WMI1 | 0N | 1852 | 10 | 377 | 48 | 20 | 9 | 0 |
| | AN | 3738 | 7 | 96 | 105 | 37 | 0 | 0 |
| WMI2 | 0N | 1705 | 1 | 225 | 21 | 0 | 1 | 0 |
| | AN | 1786 | 6 | 44 | 357 | 60 | 0 | 0 |
| WMI3 | 0N | 1095 | 8 | 150 | 15 | 0 | 0 | 0 |
| | AN | 3827 | 1 | 405 | 292 | 0 | 0 | 0 |
| LSD (0.05) | | NS | NS | NS | NS | NS | NS | NS |

[a]Hail destroyed the crop too late in 1995 to replant.

[b]Weed management intensity treatments: WMI1, no herbicide application; WMI2, trifluralin PPI and prometryn PRE (and fluazifop-P-butyl POST applied once in 1991); and WMI3, trifluralin PPI and prometryn PRE with fluazifop-P-butyl, hand hoeing, and mepiquat chloride as required.

[c]Nitrogen source/placement treatments: 0N, no nitrogen was applied; AN, ammonium nitrate broadcast.

[d]Computer code designations for weeds: SORHA, johnsongrass; PROLO, devil's-claw; AMAPA, Palmer amaranth; IPOZZ, ivyleaf and pitted morningglory; SOLEL, silverleaf nightshade; PANTE, Texas panicum; and DIGSA, large crabgrass.

*Appendix Table 6*. Weed counts and plant biomass of two weed species in the irrigated experiment near Altus[a].

| Weed management intensity[b] | Nitrogen source/ placement[c] | Weed counts 1991 | 1992 | 1993 | 1994 | Plant biomass 1992 | 1993 | 1994 |
|---|---|---|---|---|---|---|---|---|
| | | no./90 $m^2$ | | | | g/3 $m^2$ | | |
| | | PANTE[d] | | | | | | |
| WMI1 | ON | 31 | 0 | 0 | 0 | — | — | — |
| | AN | 0 | 23 | 0 | 0 | — | — | — |
| WMI2 | ON | 1 | 1 | 0 | 0 | — | — | — |
| | AN | 0 | 17 | 1 | 0 | — | — | — |
| WMI3 | ON | 6 | 0 | 1 | 0 | — | — | — |
| | AN | 0 | 0 | 0 | 0 | — | — | — |
| LSD (0.05) | | NS | NS | NS | NS | — | — | — |
| | | DIGSA | | | | | | |
| WMI1 | ON | 0 | 38 | 0 | 0 | — | — | — |
| | AN | 0 | 0 | 0 | 0 | — | — | — |
| WMI2 | ON | 0 | 0 | 0 | 0 | — | — | — |
| | AN | 0 | 0 | 0 | 0 | — | — | — |
| WMI3 | ON | 0 | 0 | 0 | 0 | — | — | — |
| | AN | 0 | 0 | 0 | 0 | — | — | — |
| LSD (0.05) | | NS | NS | NS | NS | — | — | — |

[a]Dashes indicate no data. Plant biomass was not determined in 1991. Hail destroyed the crop too late in 1995 to replant. Other weeds reported in Table 6.

[b]Weed management intensity treatments: WMI1, no herbicide application; WMI2, trifluralin PPI and prometryn PRE (and fluazifop-P-butyl POST applied once in 1991); and WMI3, trifluralin PPI and prometryn PRE with fluazifop-P-butyl, hand hoeing, and mepiquat chloride as required.

[c]Nitrogen source/placement treatments: ON, no nitrogen was applied; AN, ammonium nitrate broadcast.

[d]Computer code designations for weeds: PANTE, Texas panicum; and DIGSA, large crabgrass.

# VITA

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