BUDGET ANALYSIS OF GLYPHOSATE-RESISTANT PALMER AMARANTH CONTROL AND SEED TECHNOLOGY CHOICES IN GEORGIA COTTON

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Abstract

Palmer amaranth (pigweed) resistance to glyphosate was first confirmed in Georgia during 2004. By the Fall of 2009, resistance was confirmed in 51 counties infesting over 1 million acres of land. In 2010, producers must consider both technology choices and Palmer amaranth resistance management when choosing which varieties to plant.

A survey of county Extension agents was conducted in 2009 in Georgia counties already known to be confirmed with glyphosate-resistant Palmer amaranth. In counties considered to have severe resistance, approximately 90% of acres were treated with a DNA herbicide (Prowl, Treflan, etc.) or other residual herbicide in 2008 after having resistance compared to only 25% in 2004 prior to having resistance. Conservation tillage declined from over 80% of acres in 2004 to less than 50% in 2008. Also in 2008, 20 to 25% of the acres were cultivated and 45% required hand weeding.

Typical weed control costs have increased from $25 per acre prior to resistance to $46 to $64 per acre if managing for moderate to heavy resistance. In 2010, single-gene Bt technology is no longer available and producers must shift to two-gene technologies while also managing glyphosate resistance.

There are differences in production costs associated with the choice of technology. Estimates show that “system costs” (seed, technology fees, herbicides, insecticides, and application) can vary by as little as $2 to $3 per acre to as much as $35/acre or more. These differences, however, are considered relatively small.

The key factor in variety and technology choice will continue to be yield potential. Differences in cost are relatively minor and can be offset by small differences in yield.

Situation and Background

Over 99% of Georgia’s cotton acreage is planted to transgenic (herbicide-tolerant and/or insect tolerant) varieties (USDA-AMS, 2009). More importantly, one such variety, DP555BR, has dominated the state’s acreage since its availability. DP555BR comprised 86% of Georgia acres planted in 2008 and 82.5% in 2009.

The fact that a single variety and technology account for the overwhelming majority of acreage is critical because single-gene BollGard® technologies such as B and BR

expired on September 30, 2009. Beginning with the 2010 crop, with exception of any remaining single-gene stocks available for purchase, cotton producers must switch to non-Bt or 2-gene varieties Widestrike® (W) or Bollgard II® (B2).

Most W and B2 varieties are packaged with Roundup-Ready® (R or RR), Roundup-Ready Flex® (RF or F), or Liberty-Link® (LL) technology. DP555BR has been a high-yielding variety for Georgia producers. The majority of Georgia producers, if planting a 2-gene variety, must switch from BR to B2R, B2RF, LLB2, W, WR, or WRF varieties.

Palmer amaranth (pigweed) resistance to glyphosate was first confirmed in one county in Georgia in 2004 and by season's end of 2009 it was confirmed in 51 cotton-producing counties (Culpepper, et al, 2010). Resistance is expected to be confirmed in all major cotton producing counties by the end of 2010. In 2010, producers must consider both technology choices and Palmer amaranth resistance management when choosing varieties to plant.

Objectives

An objective of this study is to explore trends in seed technology in Georgia cotton. This study will also examine the glyphosate resistance issue and how herbicide costs have changed over time due to the need for producers to manage resistance.

This study compares seed technology choices and related herbicide and insecticide program options for 2010 and cost estimates for these various choices. Herbicide programs assume the producer is managing glyphosate-resistant Palmer amaranth and based on University of Georgia Extension recommendations (Collins, et al., 2010).

Extension recommendations are numerous and encompass many alternatives. Likewise, producers vary in their approach and use of various products. The weed control programs used in this research are thought to be typical of those used on Georgia farms but are not meant to represent the only possible program, nor are they an endorsement or recommendation for a particular product.

Results

When RR varieties were first released in the late 1990's, grower acceptance was slow due to their low yield. When "stacked-gene" BR technology became available, growers accepted these varieties more quickly– as much for the yield compared to RR as for the utility of the technology. Most of the BR acreage planted in Georgia has been to a single, very high-yielding variety– DP555BR. In paying for the BR technology and planting this variety, producers were willing to pay for the additional yield potential as well as the technology.

In the past few years, acreage of B2, W, and RF varieties has increased. Two-gene technology accounted for just over 14% of acres in 2009— 9% to B2 packaged with R, RF, or LL and over 5% to W or W packaged with R or RF (USDA-AMS, 2009).

BR acreage has still been over 80% of Georgia plantings, however, and Georgia growers have been slow to adopt these newer technologies as long as DP555BR was available. With the loss of single-gene Bt technology after the 2009 crop season, 2010 will usher in a shift in varieties planted and seed technology.

Glyphosate Resistance

A survey of county Extension agents was conducted in 2009 in Georgia counties already known to be confirmed with glyphosate-resistant Palmer amaranth. Agents were asked to compare weed control regimes in 2004, prior to resistance, to 2008 with resistance (Table 1).

In counties considered to have severe resistance, approximately 90% of acres were treated with a DNA or other residual herbicide in 2008, compared to only 25% in 2004. Strip-till (the predominant conservation tillage system in Georgia) declined from over 80% of acres in 2004 to less than 50% in 2008. Also in 2008, 20 to 25% of acres were cultivated and 45% required hand weeding.

Table 1. Results of a 2009 survey of county extension agents in Georgia counties with glyphosate-resistant Palmer amaranth.

	GR Palmer amaranth Infestation Level in 2008					
	Severe		Light to Moderate		Light	
	2004[a]	2008	2004[a]	2008	2004[a]	2008
% Acres Treated with a DNA Herbicide	25	92	75	95	70	91
% Acres Treated with Residual Herbicide other than DNA	25	88	61	95	35	71
% Acre in Strip-Till Production	83	48	45	45	30	60
% Acres Using PPI Herbicide	0	5	0	0	0	0
% Acres Using Glufosinate	0	26	0	5	0	2
% Acres Cultivated	0	20	0	25	22	12
% Acres Hand-Weeded	0	45	0	35	1	37

[a]No resistance present in 2004 but confirmed by 2008.

In counties with both light and moderate infestations, use of DNA and other residual herbicides has also increased. Strip-till production has remained about the same or increased. Use of Ignite® herbicide (glufosinate) has increased especially in counties with a severe resistance problem.

After the adoption of Roundup-Ready cotton technology but before glyphosate-resistant Palmer amaranth, weed control (herbicides only) was a $25 per acre expenditure (Table 2). This estimate is based on 2010 herbicide prices and UGA Extension recommendations for what was considered a typical regime at that time. Morningglory and spiderwort have been a problem for many producers. For that reason, residual

chemistries have often been used even in a glyphosate-based program prior to resistance.

When resistance began to be a concern, UGA Extension recommended that producers increase the use of residual herbicides and reduce the use of glyphosate. The objectives in weed control were to delay further development of resistance to glyphosate, reduce the spread of resistance geographically, and reduce the seed-bank. Increased use of residual herbicides in a glyphosate-based, RR cotton program resulted in weed control costs of $30 to $35 per acre based on UGA recommendations at 2010 herbicide prices (Table 2).

Table 2. Example herbicide programs in Roundup Ready cotton.

	Pre-Resistance			Delaying Resistance		
Application	Material	Rate	Cost/Acre	Material	Rate	Cost/Acre
Preplant or PPI						
PRE	Prowl	2pts	$6.88	Prowl	2pts	$6.88
POST OTT	Glyphosate + Dual	32 oz 1 pt	$4.00 $10.60	Glyphosate + Staple	32 oz 1.9 oz	$4.00 $10.45
POST Directed	Glyphosate	32 oz	$4.00	Glyphosate + Diuron	32 oz 2 pt	$4.00 $5.40
Total			$25.48			$30.73

Technology Choices and Managing Resistance

Producers could purchase any remaining single-gene Bt seed stocks available by September 30, 2009. These seed can be planted in 2010. Otherwise, cotton producers have two seed technology choices for 2010 and beyond - plant non-Bt varieties and/or plant two-gene varieties. Non-Bt varieties include conventional (non-transgenic), Roundup Ready (RR or R), Roundup-Ready Flex (RF or F), or Liberty Link (LL). Two-gene varieties include Bollgard II (B2) and Widestrike (W), and most come combined with R, RF, or LL (B2, B2R, B2RF, LLB2, W, WR, and WRF).

Producers must select a non-Bt or two-gene variety (B2 or W) while also considering the need for managing glyphosate-resistant Palmer amaranth. Producers will have choices among glyphosate-based systems (R or RF) or an Ignite (glufosinate)-based system (LL).

Tables 3 and 4 are example weed control programs based on UGA Extension recommendations (Culpepper and Kichler, 2010), assuming resistance is present and the producer is managing resistance. Table 3 illustrates example recommended programs in conventional and strip-till production for R and RF varieties. Table 4 illustrates example recommended programs in conventional and strip-till production for LL varieties.

In these programs, there is little or no difference between irrigated and non-irrigated practices. It should be especially noted, however, the glyphosate-based production in

non-irrigated conservation-tillage situations where resistance is present is very risky. This is due to lack of preplant tillage and soil incorporated herbicides and uncertainty of rainfall needed for timely activation.

In this situation, Ignite (glufosinate)-based programs (Table 4) are more effective if there is a significant level of glyphosate-resistant Palmer amaranth. Otherwise, non-irrigated conservation tillage will almost certainly require hand weeding and/or deep plowing prior to conservation tillage and/or use of a very heavy cover crop to eliminate the emergence of Palmer amaranth seed.

Table 3. Example herbicide program, managing resistance in Roundup Ready cotton.

Conventional		Strip-Till	
Application	Product	Application	Product
Preplant Broadcast		Preplant Broadcast	Valor
PPI		PPI	
PRE	Prowl[1] + Reflex	PRE	Prowl + Staple + Diuron
POST OTT	Glyphosate + Staple	POST OTT	Glyphosate + Dual
POST Directed	MSMA + Diuron	POST Directed	MSMA + Diuron

[1]Applied PPI in non-irrigated production.

Table 4. Example herbicide program, managing resistance in Ignite-based programs.

Conventional		Strip-Till	
Application	Product	Application	Product
Preplant Broadcast		Preplant Broadcast	Valor
PPI		PPI	
PRE	Prowl + Reflex	PRE	Prowl + Staple
POST OTT	Glufosinate + Dual	POST OTT	Glufosinate + Dual
POST Directed	MSMA + Diuron	POST Directed	MSMA + Diuron

Ignite® (glufosinate) herbicide is used in conjunction with Liberty Link® technology. There are only a few differences between the example Ignite-based programs and Roundup Ready programs illustrated in Tables 3 and 4. The only significant difference is the use of glufosinate instead of glyphosate. Both systems rely on similar use of residual herbicides and modes of application.

Cost Comparison of Seed Technologies and Weed Control Systems

Tables 5 and 6 are a cost comparison of two-gene systems based on UGA recommendations (Tables 3 and 4) and 2010 prices. These costs are “systems costs”—the cost of inputs and production practices that are strictly a function of seed technology choice. These costs are based on managing for glyphosate-resistant

Palmer amaranth and are the average of irrigated and non-irrigated production. Cost excludes hand weeding, if needed. Cost includes the cost of herbicide and insecticide application (Shurley and Smith, 2010).

Weed control costs (number of applications, amount applied, and other materials used) are assumed the same for R and RF, as weed control programs are identical for both these technologies in areas with resistance. These estimates also assume no difference in insect control and cost between B2 and W. Cost includes in-furrow insecticide and 2 sprays for bugs but no sprays for caterpillar pests.

Table 5. Systems cost per acre for two-gene seed technologies, managing glyphosate resistance in strip-tillage.

	Seed Technology					
	B2R	B2RF	LLB2	W	WR	WRF
Seed	$22.38	$22.15[a]	$39.77[b]	$21.17	$21.17	$21.17
Technology Fees	$52.99	$59.87	$30.46	$15.01	$47.24	$56.75
Herbicides	$46.45	$46.45	$56.59	$56.59[c]	$46.45	$46.45
Insecticides	$19.40	$19.40	$19.40	$19.40	$19.40	$19.40
Application	$10.44	$10.44	$8.69	$8.69	$10.44	$10.44
TOTAL	$151.66	$158.31	$153.91	$120.86	$144.70	$154.21

[a]Average of DeltaPine, Stoneville, and Fibermax varieties. All technologies are 36-inch rows, 2.5 seed per foot.
[b]Includes Liberty Link fee.
[c]Ignite program- not endorsed by Dow AgroSciences or Bayer CropScience, not recommended by UGA Extension.

Table 6. Systems cost per acre for two-gene seed technologies, managing glyphosate resistance in strip-tillage.

	Seed Technology					
	B2R	B2RF	LLB2	W	WR	WRF
Seed	$24.62	$24.36[a]	$42.65[b]	$23.29	$23.29	$23.29
Technology Fees	$58.29	$65.86	$33.51	$16.51	$51.96	$62.42
Herbicides	$56.77	$56.77	$63.95	$63.95[c]	$56.77	$56.77
Insecticides	$19.40	$19.40	$19.40	$19.40	$19.40	$19.40
Application	$10.02	$10.02	$10.02	$10.02	$10.02	$10.02
TOTAL	$169.10	$176.41	$169.53	$133.17	$161.44	$171.90

[a] Average of DeltaPine, Stoneville, and Fibermax varieties. All technologies are 36-inch rows, 2.75 seed per foot.
[b]Includes Liberty Link fee.
[c]Ignite program- not endorsed by Dow AgroSciences or Bayer CropScience, not recommended by UGA Extension.

Widestrike (W) without R or RF assumes these varieties are produced using an Ignite-based program. While *not endorsed by Dow and Bayer and not recommended by UGA Extension*, if planted in a resistance situation, Ignite is likely being used (glyphosate could not be used, leaving glufosinate or residual chemistries only as the options). While not endorsed or recommended, it is nevertheless likely being done.

In conventional production (Table 5), cost ranges from $121 to $158 per acre. Excluding W, cost varies from $145 to $158 per acre. In conservation tillage (strip-till) production (Table 6), cost ranges from $133 to $176 per acre. Excluding W, cost varies from $161 to $176 per acre. The Widestrike systems (WR and WRF) tend to be cheaper than similar Bollgard II systems (B2R and B2RF) but differences are relatively minor.

Both conventional and strip-till estimates are the average of irrigated and non-irrigated production. In non-irrigated conservation tillage, if significant resistance is present, Ignite-based systems are the most effective option. Non-irrigated conservation tillage with resistance present is risky and almost surely will require hand weeding and/or heavy cover crop. Results from a UGA Extension survey noted that hand weeding occurred on 54% of the Georgia cotton acres during 2009 with cost ranging from $3 to $100 per acre with an average expense of $26 per acre.

Summary and Conclusions

Due to glyphosate-resistant Palmer amaranth, weed control cost has more than doubled when compared to a period prior to resistance management. If managing for moderate to heavy infestation, herbicide cost can be $46 to $64 per acre; excluding application, hand weeding if needed, and seed technology fee.

In 2010, single-gene Bt technology is no longer available and producers must shift to other technology while, for an increasing number of producers, also managing glyphosate resistance. Two-gene technologies include B2 and W and are most often available only as packaged with R, RF, or LL technology.

There are differences in production cost associated with the choice of technology. Estimates show that "system costs" (seed, technology fees, herbicides, insecticides, and application) can vary by as little as $2 to $3 per acre to as much as $35/acre, or more. These differences, however, are considered relatively small.

When purchasing seed, producers are purchasing a management regime. Choice of variety determines not only yield and fiber quality potential, but also a set of recommended management practices.

Although costs can vary, the key factor in variety and technology choice is likely to continue to be yield potential. The differences in cost are relatively minor and can be offset by small differences in yield. Choice of variety is likely to continue to be determined by yield and the technology that best suits the weed and insect management needs of the individual producers.

References

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