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Bt Cotton Technology in Oklahoma: An Overview

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Introduction

The Bollgard® gene that is expressed in transgenic cotton varieties is an important IPM tool for management of Lepidopterous pests. Its acceptance by Oklahoma cotton producers has grown steadily since its introduction. Unlike insecticide sprays that kill by contact, the in-plant protection provided by Bollgard® must be consumed first before death occurs. This lag period between hatch and when the susceptible caterpillars die, raises concerns from producers and consultants alarmed at larval survival and associated fruit damage. Subtle adjustment in scouting techniques and economic thresholds were made to account for differences in Bt-technology and management of conventional cotton. This paper highlights the Bt-technology including proper scouting techniques and economic thresholds required to enhance its value to Oklahoma's cotton industry.

Reasons Producers Grow Bollgard® Cotton

(Rank; 1 = most important, 4 = least important)

Reduced Insecticide Usage	1.3
Increased Porfits	2.3
Reduced Inputs	3.3
Increase Yields	3.3

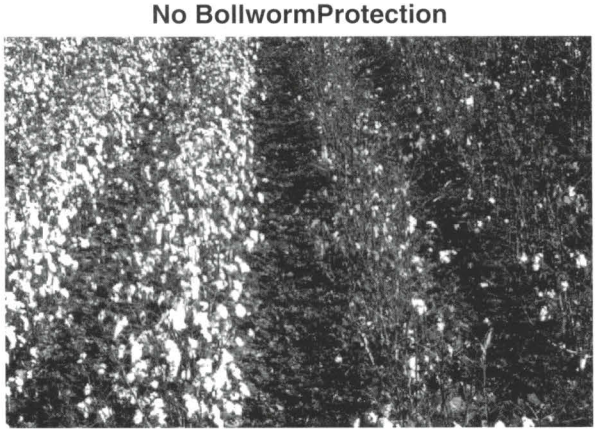
Consultant Survey - Fall 1999

Bollgard®

Bollgard® is the first in-plant insect protection available to cotton producers. The in-plant protection provided by Bollgard® is quite different than typical insecticide control applied as foliar sprays. According to Monsanto Chemical Company, expression of the Bt protein (derived from the soil born bacteria - *Bacillus thuringiensis*) is highest in actively growing terminals and although effective, concentrations decrease further down the plant. The Bt toxin is relatively high in component parts of the plant with the exception of the pollen of flowers and flower tags. There expression is significantly lower than elsewhere in the plant.

Bt-cotton is highly effective against tobacco budworms and bollworms, greatly reducing the number of foliage sprays required to prevent economic loss by this important pest complex. It is less effective on other caterpillar pests, e.g. beet armyworms and fall armyworms, and shows no activity towards non-caterpillar pests, e.g. cotton aphids and cotton fleahoppers.

No BollwormProtection



NuCOTN 33B **DP 90**

1996

Reduce Insecticide Usage

Pros

Insecticide usage has decreased in Bt-cotton (Table 1). Bt-cotton provides several advantages over conventional cotton. Boll-worms are suppressed, fewer insecticide sprays are required, and resident beneficial insects are preserved. Conservation of beneficial insects is of utmost importance and is essential in maintaining a successful IPM program. Reduced insecticide usage with Bt-cotton, especially sprays

Table 1. Cotton consultants' survey results – comparison of insecticide usage 1996 - 1999.

	Conventional Cotton	*Bollgard® Cotton*
	Number of Insecticide Applications	
	1996	
Total	**11.5**	
Boll Weevil	5.5	na[1]
Bollworm	3.0	na
Cotton Aphid	1.5	na
Cotton Fleahopper	1.5	na
	1997	
Total	**10.5**	**8.0**
Boll Weevil	5.0	4.0
Bollworm	3.5	1.0
Cotton Aphid	1.0	2.0
Beet Armyworm	1.0	1.0
	1998	
Total	**12.5**	**6.0**
Boll Weevil	4.0	2.0
Bollworm	3.0	0.0
Beet Armyworm	2.5	1.0
Cotton Aphid	1.0	1.0
Cotton Fleahopper	2.5	2.0
	1999	
Total	**5.8**	**3.5**
Boll Weevil	1.0	1.0
Bollworm	1.5	0.0
Cotton Fleahopper	2.3	1.5
Cotton Aphid	1.0	1.0
Thrips	0.0	1.0

[1]NA = not available

targeted at the bollworm/budworm complex, lessens the chance of selection for resistance in populations of non-target pests especially after boll weevil eradication is completed

Cons

On the negative side, the reduction or elimination of bollworm sprays also reduces the non-target control these sprays provide Reduced insecticide usage in Bt-cotton may allow other secondary pests to increase in importance (e g tarnished plant bug, stink bug, and fall armyworm) as planted acres shift in favor of Bt-cotton

Scouting Dilemma

During the 1996 growing season, consultants considered raising their scouting fees because of the number of repeated visits required to monitor bollworm development on Bollgard® cotton Much of their apprehension centers around proper scouting techniques to locate larval survivors and associated damage within the plant This apprehension was expected since most consultants tend to modify worm thresholds during bloom, timing insecticide applications to coincide with egg hatch Terminal examinations and inspections for square damage are of little value in Bt-cotton since few escaping larvae are detected in the plant terminal or feeding on squares Most of the surviving larvae are located within the plant in open white or red blooms, inside dried bloom tags, or feeding on young bolls

There is not a particular point at which a caterpillar can be identified as an escape, however, once an individual larva exceeds one-fourth of an inch long and appears healthy, then the odds for continued survival are good The apparent fruit

Table 2a. Cotton budget and analysis – 1996.

Return[1]		***Bollgard®***		*Conventional*
Cotton	775 lbs	**$465.00**	572 lbs	$343 20
Operating Inputs				
Seed	14 lbs @ 70	**$ 9.80**		$9 80
Bt Cost		**32.00**		—
Hoeing		**15.00**		15 00
Herbicide		**6.40**		6 40
Nitrogen		**16.00**		
16 00				
Phosphorous		**5.40**		5 40
Ginning		**23.25**		17 16
Spraying[2]		**34.70**		53 45
Crop Insurance		**18.00**		18 00
Custom Harvest		**69.75**		51 48
Labor		**22.75**		22 75
Fuel, Lube & Repair		**22.00**		22 00
Irrigation		**40.00**		40 00
Operating Interest		**10.20**		9 54
Total Operating Cost		**$325.25**		$286 98
Return to Land, Overhead, Risk & Management		**$139.75**		$56 22
				$83.53

[1] Based on ten replicated tests

[2]Spraying is the total cost of controlling insects Application costs, bollworms = $12 50/acre and all other insect pests = $6 50/acre Bollgard® cotton averaged 4 10 (0 80 application for bollworms and 3 80 applications for all other insects) applications compared to conventional cotton 6 10 (2 30 applications for bollworms and 3 80 applications for all other insects) applications

Table 2b. Cotton budget and analysis – 1997.

Return[1]		*Bollgard®*	*Conventional*
Cotton	1,473 lbs	**$883.80**	1,350 lbs $810 00
Operating Inputs			
Seed	14 lbs @ 70	**$ 9.80**	$9 80
Bt Cost		**32.00**	—
Hoeing		**15.00**	15 00
Herbicide		**6.40**	6 40
Nitrogen		**16.00**	16 00
Phosphorous		**5.40**	5 40
Ginning		**44.19**	40 51
Spraying[2]		**20.81**	20 81
Crop Insurance		**18.00**	18 00
Custom Harvest		**132.57**	121 51
Labor		**22.75**	22 75
Fuel, Lube & Repair		**22.00**	22 00
Irrigation		**40.00**	40 00
Operating Interest		**8.51**	7 91
Total Operating Cost		**$394.43**	$346 08
Return to Land, Overhead, Risk & Management		**$489.37**	$463 91
			$25.46

[1] Based on 16 replicated tests

[2] Spraying is the total cost of controlling insects Application costs, bollworms = $12 50/acre and all other insect pests = $6 50/acre Bollgard® cotton averaged 4 10 (0 625 application for bollworms and 2 00 applications for all other insects) applications compared to conventional cotton 6 10 (0 625 applications for bollworms and 2 00 applications for all other insects) applications

Table 2c. Cotton budget and analysis – 1998.

Return[1]		*Bollgard®*	*Conventional*
Cotton	1,050 lbs	**$630.00**	859 lbs $515 40
Operating Inputs			
Seed	14 lbs @ 70	**$ 9.80**	$9 80
Bt Cost		**32.00**	—
Hoeing		**15.00**	15 00
Herbicide		**6.40**	6 40
Nitrogen		**16.00**	16 00
Phosphorous		**5.40**	5 40
Ginning		**31.50**	27 77
Spraying[2]		**22.74**	28 40
Crop Insurance		**18.00**	18 00
Custom Harvest		**94.50**	77 31
Labor		**22.75**	22 75
Fuel, Lube & Repair		**22.00**	22 00
Boll weevil Eradication		**18.00**	16 09
Irrigation		**40.00**	40 00
Operating Interest		**9.60**	8 29
Total Operating Cost		**$363.69**	$313 21
Return to Land, Overhead, Risk & Management		**$266.31**	$202 19
			$64.12

[1] Based on 12 replicated tests

[2] Spraying is the total cost of controlling all insects Application costs, bollworms = $12 50/acre and all other insect pests = $6 50/acre Bollgard® cotton averaged 3 34 (0 17 application for bollworms and 3 17 applications for all other insects) applications compared to conventional cotton 3 75 (67 applications for bollworms and 3 08 applications for all other insects) applications

and boll damage associated with these larvae were unnerving to consultants and producers alike However they quickly learned at harvest that "excessive" fruit damage did not reduce yields as expected Achieving high yields in spite of the apparent damage helped consultants adjust economic thresholds accordingly

Modified Whole Plant Examination

In Bt-cotton, consultants need to concentrate scouting efforts on the middle to upper zone of the plant, just beneath the white blooms, to detect developing caterpillars A modified examination of the entire plant is suggested With this method all red and/or dried blooms should be examined as well as five to ten day-old bolls on selected plants Even with these modifications, whole plant examinations may still be too time consuming for consultants to follow completely

Another method that shows merit is pulling and examining flowers Pulling flowers is similar to pulling squares to detect boll weevils Blooms are picked at random from the same region of the plant described in the modified zone search Spray decisions are based on the number of larvae found per 100 blooms and corresponding fruit and boll damage

Insecticide Protection Warranted

Insecticide sprays are recommended when eight or more (3/8 inch) larvae are found per 100 plants or 100 blooms If larvae are less than 3/8 of an inch long, recheck the field in two to three days to see if larvae are killed by consuming the ***Bollgard® gene.***

Monetary Value

To help determine the economic value of Bollgard® cotton to Oklahoma, budgets and cost analyses were prepared (Table 2a, 2b, 2c, 2d, & 2e) This information is based on four years of replicated data collected from 52 irrigated cotton trials These comparisons lumped varieties into two groups (Bollgard® and conventional) regardless of maturity, variety type, or spray regime Regardless of the management scheme or insect pressure, Bollgard® cotton yielded best and increased profitability (return per acre) for all four years The profit margin for Bollgard® cotton varied between $25 46 to

Table 2d. Cotton budget and analysis – 1999.

Return[1]		*Bollgard®*	*Conventional*
Cotton	969 lbs	**$484.50**	814 lbs $407 00
Operating Inputs			
Seed	14 lbs @ 70	**$ 9.80**	$9 80
Bt Cost		**16.47**	—
Hoeing		**15.00**	15 00
Herbicide		**6.40**	6 40
Nitrogen		**16.00**	16 00
Phosphorous		**5.40**	5 40
Ginning		**29.07**	24 42
Spraying[2]		**14.75**	14 75
Crop Insurance		**18.00**	18 00
Custom Harvest		**87.21**	73 26
Labor		**22.75**	22 75
Fuel, Lube & Repair		**22.00**	22 00
Boll weevil Eradication		**17.19**	15 64
Irrigation		**40.00**	40 00
Operating Interest		**8.43**	7 61
Total Operating Cost		**$328.47**	$291 03
Return to Land, Overhead, Risk & Management		**$156.03**	$115 97
			$40.06

[1] Based on 14 replicated tests

[2]Spraying is the total cost of controlling all insects Application costs, bollworms = $12 50/acre and all other insect pests = $6 50/acre Bollgard® cotton and conventional cotton averaged 2 14 (0 14 application for bollworms and 2 00 applications for all other insects) applications

Table 2e. Cotton budget and analysis – 1996 - 1999.

Return		*Bollgard®*	*Conventional*
Cotton	1,106 lbs	**$635.95**	943 lbs $542 23
Operating Inputs			
Seed	14lbs @ 70	**$ 9.80**	$9 80
Bt Cost		**28.12**	—
Hoeing		**15.00**	15 00
Herbicide		**6.40**	6 40
Nitrogen		**16.00**	
16 00			
Phosphorous		**5.40**	5 40
Ginning		**33.18**	28 29
Spraying[2]		**22.28**	27 28
Crop Insurance		**18.00**	18 00
Custom Harvest		**99.54**	84 87
Labor		**22.75**	22 75
Fuel, Lube & Repair		**22.00**	22 00
Boll weevil Eradication		**17.88**	16 49
Irrigation		**40.00**	40 00
Operating Interest		**9.39**	8 23
Total Operating Cost		**$365.74**	$320 51
Return to Land, Overhead, Risk & Management		**$270.21**	$221 72
			$48.49

[1] Based on 4 years of replicated data for 52 trials

[2]Spraying is the total cost of controlling all insects Application costs, bollworms = $12 50/acre and all other insect pests = $6 50/acre Bollgard® cotton averaged 4 10 (0 42 application for bollworms and 2 62 applications for all other insects) applications compared to conventional cotton 6 10 (83 applications for bollworms and 2 60 applications for all other insects) applications

$83 53 per acre in 1999 and 1996 respectively This research indicates the value of investing in Bollgard® technology throughout these four years was $48 49 per acre (weighted average) or $ 3,713,364 dollars (Bollgard® acreage = 76,580 acres for four years)

Conclusions

The popularity of Bollgard® cotton continues to grow and its future looks bright in Oklahoma Introduction of stripper varieties and basing rental fees on seeding rates makes it enticing and affordable for dryland production **With its increased popularity, cotton producers must follow and adhere to Monsanto's Bollgard® resistance management guide-lines.** Bollgard® technology will play an integral part in the IPM program particularly after eradication of the boll weevil

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