2005 Beltwide Cotton Conferences, New Orleans, Louisiana - January 4 - 7, 2005

EFFECTS OF DIFFERENT HERBICIDES, THEIR RATES, AND TIMINGS TO TERMINATE COTTON STALKS

Shoil M. Greenberg, Joe M. Bradford, C. Yang, Randy J. Coleman and Allan T. Showler
ARS-USDA
Weslaco, TX
John W. Norman, Alton N. Sparks and Charles Stichler
Texas Cooperative Extension
Weslaco, TX

Abstract

Cotton stalk destruction is a prime tool in management of several species of cotton pests in the Lower Rio Grande Valley of Texas. Mechanical methods of stalk destruction are generally successful, but some stalks may survive these operations. Moreover, adverse weather conditions and conservation tillage may often impede immediate and complete stalk destruction using typical tool implements. These studies provide an examination of different herbicides (thidiazuron [Harmony Extra]; dicamba diglycolamine salt [Clarity]; 2,4-D Amine [Savage]; flumioxazin [Valor]; and Aim), rates, spray volumes, and application timings on shredded and standing cotton stalks after stripper and picker harvest. 2,4-D Amine applied at one pound of formulated product in 10.0 gallons of water per acre provided 100% control of cotton stalks when applied immediately after harvest or shredding and followed by a second application at 14 or 21 days.

Introduction

Cotton (*Gossypium hirsutum* L.) is a perennial shrub that may survive for many years in a favorable environment. The perennial habit of cotton allows it to regrow following harvest and produce reproductively suitable fruit in three to four weeks for boll weevil (*Anthonomus grandis grandis* Boheman) during the regulated cotton free period. Because cotton stalk destruction is a prime tool for managing overwintering boll weevils by reducing or eliminating the habitat and food available to the insect. Thus, cotton stalk destruction is an integral part of boll weevil management in regions where rainfall and warmer temperatures prolong fall cotton growth, particularly in southern and eastern parts of Texas, including the Lower Rio Grande Valley (LRGV). In the western and northwestern regions of Texas, freezing temperatures generally kill cotton plants prior to regrowth. Early destruction of cotton stalks by plowing or burning was among the initial and most significant recommendations for control of the boll weevil (Townsend 1895; Howard 1896; Mally 1901, 1902; Hunter 1907, 1909; Newell 1906; Hinds 1908). In the LRGV of Texas, weevils can survive during the winter in bolls on undestroyed stalks in scattered cotton fields. These unattended plants also allow cotton to fruit through the winter and in spring weevils produced from such locations become a serious threat (Bergman et al. 1983; Norman et al. 1984; Summy et al. 1988). A new stalk destruction law (The Boll Weevil Control Act) was passed by the Texas Legislature in 1987. Under this law, stalk destruction is required by September 1 in the LRGV. Mechanical control continues to be a significant means for destroying stalks. The shredding of stalks after harvest is employed to reduce the stalk size so that plows can easily kill the roots. After shredding, a disk is often used to flatten beds to allow deep tillage operations used to break hardpan. Stubble stalk pullers are also used to uproot the stalks. These mechanical methods are generally successful, but some stalks may survive these operations. Moreover, mechanical operations for stalk destruction can be easily disrupted by adverse soil or weather conditions and are contrary to conservation tillage which LRGV cotton producers increasingly have adopted. Many producers using conservation tillage choose to leave the stalks standing through the winter for wind erosion control and need an efficacious way to control standing cotton. All of these problems contribute to the need for evaluation of alternative stalk control methods for both shredded and standing stalks. Since 2001, studies with selected herbicides for stalk destruction were started in the LRGV (Sparks et al. 2002; Norman et al. 2003) and continued in the Coastal Bend, Upper Gulf Coast, and Blacklands regions of Texas (Lemon et al. 2004; Livingston 2004). Remote sensing technology provides an alternative method for evaluating cotton regrowth control for stalk destruction compared with traditional visual observations and ground measurements (Yang et al. 2003; 2004). The objectives of our studies were to evaluate the efficacy of different herbicides, their rates, spray volumes, and application timings on shredded and standing cotton stalks after stripper and picker harvest in the LRGV; and to examine the usefulness of remote sensing technology for evaluating herbicide-based regrowth control treatments.

Materials and Methods

The experiments were conducted in the field plots of USDA-ARS-APMRU, South and North Farms, Weslaco, Texas; and Texas A&M Research and Extension Center's Hiler Farm, Weslaco, Texas during 2001-2004.

Herbicides Tested

2,4-D Amine - brand name: Savage®; chemical name: 2,4-D; Dimethylamine salt of 2,4- Dichlorophenoxyacetic acid; active ingredient: Dimethylamine salt of 2,4-D Dichlorophenoxyacetic acid - 95%, inert ingredients - 5% (Loveland Products Inc., Greeley, CO).

Dicamba Diglycolamine Salt - brand name: Clarity®; chemical name: 2- (2-aminoethoxy) ethanol salt of 3,6-dichloro-o-anisic acid (synonyms: diglycolamine salt of 3,6-dichloro-o-anisic acid); active ingredients: diglycolamine salt of 3,6-dichloro-o-anisic acid - 56.8% (BASF Agricultural Products Group, NC).

Thidiazuron - brand name: Harmony® Extra; chemical name: 1-phenyl-3-(1,2,3-thiadiazol-5-yl) urea; active ingredients: Thifensulfuron-methyl Methyl 3-[[[[(4-methyoxy-6-methyl-1,3,5,-triazin-2-yl) amino] carbonyl] amino] sulfonyl]-2-thiophenecarboxylate - 50%, Thifensulfuron-methyl Methyl 2-[[[[N-(4-methoxy-6-methyl-1,3,5-triazin-2-yl)methylamino]cxarbonyl]amino] sulfonyl]benzoate - 25% (DuPont, de Nemours and Company, Wilmington, DE).

Flumioxazin - brand name: Valor™; chemical name: N-(7-fluoro-3,4-dihydro-3-oxo-4-prop-2ynyl-2H-1,4-benzoxazin-6-yl)cyclohex-=1-ene-1,2-dicarboxamide; active ingredients: flumioxazin - 51% (Valent, Walnut Greek, CA).

Aim™ - active ingredients: Carfentrazone-ethyl; Ethyl, 2-dichloro-5-[4-(difluoromethyl)- 4,5-dihydro-3-methyl-5-oxo-1H- 1,2,4-triazol-1-yl]-4-fluorobenzenepropanoate - 40%.

Experimental Design

Year 2001. The experiments were conducted at the Texas Agricultural Experiment Station's Hiler Farm, near Weslaco, Texas in two irrigated fields. Cotton (SureGrow 125) was planted on February 20, and harvested on July 23 in both fields. Half of each field was shredded with a two row rotary shredder immediately after cotton was harvested and the other half was non-shredded (standing) cotton stalks. Two herbicides were used in these tests (2,4-D Amine and Thidiazuron). One herbicide in each test consisting of a factorial arrangement of the following application factors: two rates of the herbicide (1.0 and 1.5 lb AI/ac for 2,4-D Amine and 0.4 and 0.6 oz AI/ac for Thidiazuron); three application timings (sprayed immediately [0 d], 7 days, and 14 days after cotton was harvested and shredded); two spray volumes (low volume of water [8.18 or 8.54 gallons {31.1 or 32.4 liters} per acre - GPA] and high volume [13.9 or 14.2 GPA]{52.8 or 54.0 liters}); two post-harvest stalk conditions (shredded and standing picker harvested cotton stalks), and untreated control. Each treatment was replicated 4 times in a randomized block design for a total of 96 plots (four blocks of 24 plots). Each plot consisted of four rows on 40 inch centers (1.02 m) by 40 feet (12.2 m). Plots were separated down the row by 15 foot (4.6 m) alleys and across the rows by two rows of standing cotton stalks. All applications were made with a compressed air pressurized sprayer mounted on a Spider Sprayer with three hollow cone nozzles per row. The low volume application used #23 cores with D3 tips and the high volume application used #25 cores with D5 tips.

Year 2002. The experiment was conducted at the USDA-ARS-APMRU, South Farm, Weslaco, Texas in an irrigated field. Cotton (DPL-5415 RR) was planted on February 22, picker harvested and shredded by Bush Hog Rotary Shredder on July 25. Four herbicides were used and tested at one rate each: 2,4-D Amine at 1.0 lb formulated product per acre + 0.5% v/v surfactant, Dicamba Diglycolamine Salt at 1.0 pt/acre, Flumioxazin at 1.0 oz (28.3 g) formulated product per acre + Roundup, 1.0 qt (946.3 ml)/ac), Thidiazuron at 0.4 oz (11.3 g) formulated product per acre, and untreated control. Chemicals were sprayed immediately [0 d], 7 days, and 14 days after cotton was harvested and shredded with a calibrated Spider Track sprayer with 2 nozzles of drops and 1 nozzle (TurboTeeJet-11002) over the top of each row (12 gal/ac). There were 13 treatments. Each treatment was replicated 3 times in a randomized block design. There were 39 plots (laid out in a 3 blocks of 10 plots). Each plot consisted of four rows on 40 inch centers (1.02 m) by 148 feet (45.0 m). Plots were separated across the rows by two rows of standing cotton stalks.

Year 2003. All small field plot experiments were conducted at the USDA-ARS-APMRU, South Farm, Weslaco, Texas in irrigated fields. Cotton (DPL-5415 RR) was planted on February 28 at one field and on March 4, at the second field. The first field was picker harvested and shredded on July 22. Three herbicides were tested at one rate each: 2,4-D Amine alone at 1.0 lb formulation per acre and sprayed once - immediately [0 d] after shredding, and twice - 0 +14 days, 0+21 days, or 0 + 28 days after cotton was harvested and shredded; 2,4-D Amine at 1.0 lb/ac in combination with Aim (0.75 oz/ac) sprayed once - 7 days after shredding, and twice - 0 d + 7 days or 0 d + 14 days after cotton was harvested and shredded, and Dicamba Diglycolamine Salt at 1.0 pt (473.2 ml) of formulated product per acre sprayed once - immediately [0 d] or 7 days after shredding, and twice - 0 +28 days or 7 + 28 days after cotton was harvested and shredded. Herbicides were applied in 10 gallons of water per acre with a Spider Sprayer. The plot distributions in the field were similar to that described above.

The second field was harvested July 30, with 92 rows on 40 inch centers by 148 feet (45 m) long harvested by stripper and 92 rows on 40 inch centers by 148 feet long harvested by picker. In each stripper and picker harvested plot, the rows were divided and 46 of them were shredded on July 31 and the other 46 rows were left standing. Each plot was treated with 2,4-D Amine at a rate of 1.0 lb /ac and two application timings (sprayed immediately once [0 d], and twice - 0 d + 21 days after cotton was harvested) on shredded and standing cotton stalks after stripper and picker harvest. The plot distribution in the field was similar to that described above in a randomized block design. Each treatment was replicated 3 times.

Year 2004. Small field plot experiments were conducted at the USDA-ARS-APMRU South Farm, in two irrigated fields (3.0 acres of Bollgard II cotton were planted February 28, and 2.0 acres of DPL-5415 RR were planted March 1); and at the North Farm in one irrigated field (1.5 acres Bollgard II cotton was planted March 20) in Weslaco, Texas. At the two South Farm fields, cotton was harvested by stripper and picker on July 21 in a randomized block design. There were 27 plots laid out in three blocks of 9 treatments: (1) standing cotton after picker harvest; (2) standing cotton after picker harvest and sprayed with 2,4-D Amine immediately [0 d] after cotton was harvested; (3) standing cotton after picker harvest and sprayed with 2,4-D Amine twice - immediately [0 d] and again 14 days post-harvest; (4) standing cotton after stripper harvest; (5) standing cotton after stripper harvest and sprayed with 2,4-D Amine immediately [0 d] after cotton was harvested; (6) standing cotton after stripper harvest and sprayed with 2,4-D Amine twice - immediately [0 d] and again 14 days post-harvest; (7) shredding cotton immediately after stripper harvest; (8) shredding immediately after stripper harvest and spraying cotton with 2,4-D Amine; (9) shredding and spraying cotton with 2,4-D Amine twice - immediately [0 d] and again 14 days post-stripper harvest. 2,4-D Amine was applied at 1.0 lb/ac in all treatments. The North Farm cotton field wasn't harvested, but was only shredded on July 26 (about 50% bolls were opened). Half of the field was sprayed with 2,4-D Amine, at 1.0 lb/ac, immediately after shredding and the other half was sprayed with 2,4-D Amine twice, immediately and 14 days later.

Standard cotton production practices were used in all experimental plots in all years. Before cotton was harvested (≈50 % open bolls), the fields were sprayed with Def at 1pt AI/ac + Dropp 50WP at 0.1 lb AI/ac + Guthion at 0.125 lb AI/ac for defoliation and to reduce the number of overwintering boll weevils (Greenberg et al. 2004).

Ground reflectance spectra and airborne multispectral digital imagery data were collected from the experimental plots during the 2002-2003 growing seasons. Spectral variables including green, red, and near-infrared bands of the airborne multispectral imagery and vegetation indices derived from the three bands were used to compare the differences among the treatments.

Experimental Indices and Their Assessment

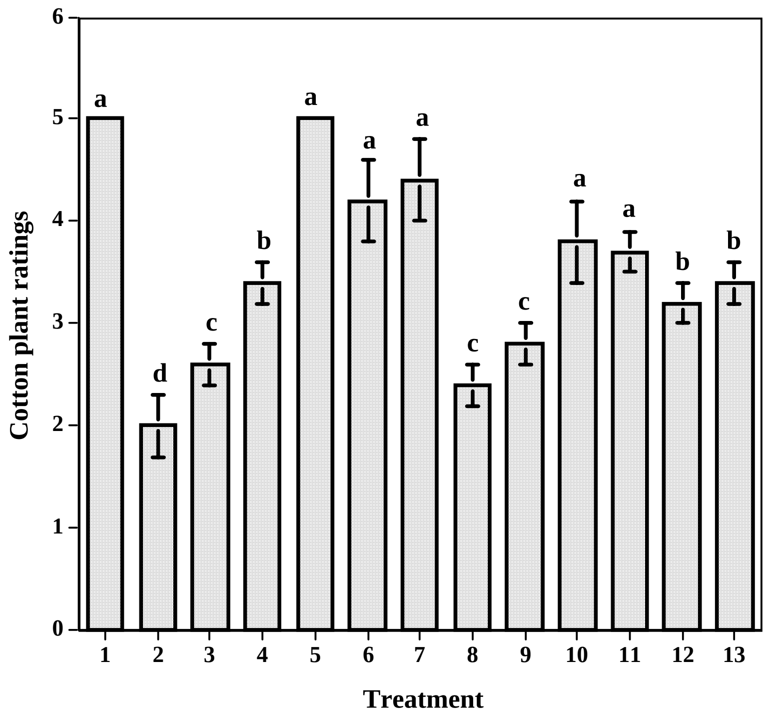
Plots were visually rated on a weekly basis until it was necessary to terminate each treatment or test. Although the Texas Department of Agriculture approved requests for stalk destruction deadline extensions for these studies, it was agreed that individual treatments would be eliminated prior to production of fruiting structures. Thus, the extensions granted allowed for thorough evaluation of stalk destruction and potential survival, while individual treatment termination at first squaring prevented reproduction by boll weevils Plots were rated on a 1 to 5 scale as

follows: 1-no live plants; 2-some plants alive, but exhibited herbicide injury; 3-most plants alive, but exhibited herbicide injury; 4-some apparently healthy plants; and 5-most plants appear healthy.
Before the plants were destroyed, root mortality and number of fruiting plants per treatment were determined. Root mortality evaluations were made by pulling out cotton plants from 1 meter of row from 10 randomly selected sites in each plot, cleaning the epidermis of the roots and determining whether roots were dead or alive. Those with brown color, dry, and easily broken were considered to be dead. About 100-150 randomly selected plants per treatment were examined for presence of fruit.

Statistical Analyses.
Data were analyzed using analysis of variance (ANOVA), and means were separated by Tukey Studentized range honestly significant difference (HSD) test (α=0.05; Wilkinson et al. 1992). Percentage data were transformed using the arcsine-square root method (Sokal and Rohlf 1994), but were presented as non-transformed means. Differences in pairs of means were tested for significance with *t* - tests.

Results and Discussion

In the field experiments, no significant effect was detected between rates (1.0 vs. 2.0 lb) of 2,4-D Amine (*t*-0.219), rates of Thidiazuron - 0.4 vs. 0.6 lb AI/ac (*t*-0.618); or the two spray volumes (low volume of water (8.18 or 8.54 gallons per acre) and high volume (13.9 or 14.2 GPA) with 2,4-D Amine (*t*-0.096) and Thidiazuron (*t*-0.704). One month after the experiment was initiated, most plants in the untreated control and in the Flumioxazin + Roundup, 0 day after harvest (DAH) on shredded cotton, 7 DAH, and 14 DAH treatments appeared healthy by visual ratings (rating 5) (Fig. 1). In the treatment with 2,4-D Amine 0 DAH on immediately shredded cotton, the visual rating was

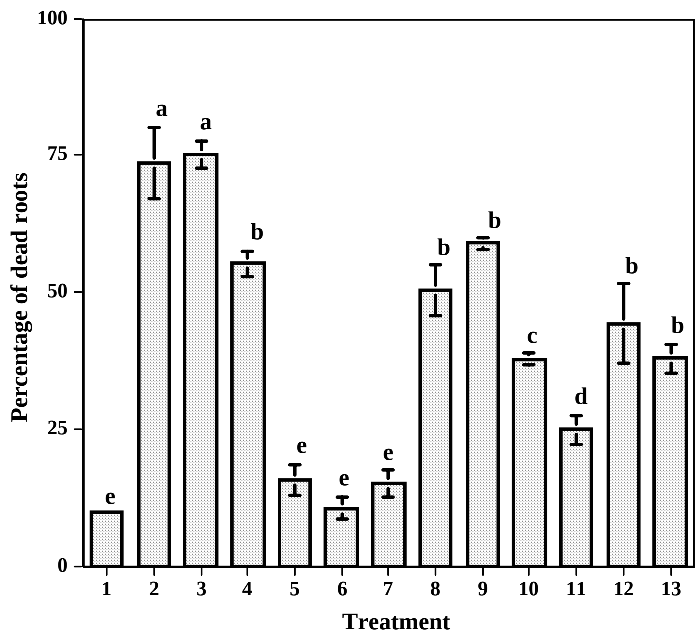


1 - Control **8 - Dicamba 0 DAH**
2 - 2,4-D Amine 0 DAH* **9 - Dicamba 7 DAH**
3 - 2,4-D Amine 7 DAH **10 - Dicamba 14 DAH**
4 - 2,4-D Amine 14DAH **11- Thidiazuron 0 DAH**
5 - Flumioxazin 0 DAH **12 - Thidiazuron 7 DAH**
6 - Flumioxazin 7 DAH **13 - Thidiazuron 14 DAH**
7 - Flumioxazin 14 DAH
***DAH-Day After Harvest**

Fig. 1. Effects of different herbicides and application timings on cotton plant ratings

2 (only some plants were alive but appeared sick), and significantly higher cotton mortality than in other treatments. While in the treatments with 2,4-D Amine 7 DAH and Dicamba 0 and 7 DAH on immediately shredded cotton the visual rating was between some plants alive but appeared sick (2) and most plants alive but appear sick (3), closer to rating 3, and significantly higher efficacy than in the same treatments applied 14 days after harvest on immediately shredded cotton. Thidiazuron showed significantly lower efficacy than 2,4-D Amine and Dicamba. The condition of the plants treated with Thidiazuron was between ratings 3 (most plant alive, but appeared sick) and 4 (some apparently health plants). Thidiazuron performed better when applied after shredded cotton started regrowth (on 7 and 14 DAH) **(**F=26.8; df=12, 187; P=0.001. Fig. 1). The greatest effects of 2,4-D Amine and Dicamba were achieved when they were applied soon after shredding, while Thidiazuron performed better after regrowth occurred. It is assumed that application of 2,4-D Amine and Dicamba on plant tissue freshly damaged by shredding allowed for active uptake of these products. Once this tissue 'healed', uptake and performance was reduced. Thidiazuron penetrates through leaf tissue and therefore performed best after plants had been allowed to regrow, allowing for increased leaf area for uptake of this product.

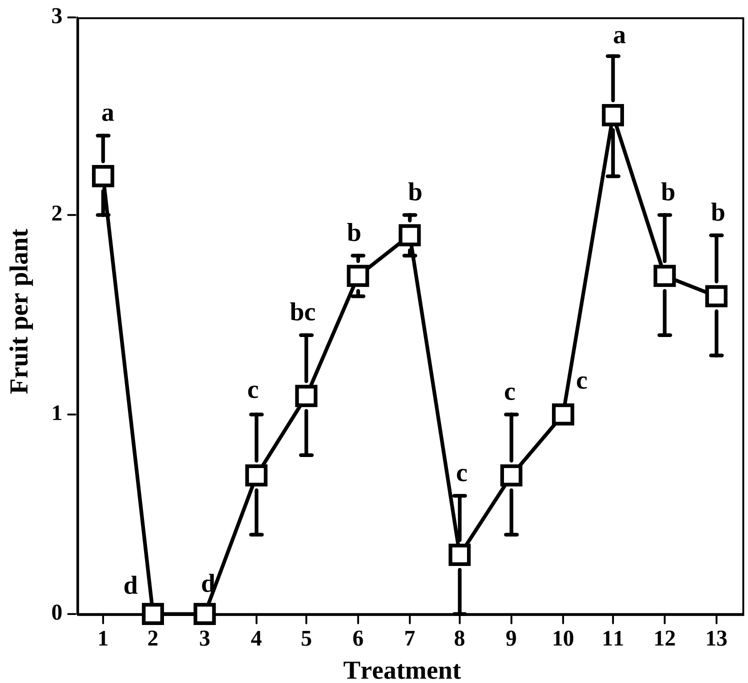
One month after herbicide treatments on shredded cotton, no significant differences were observed in root mortality (P = 0.189); however, significant differences between treatments were obvious by two months after shredding and initial herbicide applications (F= 38.6; df=12, 26; P=0.001) (Fig. 2).



1 - Control
2 - 2,4-D Amine 0 DAH*
3 - 2,4-D Amine 7 DAH
4 - 2,4-D Amine 14DAH
5 - Flumioxazin 0 DAH
6 - Flumioxazin 7 DAH
7 - Flumioxazin 14 DAH
8 - Dicamba 0 DAH
9 - Dicamba 7 DAH
10 - Dicamba 14 DAH
11- Thidiazuron 0 DAH
12 - Thidiazuron 7 DAH
13 - Thidiazuron 14 DAH
***DAH-Day After Harvest**

Fig. 2. Effects of different herbicides and application timings of cotton root mortality

The highest percentage of root mortality was in treatments where cotton was sprayed with 2,4-D Amine immediately or 7 days after cotton was harvested and shredded (73.6±6.6 and 75.2±2.5, respectively) and the lowest percentage in the untreated control (10.0±0.8) and all three treatments with Flumioxazin (from 10.8±2.1 to 16.0±2.8). At two months after shredding and initial applications only the 2,4-D Amine sprayed immediately or 7 days after shredding prevented cotton fruiting, while in other treatments the plants had from 0.3 to 2.5 fruit per plant (F=6.7; df=12, 26; P=0.001) (Fig. 3).



1 - Control
2 - 2,4-D Amine 0 DAH*
3 - 2,4-D Amine 7 DAH
4 - 2,4-D Amine 14DAH
5 - Flumioxazin 0 DAH
6 - Flumioxazin 7 DAH
7 - Flumioxazin 14 DAH
8 - Dicamba 0 DAH
9 - Dicamba 7 DAH
10 - Dicamba 14 DAH
11- Thidiazuron 0 DAH
12 - Thidiazuron 7 DAH
13 - Thidiazuron 14 DAH
***DAH-Day After Harvest**

Fig. 3. Effects of different herbicides and application timings on cotton fruiting

All tests showed that one application with 2,4-D Amine (at 0 or 7 DAH) after shredding cotton provided the best control of live cotton stalks, but 100% of the plants were not killed. Only after a second application with 2,4-D Amine at 14 or 21 days after the first application was 100% control of regrowth cotton obtained. The visual rating of these treatments was between 1 and 2, closer to one and significantly better than in other treatments (F=16.8; df=11, 124; P=0.001) (Table 1). The percentage of root mortality in these treatments was about 100 (F=18.9; df=11, 124; P=0.001). A significant reduction in the regrowth cotton was also observed in treatments sprayed with Dicamba at 0 or 7 DAH on shredded cotton followed by a second application with 2,4-D Amine after 28 days. The second application would 'clean up' any regrowth surviving and would control any volunteer cotton which had sprouted after the initial application. The second application would include additional or alternative herbicides to provide control of weeds.

Table 1. Response to herbicides, number of applications, and timings for cotton stalk termination.

Treatment	Plant Ratings	Percentage root mortality
2,4-D Amine sprayed 0 DAH* on immediately shredded cotton	2.2 ± 0.2b	72.0 ± 3.9c
2,4-D Amine sprayed 0 DAH on immediately shredded cotton (1st) + 14 days later (2^{nd})	1.4 ± 0.1c	95.0 ± 2.2ab

2,4-D Amine sprayed 0 DAH on immediately shredded cotton (1st) + 21 days later (2nd)	1.1 ± 01c	100 ± 0.0a
2,4-D Amine sprayed 0 DAH on immediately shredded cotton (1st) + 28 days later (2nd)	1.9 ± 0.2bc	86.0 ± 3.7b
2,4-D Amine and Aim sprayed 0 DAH on immediately shredded cotton (1st) + 7 days later (2nd)	1.8 ± 0.2bc	85.0 ± 2.7bc
2,4-D Amine and Aim sprayed 0 DAH on immediately shredded cotton (1st) + 14 days later (2nd)	1.2 ±0.1c	97.0 ±2.1a
2,4-D Amine and Aim sprayed 7 DAH on immediately shredded cotton	2.8 ± 0.1b	70.0 ± 3.9c
Dicamba sprayed 0 DAH on immediately shredded cotton	3.0 ± 0.2b	60.3 ± 4.2c
Dicamba sprayed 0 DAH on immediately shredded cotton (1st) + 28 days later (2nd)	1.6 ± 0.2c	85.7 ± 3.3b
Dicamba sprayed 7 DAH on immediately shredded cotton	2.9 ± 0.3b	58.5 ± 2.7c
Dicamba sprayed 7 DAH on immediately shredded cotton (1st) + 28 days later (2nd)	1.2 ± 0.1c	100 ± 0.0a
Control	4.6 ± 0.2a	11.2 ± 0.2d

Mean (±SE) in column followed by the same letter are not significantly different (Tukey honestly significant difference, P<0.05)
*DAH (Days After Harvest)

Livingston et al. (2004) showed that for shredded stalks treated with the 1.0 or 1.5 lb/ac rates of 2,4-D Amine , regrowth suppression persisted over a 28-35 day period and cotton plants did not produce fruit. All alternative products provided 30-50% of the suppression resulting from 1.0 to 1.5 lb AI/ac of 2,4 D Amine applied immediately following shredding. Studies conducted in central Texas and Arkansas demonstrated that the 2,4-D ester and amine formulations applied at 1.5 lb AI/ac provided the best overall performance. Clarity (Dicamba) and Harmony Extra (Thidiazuron) showed the least regrowth control (Lemon et al. 2004).

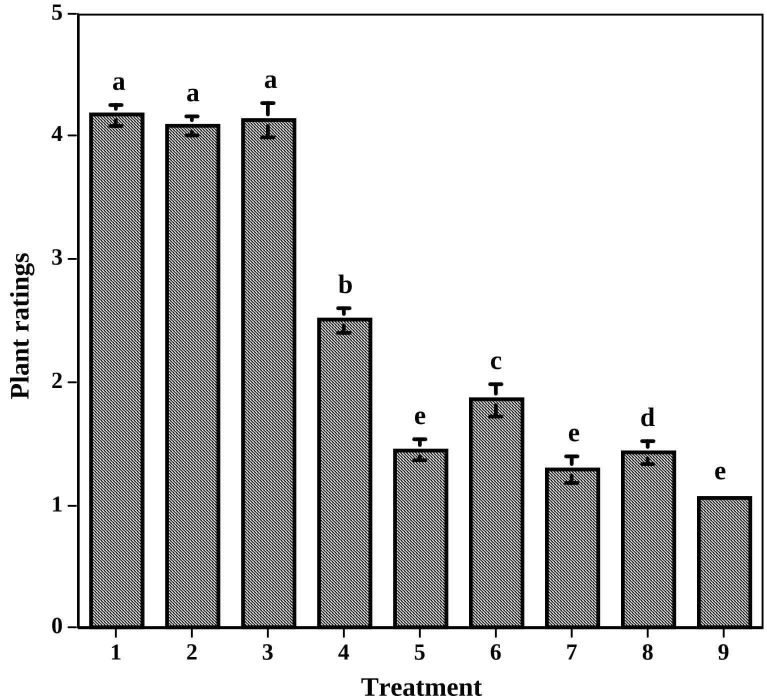
Our field studies also investigated the influence of herbicide applications to shredded vs. standing cotton stalks after picker and stripper harvest. Prior to this research, it was believed that stalks may require shredding (15-20 cm) for effective control. However, some growers in the Coastal Bend had been treating standing stalks and reporting excellent results. A study by Lemon et al. (2004) confirms these producers' experience. The authors showed that picker harvested standing stalks can be more effectively destroyed with 2,4-D Amine than stripper harvested standing stalks. In the treatments with 2,4-D Amine sprayed immediately or 7 days after cotton was harvested (2001 tests), a significantly greater impact on plant growth (plant ratings) was observed on shredded cotton compared to standing picker harvested cotton (F = 7.2; df = 5, 84; P = 0.001) (Table 2). When cotton was sprayed 14 days after harvest, there was no significant difference. Standing cotton squared on all three timing treatments (0.1-0.4 fruit per plant) but shredded cotton fruited only at the last sprayed treatment (14 days after cotton was harvested, 0.25 fruit per plant). The best results with Thidiazuron were obtained in the plots that had been shredded and allowed to regrow for 14 days prior to application, but even these plots contained numerous squares (Table 2). Standing cotton squared (3.5-4.3 fruit per plant) earlier than the shredded cotton (1.7-5.2 fruit per plant).

Table 2. Effects of different agricultural and chemical practices on post-harvest cotton stalk destruction (field tests, 2001)

Treatment	Standing cotton		Shredded cotton	
	Plant ratings	Fruit per plant	Plant ratings	Fruit per plant
2,4-D Amine 0 DAH*	1.9 ± 0.2bA	0.1 ± 0.06bA	1.2 ± 0.1cB	0bA
2,4-D Amine 7 DAH	2.2 ± 0.2bcA	0.4 ± 0.02bA	1.4 ± 0.1cB	0bA
2,4-D Amine 14 DAH	3.0 ± 0.2acdA	0.3 ± 0.02bA	2.7 ± 0.6bA	0.25 ± 0.01bA
Thidiazuron 0 DAH	4.2 ± 0.2aA	3.5 ± 0.4aA	3.9 ± 0.2aA	4.4 ± 0.9aA
Thidiazuron 7 DAH	4.1 ± 0.1aA	4.3 ± 0.3aA	4.0 ± 0.2aA	5.2 ± 0.5aA
Thidiazuron 14 DAH	3.6 ± 0.3adA	3.7 ± 0.5aA	3.1 ± 0.1abB	1.7 ± 0.2aB
Control	4.8 ± 0.1aA	4.1 ± 0.3aA	4.6 ± 0.1aA	4.4 ± 0.3aA

*DAH (Days After Harvest)
Means (±SE) within a column followed by the same lower case letter and within the row by the same capital letter are not significantly different (Tukey honestly significant difference, P<0.05)

Non-treated plots with standing cotton after stripper and picker harvest, or plots with immediately shredded cotton after harvest did not suppress regrowth (plants were visually rated as healthy, dead roots were 12.8-36.7%, and plants contained numerous fruit) (Figs. 4, 5).



1 - Standing picker harvest cotton
2 - Standing stripper harvest cotton
3 - Shredded immediately after harvest
4 - Standing picker harvest cotton sprayed with 2,4-D Amine 0 DAH*
5 - Standing picker harvest cotton sprayed with 2,4-D Amine 0+14 DAH
6 - Standing stripper harvest cotton sprayed with 2,4-D Amine 0 DAH
7 - Standing stripper harvest cotton sprayed with 2,4-D Amine 0 + 14 DAH
8 - Shredded cotton sprayed with 2,4-D Amine 0 DAH
9 - Shredded cotton sprayed with 2,4-D Amine 0 + 14 DAH

Fig. 4 Effects of the number of applications and timings of 2,4-D Amine on plant ratings for shredded and standing cotton

When standing stripper harvested cotton was sprayed with 2,4-D Amine immediately after harvest, its rating (1.8) was significantly more effective than on sprayed standing picker harvest cotton (2.5) (F = 140.9; df = 8, 303; P = 0.001). The root mortality was significantly higher on standing stripper harvest cotton compared with standing picker harvest (82.2 vs. 62.2%) (F = 88.1; df = 8, 153; P = 0.001). Stripper harvest caused more wounds and abrasions to the cotton plants than picker harvest**.** This contributed more and faster penetration of herbicides in plants and increased their efficacy. On the standing picker harvest cotton, we observed 0.03 fruits per plant, while standing stripper harvest cotton did not form fruit. When shredded cotton was sprayed with 2,4-D Amine once, immediately after harvest, all vegetative indices were significantly better than in standing cotton (plant ratings was 1.425, root mortality - 87.8%, and 0 fruit per plant). In this experiment, the best results were obtained when standing (stripper and picker harvest) or shredded cotton was sprayed with 2,4-D Amine twice, at 0 and 14 days after cotton was harvested, and we did not observe significant differences between treatments.

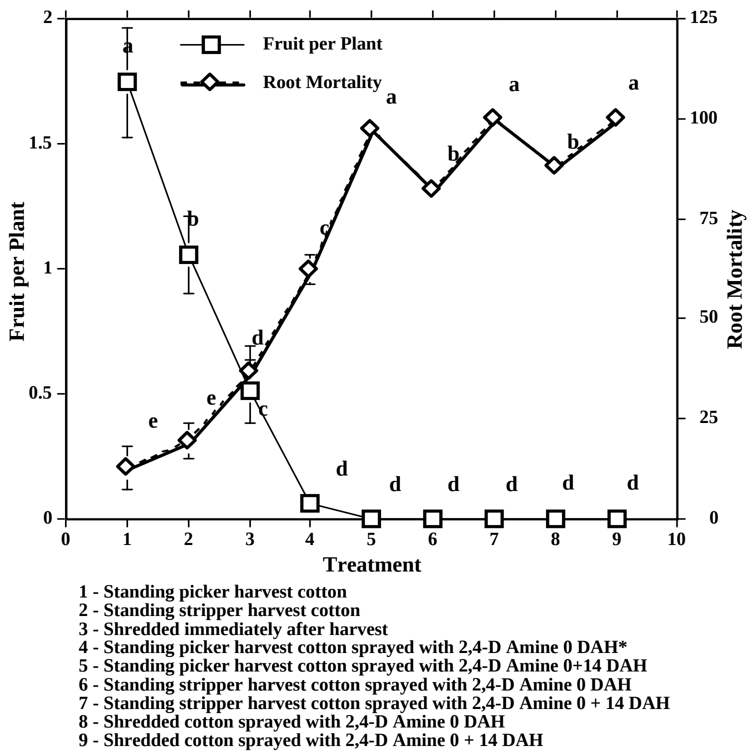


Fig. 5. Effects of the number of applications and timings of 2,4-D Amine on root mortality and fruiting for shredded and standing cotton

Our study demonstrated that 2,4-D Amine sprayed once (0 or 7 days) after cotton was harvested at the rate of 1 lb AI per acre and at a spray volume of 10 gallons water per acre with 0.5 % v/v surfactant, is extremely effective in stalk destruction. The best results were achieved when herbicide was applied immediately after the cotton was shredded, followed by application to standing stripper harvested cotton immediately after harvest, and the lowest efficacy was obtained on standing picker harvested cotton treated immediately after harvest. The herbicide 2,4-D Amine applied twice 0 and 14, 21, or 28 days after cotton was harvested was proven to be 100% effective in killing stalks when the first application was applied immediately after shredding or to standing cotton stalks immediately after stripper or picker harvest. In commercial production, the second application would also serve to control volunteer cotton and weeds.

Using reflectance spectra data, we were able to visually separate regrowth differences among some of the treatments. Although the airborne imagery did not provide sufficient visual differences among the treatments because of the limited amount of regrowth, the reflectance information extracted from the imagery allowed quantitative comparisons among the treatments. Statistical results showed that with the use of vegetation indices, we were able to differentiate among the treatments. These results generally agreed well with the ground observation results for these experiments. Remote sensing technology can be a useful tool for evaluating herbicide-based regrowth control strategies for cotton stalk destruction. If a large number of treatments are to be evaluated over large areas, this technique can reduce the time and labor cost for accurate and objective assessments of various regrowth control treatments.

References

Bergman, D., T. J. Henneberry, and L. A. Bariola. 1983. Overwintering boll weevil populations in southwestern Arizona cultivated cotton, pp. 182-185. *In* Proc. Beltwide Cotton Prod. Res. Conf.

Greenberg, S. M., T. W. Sappington, G. W. Elzen, J. W. Norman, and A. N. Sparks. 2004. Effects of insecticides and defoliants applied alone and in combination for control of overwintering boll weevil (Anthonomus grandis; Coleoptera: Curculionidae) - laboratory and field studies. Pest Manag. Sci. 60: 849-858.

Hinds, W. E. 1908. The first and last essential step in combating the boll weevil. J. Econ. Entomol. 1: 233-243.

Howard, L. O. 1896. Insects affecting the cotton plant. USDA Office of Exp. Sta. Bull. 33.
Hunter, W. D. 1907. The most important step in the control of the boll weevil. USDA, Bur. Entomol. Circ. 95.
Hunter, W. D. 1909. The boll weevil problem with special reference to means of reducing damage. USDA. Farmers' Bull.. 344.
Lemon, R., D. Fromme, R. Lahn, and D. J. Pigg. 2004. Cotton stalk destruction with 2,4-D herbicide. *In* Proc. Beltwide Cotton Prod. Res. Conf. CD-ROM.
Livingston, S. D., R. D. Parker, J. R. Stapper, R. Mercado, A. Z. Matthies, Jr. 2004. An evaluation of chemical application techniques and timing to terminate cotton stalks in south Texas. *In* Proc. Beltwide Cotton Prod. Res. Conf. CD-ROM.
Mally, F. W. 1901. The Mexican cotton boll weevil. USDA Farmers' Bull. 130.
Mally, F. W. 1902. Report of the boll weevil. The Agricultural and Mechanical College of Texas. Von Boeckmann, Schultze and Co., Austin, Texas.
Newell, W. 1906. The remedy for the boll weevil. La. Crop Pest Comm. C. 3: 20.
Norman, J. W., K. R. Summy, and J. R. Cate. 1984. Boll weevil management through cotton stalk destruction, pp. 216-218. *In* Proc. Beltwide Cotton Prod. Res. Conf.
Norman, J. W., Jr., S. Greenberg, A. N. Sparks, and C. Stichler. 2003. Termination of cotton stalks with herbicides in the Lower Rio Grande Valley of Texas. *In* Proc. Beltwide Cotton Prod. Res. Conf. CD-ROM.
Sokal, R. R., and F. J. Rohlf. 1995. Biometry. The principles and practice of statistics in biological research. 3rd edition. W. H. Freeman and Co.; New York. 887 p.
Sparks, A. N., J. W. Norman, Jr., C. Stichler, J. Bremer, S. Greenberg. 2002. Cotton stalk destruction with selected herbicides and effect of application methodology. *In* Proc. Beltwide Cotton Prod. Res. Conf. CD-ROM.
Summy, K. R., W. W. Hart, M. R. Davis, J. R. Cate, J. W. Norman, Jr., C. W. Wofford, Jr., M. D. Heilman, and L. N. Namken. 1988. Region wide management of boll weevil in southern Texas, pp. 240-247. *In* Proc. Beltwide Cotton Prod. Res. Conf.
Townsend, C. H. T. 1895. Report on the Mexican cotton boll weevil (*Anthonomus grandis* Boh.) in Texas. Insect Life 7: 295-309.
Wilkinson,L., M. A. Hill, and E. Vang. 1992. SYSTAT: statistics, version 5.2. Systat, Inc. Evanston, IL.
Yang, C., S. M. Greenberg, J. H. Everitt, M. R. Davis and J. W. Norman, Jr. 2003. Evaluation of cotton regrowth control using remote sensing. *In* Proc. Beltwide Cotton Prod. Res. Conf. CD-ROM.
Yang, C., S. M. Greenberg, J. H. Everitt, and J. W. Norman, Jr. 2004. Assessing cotton regrowth control using remote sensing. *In* Proc. Beltwide Cotton Prod. Res. Conf. CD-ROM.

Acknowledgments

We acknowledge the technical assistance of J. Alejandro, J. Caballero, A. Castro, R. Dominguez, R. Johnson, and L. Leal. We are grateful to Drs. J. Robinson (TAES) and D. Robacker (SARC-ARS-USDA) for critical reviews of the manuscript**.**