PERENNIAL WEED MANAGEMENT WITH A POSITION SENSITIVE, MULTIPLE RATE SPRAY APPLICATOR

James P. Bordovsky and J. Wayne Keeling
Texas Agricultural Experiment Station
Lubbock/Halfway, TX

Abstract

A spray tillage tool was constructed which incorporated the use of a commercially available row guidance system and differential global positioning system to provide precise placement of mechanical tillage devices and nozzles in a crop canopy and to trigger applications of chemical solutions. The tool was evaluated in a LEPA irrigated cotton production system where perennial weeds were the targeted pest. Results indicate that the variability of cotton lint yield within the test area was more highly correlated to crop water use factors than other factors including perennial weed infestation. The site-specific control of perennial weeds should have a long-term positive effect on weed control, but did not show an economic advantage over traditional cultural practices within the two years of the experiment. Precision cultivation for the control of dense populations of woollyleaf bursage in cotton was very positive.

Introduction

A precision farming project was initiated in 1997 by the Texas Agricultural Experiment Station (TAES) to develop, quantify, and evaluate various aspects of site-specific production on the Texas High Plains. One part of that effort was to construct and evaluate a position sensitive, variable rate spray/tillage tool that could be used in farming systems irrigated by Low Energy Precision Application (LEPA) systems.

Differential global positioning system (DGPS) controllers can be used to trigger agricultural spray applications based on location maps of perennial weeds allowing application of chemicals to specific target areas at optimum rates with minimal operator input (Clark and McGuckin, 1996). The additional use of a commercially available guidance systems for the precise lateral placement of shields, spray nozzles, and tillage devices within a row can insure proper treatment of targeted plants and land areas and further reduce chemical application volumes (Coates and McCloskey, 1998). Broadleaved species such as silverleaf nightshade, woollyleaf bursage, and Texas blueweed occur in heavy, localized populations and are spreading on the Southern High Plains. Therefore, the construction and use of a position sensitive, variable rate spray/tillage tool has potential for immediate benefit in the control of perennial weeds in cotton. The objective of this paper is to provide an overview of equipment and its evaluation during the first two years of this project.

Equipment

A variable rate spray/tillage tool was assembled and field evaluations initiated in 1998. The operation of the tool was refined and its evaluation continued in 1999. The spray/tillage tool system was composed of the following elements:

- Hamby 4-row tool carrier with gauge wheels to accommodate alternate row LEPA
- Acura-Trak® row guidance system
- Satloc® L-band DGPS
- Fujitsu® 1200 tablet field computer
- Field Rover® v1.0 (SSToolbox®) - field data acquisition software
- Arcview®/ SSToolbox® - data analysis software
- AgView® by GIS Solutions - field software
- Raven® SCS700 variable rate controller w/valves, meters, radar, etc.

Two positioning elements were contained in this tool. The first provided relative location "down the row" using DGPS that changed chemical application rates as the tool moved along established traffic paths. The second element sensed relative location "within the row" using a guidance system which mechanically tracked a pre-established seed row or trench. This allowed precise positioning of spray nozzles and tillage devices within a crop canopy. A very aggressive "precision cultivation" operation was achieved by using the row guidance system to position barring-off disks, knives and sweeps within 1.5 inches of the seed row. Figure 1 shows the assembled spray/tillage tool containing the two positioning elements constructed in 1998. Laboratory and field evaluation of a revised solution control system for the variable rate spray applicator and the construction of additional shielding for targeted solution applications within a canopy were completed in 1999. This basic control system could be modified for site-specific applications of nutrients, pesticides, seed, etc. as research and demonstration needs dictate.

Field Experiments

Several field experiments were initiated at the TAES, Halfway using the precision spray/tillage tool. These experiments included:

- Perennial weed control by site-specific techniques in irrigated cotton. The objective was to evaluate the use of site-specific applications for the long

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term control of perennial weed species in cotton and to document yield variability due to weed infestation, soil parameters, slope and irrigation levels.

- Comparison of methods to control woollyleaf bursage in cotton production. The objective was to evaluate the use of a guidance system for placement of chemicals and tillage devices to control the growth and spread of this noxious weed in West Texas cotton fields.

Site-Specific Perennial Weed Control

Cotton was planted on a 9-acre field under an 8-span center pivot at the TAES at Halfway, TX. The soil was a silty clay loam, the field slope was 0 to 2 percent, and the research area was adjacent to a playa lake. Typical cultural practices were used in the 1998 and 1999 growing seasons following grain sorghum grown in 1997. Irrigations were by the LEPA method with crop rows following the circular pathways parallel to the wheel tracks.

In the course of evaluating the spray/tillage equipment, measurements were made in an attempt to explain resulting cotton lint yield. Various soil and plant parameters were quantified at each of 40 regularly spaced, geo-referenced sites in the 9-acre area. Depending on the attribute, measurements were obtained once (soil texture), or multiple times (soil water content) over the two year period. Initial weed boundaries were recorded in 1998 by walking the perimeter of the more densely populated weed locations using a DGPS mapping system. Perennial weed areas were more clearly defined in 1999 by visually rating infestations at 360 referenced points on May 5, June 23 and September 9.

Perennial weed herbicides were applied in a site-specific manner using the spray/tillage tool under seven spans of the center pivot with the area under span 4 treated conventionally. The targeted weeds were Texas blueweed, woollyleaf bursage (lakeweed), silverleaf nightshade (whiteweed), and johnsongrass. Agronomic data and specific chemical and tillage treatments for each area and weed species are given in Table 1. Site-specific applications on johnsongrass were discontinued in 1999 due to excellent control obtained the previous year.

Woollyleaf Bursage Control

Cotton was grown in a densely infested woollyleaf bursage area in 1998 and 1999 to determine weed control and lint yields resulting from combinations of treatments with the herbicides Roundup™ and MSMA and tillage using conventional and precision cultivation (guidance system) methods. The experiment was of a completely randomized block design. The treatment area had not been used for crop production for several years prior to 1998 due to dense weed infestations. Table 2 provides agronomic data and specifics on treatments.

Results

Site-Specific Perennial Weed Control

Yield analysis using a correlation matrix of 33 measured attributes in 1998 and 42 measured attributes in 1999 was conducted. Table 3 summarizes the strength of those attributes best correlated to lint yield. The 1998 crop year was exceptionally hot and dry. The 1999 cotton crop was replanted in June due to hail while seasonal rainfall was near normal. The relationships among factors differed from 1998 to 1999. However, lint yields in both years were most strongly correlated to factors related to seasonal water use – soil texture, slope or elevation, and soil water measurements and less well correlated to nutrient and weed infestation attributes. Seasonal irrigation quantity was strongly correlated to yield in 1998. It was not an experimental variable in 1999.

Table 4 gives a summary of the differences in yield and chemical costs associated with applications on specific weed pests in site-specific versus conventional areas during the 1999 growing season. The data indicate that cotton lint value over chemical cost is greater for the conventional area than for the site-specific area. These results are *preliminary* and are contrary to results of multiple studies showing decreased lint yield with increased perennial weed infestation. We predict that weed infestations will increase in the conventional areas (reducing yields) and decrease in the site-specific areas (increasing yields) over time.

Figure 2 shows the geographic distribution of weeds over time. The areas infested with Texas blueweed and woollyleaf bursage did not change greatly from 1998 through September 1999. However, reductions of silverleaf nightshade occurred from September 1998 to May 1999 in areas treated by site-specific applications (all area except span 4). Although nightshade reappeared in previously infested areas by September 1999, young cotton plants had less competition from this pest early in the growing season and nightshade density remained highest in the conventional area (span 4).

Woollyleaf Bursage Control

The results of the weed control treatments on woollyleaf bursage are summarized in Table 5. Results show precision cultivation with no chemical application produced average yields (533 lb./A) approaching those of Roundup/transgenic cotton treatments with traditional cultivation (596 lb./A) and far exceeded yields of treatments with MSMA and traditional cultivation (254 lb./A). Precision cultivation with Roundup (624 lb./A) or with MSMA (606 lb./A) improved yield over precision cultivation alone (533 lb./A). The combination of precision cultivation and site-specific herbicide application using DGPS controlled devices provides opportunities of reducing weed infested areas without spreading this pest into non-infested areas.

Conclusions

The following preliminary conclusions were reached:

- Variability in cotton lint yield is most strongly correlated with attributes associated with crop water use (slope, elevation, soil texture, and seasonal irrigation) and with certain plant characteristics (boll count and plant height), and less well correlated with attributes related to perennial weed infestations, residual nitrogen, or plant population.
- Spray/tillage equipment using DGPS systems for site-specific control of perennial weeds is useful and should have a long-term positive effect on weed control, but has not shown an economic advantage over traditional methods under the conditions within this experiment.
- Use of a guidance system to position tillage devices and spray nozzles for the control of woollyleaf bursage in cotton irrigated with LEPA has been positive.

Acknowledgments

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References

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Table 1. Agronomic data from site-specific perennial weed experiment conducted at TAES, Halfway, 1998-99.

Area	Site-Specific Areas	Mo	Da	Yr	Activity
All					
		4	13	98	2.5 pt. Prowl/A, rolling cultivator
		4	20	98	irrigate 3.58 A-in./A, 4/20 to 4/23, LEPA
		5	5	98	100 lb. 32-0-0/A
		5	7	98	rolling cultivator
		5	7	98	rod weeder
		5	11	98	plant All-Tex Atlas w/2.5 lb. Temik/A
		5	12	98	irrigate 10.31 A-in/A, 5/12 to 9/15 in 80% ET areas
		5	12	98	irrigate 6.95 A-in/A, 5/12 to 9/15 in 50% ET areas
		7	3	98	1.5 pt. Prowl/A, hooded, 40 in. band
		3	3	99	2 pt. Prowl/A, rolling cultivator
		4	23	99	irrigate 5.53 A-in/A, 4/23 to 4/28, LEPA
		5	18	99	rolling cultivator
		5	18	99	rod weeder
		5	19	99	plant All-Tex Atlas
		5	31	99	rod weeder
		6	2	99	Plant Paymaster 183
		6	18	99	2.5 oz. Bidrin/A, 20 in. band
		6	25	99	1.6 oz. Bidrin/A, 20 in. band
		7	5	99	8 oz. Vydate/A, 20 in. band
		7	6	99	rolling cultivator
		7	9	99	8 oz. Vydate/A, 20 in. band
		7	20	99	65 lb. 32-0-0/A, LEPA chemigation
		7	20	99	irrigate 4.50 A-in/A, 7/20 to 9/1, LEPA
		7	26	99	4 oz. Pix Plus/A, 16" band
		8	24	99	6 oz. Pix Plus/A, 16" band
Conventional (Span-4 Only)					
		6	30	99	precision cultivator
		10	6	99	32 oz. Roundup/treated A, broadcast over top
Precision Farming (all except Span-4)					
		6	24	98	precision cultivation
		6	30	99	precision cultivation
	Blueweed	6	11	98	precision cultivation
		9	21	98	64 oz. Banvel/A broadcast
		10	5	99	64 oz. Banvel/treated A, shielded, 40" band
	Woollyleaf Bursage	6	15	98	64 oz. MSMA/treated A, shielded, 40" band
		7	18	98	64 oz. MSMA/treated A, directed, 10" band
		8	7	98	80 oz. MSMA/treated A, directed, 10" band
		5	13	99	64 oz. MSMA/treated A, shielded, 40" band
		8	10	99	96 oz. MSMA/treated A, directed, 10" band
	Silverleaf Nightshade	6	18	98	32 oz. Roundup/treated A, shielded, 40" band
		9	21	98	42 oz. Roundup/treated A, directed, 40" band
		10	6	99	32 oz. Roundup/treated A, shielded, 40" band
	Johnsongrass	6	12	98	32 oz. Fusilade/treated A, broadcast over top
		7	22	98	24 oz. Fusilade/treated A, broadcast over top

Table 2. Agronomic data from chemical and tillage treatment of woollyleaf bursage at TAES, Halfway, 1998-99.

Area	Chemical	Mo	Da	Yr	Activity
All					
		4	13	98	2.5 pt. Prowl/A, rolling cultivator
		4	20	98	irrigate 1.00 A-in./A, 4/20, spray
		5	7	98	rolling cultivator
		5	8	98	rod weeder
		5	8	98	plant Roundup Ready 2200 w/3.3 lb. Temik/A
		5	12	98	irrigate 10.67 A-in/A, 5/12 to 9/15
		3	3	99	2 pt. Prowl/A, rolling cultivator
		4	23	99	irrigate 5.53 A-in/A, 4/23 to 4/28, LEPA
		5	19	99	rolling cultivator
		5	19	99	rod weeder
		5	19	99	plant Roundup Ready 2200 w/4.0 lb. Temik/A
		7	20	99	65 lb. 32-0-0/A, LEPA chemigation
		7	20	99	irrigate 4.50 A-in/A, 7/20 to 9/1, LEPA
Precision Till Areas					
		5	27	98	precision cultivator
		7	7	98	rolling cultivator
		7	28	98	rolling cultivator
		6	11	99	precision cultivator
		6	30	99	precision cultivator
		7	6	99	rolling cultivator
		8	26	99	18" sweep in all middles
	MSMA	6	3	98	80 oz. MSMA/treated A, shielded, 10" band
		8	17	98	96 oz. MSMA/treated A, directed, 10" band
		6	15	99	96 oz. MSMA/treated A, shielded, 20" band
		8	11	99	96 oz. MSMA/treated A, directed, 10" band
	Roundup	6	3	98	32 oz. Roundup/treated A, shielded, 10" band
		6	15	99	32 oz. Roundup/treated A, shielded, 20" band
		8	11	99	32 oz. Roundup/treated A, directed, 10" band
Conventional Till Areas					
		7	7	98	rolling cultivator
		7	28	98	rolling cultivator
		7	6	99	rolling cultivator
		8	26	99	18" sweep in all middles

Table 3. Direction and strength of the correlation matrix relationship of cotton lint yield to measured attibutes at the TAES, Halfway, TX, 1998-99.

Year	Attibute	Correlation Level*
	Positive Correlations	
1998		
	Seasonal irrigation amount	0.70
	Bolls per plant 8/26/98	0.62
	Plant height on 8/26/98	0.60
	Elevation	0.35
	Profile water content 9/15	0.31
1999		
	Seasonal change in soil water	0.64
	% sand in the 6 to 12" profile	0.53
	Plant height on 7/5/99	0.44
	% sand in the 0 to 6"	0.43
	Plant height on 9/9/99	0.43
	Bursage rating on 9/9/99	0.31
	Bolls per plant 9/9/99	0.29
	% sand in the 12 to 24"	0.27
	NO3 residual in 0 to 36" 5/1	0.03
	Blueweed rating on 9/9	0.02
	Attibute	**Correlation Level**
	Negative Correlations	
1998		
	Slope down the furrow	-0.63
	% sand in the 12 to 24"	-0.51
	NO3 residual in 24 to 36"	-0.33
	Silverleaf nightshade rating	-0.33
	NO3 residual in 12 to 24"	-0.28
	% sand in the 24 to 36"	-0.27
	Plant population on 8/26/98	-0.24
	Seasonal change in soil water	-0.12
	Bursage rating	-0.10
1999		
	% clay in the 0 to 6"	-0.51
	Elevation	-0.34
	% clay in the 12 to 24"	-0.32
	Profile water content on 9/24	-0.31
	% clay in the 6 to 12"	-0.27
	Silverleaf Nightshade 9/9	-0.17
	Plant population	-0.04

*This value indicates the degree of linear association between variables with the value of 1.0 explaining the variation very well and the value of 0 indicating no relationship. Positive and negative signs indicating the direction of the relationship. (Correlation matrix evaluation, SST-Spatial Analysis).

Table 4. Difference in yield and chemical costs associated with site-specific and conventional perennial weed control treatments at TAES, Halfway, 1999.

Perennial Weed	Site-Specific Application Area (Area Except Span 4)	Conventional Tillage Area (Span 4)
None		
No. of Sample Points	13	
PF Chemical Costs ($/A)	0	
Avg. Yield (lb/A)	777	
Cotton Value @$.60/lb ($/A)	466.2	
Cotton Value Over Chem. Cost ($/A)	466.2	
Woollyleaf Bursage (Lakeweed)		
No. of Sample Points	10	2
PF Chemical Costs ($/A)	24	0
Avg. Yield (lb/A)	917	897
Cotton Value @$.60/lb ($/A)	550.2	538.2
Cotton Value Over Chem. Cost ($/A)	526.2	538.2
Texas Blueweed		
No. of Sample Points	5	2
PF Chemical Costs ($/A)	47	0
Avg. Yield (lb/A)	849	920
Cotton Value @$.60/lb ($/A)	509.4	552
Cotton Value Over Chem. Cost ($/A)	462.4	552.0
Silverleaf Nightshade (Whiteweed)		
No. of Sample Points	19	4
PF Chemical Costs ($/A)	5	0
Avg. Yield (lb/A)	821	836
Cotton Value @$.60/lb ($/A)	492.6	501.6
Cotton Value Over Chem. Cost ($/A)	487.6	501.6
Blueweed and Silverleaf Nightshade		
No. of Sample Points	4	2
PF Chemical Costs ($/A)	52	0
Avg. Yield (lb/A)	848	920
Cotton Value @$.60/lb ($/A)	508.8	552
Cotton Value Over Chem. Cost ($/A)	456.8	552.0
Bursage and Silverleaf Nightshade		
No. of Sample Points	5	2
PF Chemical Costs ($/A)	29	0
Avg. Yield (lb/A)	906	862
Cotton Value @$.60/lb ($/A)	543.6	517.2
Cotton Value Over Chem. Cost ($/A)	514.6	517.2

Table 5. Percent woollyleaf bursage control and cotton lint yield resulting from chemical and tillage treatments including precision tillage at the TAES, Halfway, 1998-99.

		1998		1999		
Herbicide	Tillage	% Control on 8/17	Yield (lb/A)	% Control on 9/7	Yield (lb/A)	Average Yield (lb/A)
None	None	0	0	0	0	0
	Cultivation	38	137	38	37	87
	Precision Cultivation	79	327		739	533
Roundup	None	72	249	93	733	491
	Cultivation	88	375	99	816	596
	Precision Cultivation	92	353		895	624
MSMA	None[1]	20	0	10	165	83
	Cultivation[1]	53	99	47	409	254
	Precision Cultivation	82	301		911	606

[1]1.5 lb MSMA/A + 1.0 lb Fall Banvel/A.

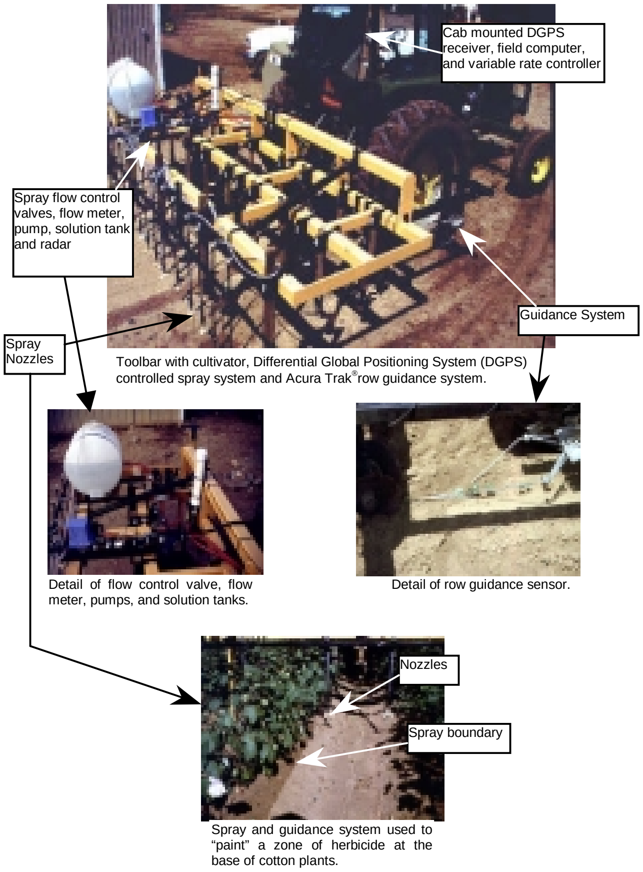

Figure 1. Spray/tillage tool constructed and used in field experiments at TAES, Halfway, TX, 1998-99.

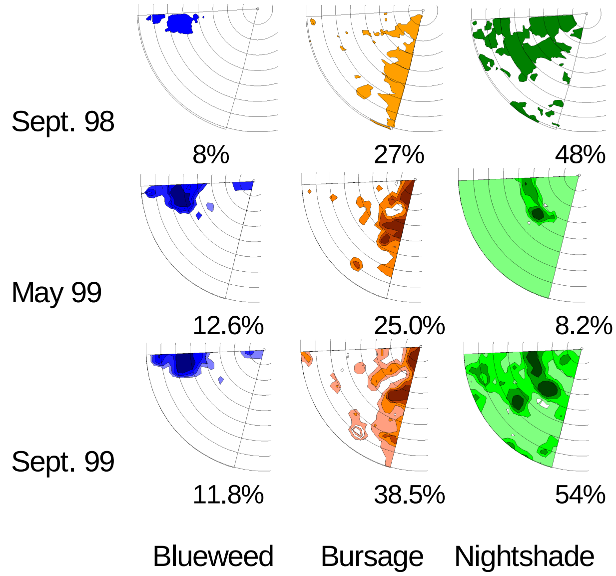

Figure 2. Location and percent of area infested by perennial weeds in 1998 through 1999 at TAES, Halfway, TX. Darker colored areas indicate more dense weed infestations (1999 data only).