GROWING PAINS ASSOCIATED WITH ADOPTION OF BOLLGARD TECHNOLOGY INTO STANDARD IPM PRACTICES IN OKLAHOMA

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Abstract

Oklahoma cotton producers planted approximately 30,000 acres of NuCOTN cotton varieties, but stormy weather in June reduced the acreage to less than 15,000 acres or 18.75% of the irrigated acres planted in 1996. Oklahoma producers were eager to see if this highly advertised technological breakthrough could help produce a cheaper crop.

Growing pains (problems) that were associated with the adoption of the Bollgard technology include:

1. seedling vigor
2. buildup of bollworms and horror stories from other areas
3. unknown economic thresholds to trigger control measures and scouting techniques
4. boll weevil havens
5. cotton aphid buildups
6. boll size

Results from research and demonstration plots of NuCOTN cotton showed NuCOTN cotton seedling vigor was not reduced by infurrow applied insecticides at-planting. Plant mapping revealed NuCOTN varieties were slightly slower in initiating fruiting; retained more first position fruiting sites; produced slightly smaller bolls and had the greatest number of bolls/acre regardless of the spray regime. NuCOTN produced more lint than conventional varieties regardless of the spray regime.

Introduction

Bollgard Cotton™ was commercially available in 1996. Besides being the first of a long list of new biotech products to reach the farmer, Monsanto introduced a rental fee along with Bollgard cotton. Interested producers had to pay a $32 per acre surcharge for the "right-to-grow" Bollgard cotton. This price is close to the average mean spent across the cotton belt annually to combat the bollworm /tobacco budworm complex. Unlike other production areas across the Beltwide, the majority of the moth flight throughout the summer in Oklahoma is made up of bollworms (Figure 1.).

Most years, between $25.00 and $40.00 per acre is spent to control bollworms in irrigated cotton under intense management. This annual expenditure barely equals the rental expense for the Bollgard technology. However Oklahoma producers were eager to see if this highly advertised technological breakthrough could help produce a cheaper crop. Much of this enthusiasm was generated by performance expectations outlined by Monsanto and Delta Pineland sales representatives at licensing meetings. Most of the producers planting NuCOTN varieties hoped the reduction in spraying would conserve beneficial insects curtailing the total number of insecticide applications, especially those aimed at controlling secondary pest outbreaks, e.g. cotton aphids.

NuCOTN planting intentions changed as planting started because of a lingering drought. Approximately 30,000 acres were planted across the State with the majority of acres centered in the Altus Irrigation District located in Jackson and Greer Counties. Stormy weather in June forced widespread replanting. Many producers switched to earlier maturing varieties or sorghum to compensate for a shortened growing season. NuCotn's share shrunk to less than 15,000 acres or 18.75% of the irrigated acreage planted in 1996.

Several "growing pains" (problems) were encountered with NuCOTN varieties in 1996. Many of the problems were similar to ones that arise any time a new product or technique is introduced. This was compounded by the fact that no NuCOTN cotton had ever been evaluated under Oklahoma conditions forcing the Extension Service to speculate about its performance and place in Oklahoma's production system. Prior to planting, several questions remain unanswered. Influence of Bollgard on other insect pests, beneficial insects, scouting methods, and economic thresholds were major concerns.

At planting, seedling vigor became an issue. Much of the cotton in the Altus Irrigation District was watered up because of limited soil moisture. Poor germination, seedling vigor, and stand establishment was noticed in NuCOTN planted fields. Seed dealers and producers were quick to blame infurrow applications of insecticides for the reduced vigor. However results of a replicated study showed NuCOTN 33B to have better stands than DP 5690 regardless of the rate of Temik applied at-planting (Table1A,B,C and D). Temik had no adverse effect on seedling vigor of NUCOTN plants. Further investigation of cotton fields with reduced germination and plant stands revealed that salt deposited while irrigating was probably at fault, not infurrow applied insecticides.

The damage inflicted by the boll weevil in the last five years forced many producers to switch to other crops in 1996. Sorghum and corn replaced cotton on thousands of acres across Southwest Oklahoma. This large tract of sorghum and corn enhanced bollworm development in June, resulting in the heaviest July moth flight in cotton in 15 years (Karner, 1996). Producers and consultants spent many a restless night in July resisting the urge to spray eggs and 1st instar larvae in NuCOTN fields. Bollgard performed as

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advertised with no fields requiring insecticidal control for bollworms. Constant bollworm pressure and rumors of Bollgard failures in the Brazos River Bottom in Texas and the mid-South kept producers and consultants on "edge". Their attention focused on flowers and bolls to detect bollworms trying to prevent a similar horror in their fields. As bollworm numbers increased and damage became obvious, producers and consultants started to doubt Bollgard performance. Consultants threatened to raise their fees because of the number of repeated visits required to monitor bollworm development on NuCOTN cotton.

Economic thresholds changed throughout the season in an attempt to allow Bollgard a chance to regulate bollworm infestations but prevent economic loss. At the start of the season, the economic threshold for Bollgard cotton was; Spray only if 10 or more worms are found per 100 plants and are nearing ½ inch long. If worms are less than ¼ inch long, recheck field in 2 to 3 days to see if worms are killed by consuming the Bollgard gene. By August, the threshold had been amended to reflect the discovery of larvae surviving in flowers. In addition to the above mentioned threshold, producers were urged to consider spraying when 6 or more larvae ¼ inch or larger were found in 100 flowers pulled at random (like sampling for boll weevils). Neither of these thresholds were ever reached or exceeded in research or extension demonstration plots of NuCOTN cotton during 1996, (Table 1A, 2A, 3A, 4A, 5A, and 6A). No larvae larger than ¼ inch were found throughout the summer.

During 1996, only 1 field of NuCOTN sustained significant bollworm damage. Oddly, damage was confined to a 20 acre portion of a 100 acre field planted to NuCOTN 35B. After inspecting the field with the consultant on August 17, 1996, I suspected the damaged portion of the field had been mistakenly planted to a conventional variety. I requested Monsanto bioassay plants to clear up the matter concerning genetic origin of plants. Bioassay results of 10 heavily infested and damaged plants revealed all plants contained the Bollgard gene. Within 5 days of this verification, 95% of NUCOTN cotton in the State was sprayed for bollworms. Protection continued the remainder of the season. Most NuCOTN fields received 2 to 4 insecticide applications to prevent bollworm damage.

NuCOTN fields not sprayed for bollworms became havens for boll weevils. The most obvious reason for this rapid buildup of boll weevils was the lack of pyrethroid applications in July to control bollworms. Producers had taken for granted the impact of these pyrethroid applications on sub-economic infestations of boll weevils. Once established these boll weevil infestations were very difficult to control. In fact in some NuCOTN fields, insecticide expenditures exceeded conventional fields' insecticide costs. Also there was no difference in cotton aphid buildups between NuCOTN and conventional varieties. Ninety percent of the NuCOTN acres received 1 to 2 aphicide applications to control cotton aphids.

Producers began complaining about the boll size of NuCOTN cotton as fields neared cutout. Plant mapping of research and extension demonstration plots revealed NuCOTN bolls were significantly smaller than conventional varieties (Table 1D, 2D, 3B, 4C, 5C, and 6C). However NuCOTN varieties regardless of the spray regime had better retention of first position bolls and more bolls per acre. I cautioned producers to hold judgment until after harvest. Regardless of the spray regime, NuCOTN cotton produced more lint than conventional varieties (Table 1D, 2D, 3B, 4C, 5C, and 6C). NuCOTN cotton produced between 31.6 lbs and 446.7 lbs more lint per acre than conventional varieties. Early season thrips protection influenced lint production more that protecting NuCOTN cotton from bollworms (Table 2D and 4C).

Conclusions

Producers agreed that NuCOTN cotton produced as good or better yields than conventional varieties. However the extra cost for seed, rental, and other contract requirements will limit the acres planted to NuCOTN in 1997. Most producers switching back to conventional varieties state they did not see a reduction in the number of insecticide sprays in NuCOTN fields. Besides the fact they believe they were promised performance (no bollworm sprays) never obtained in the field. Adoption of Bollgard technology into current cotton IPM practices will be slow until resistant problems surface.

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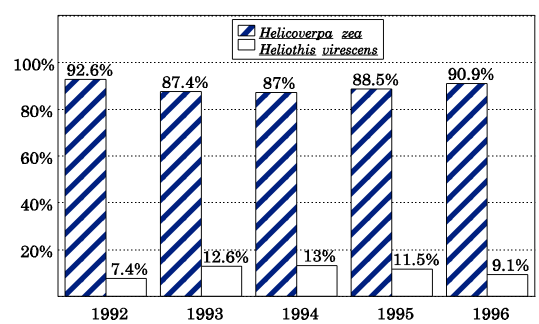

[1] Pheromone traps maintained from June 1 to September 1.

Figure 1. Species composition of moths trapped[1] across Oklahoma, 1992 - 1996.

Table 1A. Bollworm population trends on NuCOTN 33B and DP 5690 cotton with Temik applied infurrow at planting; Altus Research Station, Summer 1996.

Treatment	Number of first and second instar larvae per 100 plants[1]				
	7/18	7/22	8/2	8/5	8/9
DP 5690 Sprayed	14	0	16	20	0
N.C. 33B	16	0	10	8	0
	8/12	8/16	8/19	8/23	8/26
DP 5690 Sprayed	4	2	32	4	0
N.C. 33B	0	0	28	0	0

[1] Plots sprayed by ground delivery with 10 gallons of finish spray per acre on 7/19, 8/5 and 8/20 (see Table 1C).

Table 1B. Response of NuCOTN 33B and DP 5690 cotton varieties[1] to Temik applied infurrow at planting measured by stand establishment, fruit initiation and fruit retention, Altus Research Station, Summer 1996.

		5/30	10/1	
Variety	Temik (lbs ai/ acre)	Plants/acre	Node fruiting initiated	% Retained
N.C. 33B	.9	46,333.3 a[2]	11.0 a	68.3 a
N.C. 33B	.6	42,000.0 ab	10.3 a	67.3 a
N.C. 33B	0	41,666.7 ab	10.3 a	65.0 a
DP 5690	0	36,666.7 bc	7.7 b	56.3 b
DP 5690	.6	32,000.0 c	7.8 b	55.7 b
DP 5690	.9	31,666.7 c	8.0 b	54.7 b

[1] Planted May 16, 1996; NuCOTN 33B contains the Bollgard gene extracted protein from natural soil bacteria - Bacillus thuringiensis (Bt).
[2] Means followed by same letter do not significantly differ(P=.05,LSD)

Table 1C. In-season spray history of NuCOTN 33B and DP 5690 cotton with Temik applied infurrow at planting, Altus Research Station, Summer 1996.

Date	Chemical	Target Insect	NuCOTN 33B	DP 5690	Rate (lbs ai/ acre)
6/27	Vydate	Boll weevil	✓	✓	.125
7/19	Karate	Bollworm		✓	.03
7/19	Pix		✓	(✓)	4 oz/acre
8/5	Karate	Bollworm		✓	.03
8/12	Provado	Aphid	✓	(✓)	.04
8/20	Karate	Bollworm		(✓)	.03
8/20	Provado	Aphid	✓	✓	.04
9/2	Larvin	Beet	✓	✓	.9
10/9	Prep		✓	✓	2 pt/acre
10/9	Ginstar		✓	✓	6 oz/acre

Table 1D. Effect of Temik applied infurrow at planting on boll weight, boll produced and yield of NuCOTN 33B and DP 5690 cotton, Altus Research Station, Summer 1996.

			10/1	
Variety	Treatment[1]	Temik (lbs ai/acre)	Boll weight (oz.)	Bolls /acre
N.C. 33B	1	.9	.50 c[2]	410,000 a
N.C. 33B	2	.6	.47 c	401,000 ab
N.C. 33B	3	0	.47 c	375,000 ab
DP 5690	4	0	.54 b	304,000 cd
DP 5690	5	.6	.58 a	283,000 d
DP 5690	6	.9	.60 a	350,000 bc
Treatment	Lint (lbs/acre)	Difference in lint (lbs/acre)[3]		
		1 vs 6	2 vs 5	3 vs 4
1	838.8 a			
2	763.4 ab			
3	706.1 bc			
4	630.7 cd			75.4
5	606.1 cd		157.3	
6	583.3 d	255.5		

[1] Treatment - 1, 2 & 3 no bollworm protection, 3, 4 & 6 protected from bollworm;(see Table 1C).
[1] Means followed by same letter do not sinificantly differ (P= .05,LSD)
[2] Hand harvested October 26,1996.

Table 2A. Insect populations prior to and following treatment on NuCOTN 33B and DP 90 cotton under various spray regimes; Altus Research Station, Summer 1996.

		Insects/100 plants[1]				
Variety	S/R[2]	Thrips				
		6/6				
DP 90	1	103				
N.C. 33B	1	97				
DP 90	2	90				
N.C. 33B	2	110				
DP 90	3	70				
N.C. 33B	3	97				
DP 90	4	37				
N.C. 33B	4	143				
		Bollworm				
		larvae	larvae	eggs	larvae	larvae
		7/18	7/26	7/31	8/7	8/19
DP 90	1	60	0	93	0	0
N. C. 33B	1	67	0	93	0	0
DP 90	2	73	0	77	0	0
N.C. 33B	2	70	0	107	0	10
DP 90	3	70	0	150	0	0
N.C. 33B	3	60	0	80	0	7
DP 90	4	57	0	93	0	3
N.C. 33B	4	70	0	50	0	0

		Bollworm larvae	Beet armyworm	Yellow-stripe armyworm
		8/30	8/30	8/30
DP 90	1	1	0	7
N.C. 33B	1	0	0	10
DP 90	2	0	0	17
N.C. 33B	2	1	10	0
DP 90	3	0	0	17
N.C. 33B	3	1	7	13
DP 90	4	1	3	3
N.C. 33B	4	0	0	13

[1] Plots sprayed by ground delivery with 10 gallons of finish spray per acre on 7/19, 8/5 and 8/20.
[2] S/R - Spray Regime.
Spray regimes: insecticides applied (#)

	Thrips	Fleahopper	Bollworm
Regime 1	none	none	none
Regime 2	none	Vydate (1)	Karate (1) and Larvin (1)
Regime 3	Karate (1)	Karate (1)	Karate (3)
Regime 4	Temik	Karate (1)	Karate (3)

Table 2B. Response of NuCOTN 33B and DP 90 cotton varieties[1] to various insect management regimes measured by stand establishment, fruit initiated and fruit retention, Altus Research Station, Summer 1996.

Variety	Spray Regime[2]	Plants/acre	Node fruiting initiated	% Retained
		5/30	9/11	9/11
DP 90	1	44,000.0[3]	7.2	66.5 bc
N.C. 33B	1	43,666.7	6.7	73.0 abc
DP 90	2	42,000.0	6.6	71.4 bc
N.C. 33B	2	47,333.3	7.0	82.0 a
DP 90	3	40,333.3	6.3	64.5 c
N.C. 33B	3	45,333.3	6.8	71.0 bc
DP 90	4	40,333.3	6.7	69.3 bc
N.C. 33B	4	45,333.3	6.9	75.4 ab

		Fruit retention Difference	Difference in regimes (% Retained) 1 vs 2	1 vs 3	1 vs 4
	1				
DP 90	1				
N.C. 33B		6.5			
DP 90	2		4.9		
N.C. 33B	2	10.6	9.0		
DP 90	3			-2.0	
N.C. 33B	3	6.5		-2.0	
DP 90	4				2.8
N.C. 33B	4	6.1			2.4

[1] Planted May 16, 1996; NuCOTN 33B contains the Bollgard gene extracted protein from natural soil bacteria - Bacillus thuringiensis (Bt).
[2] Spray regimes: insecticides applied (#)

	Thrips	Fleahopper	Bollworm
Regime 1	none	none	none
Regime 2	none	Vydate (1)	Karate (1) and Larvin (1)
Regime 3	Karate (1)	Karate (1)	Karate (3)
Regime 4	Temik	Karate (1)	Karate (3)

[3] Means followed by same letter do not significantly differ(P=.05,LSD)

Table 2C In-season spray history of the various spray regimes, Altus Research Station, Summer 1996.

Date	Chemical	Target insect	Spray regimes 1	2	3	4	Rate (lbs ai/acre
5/16	Temik	Thrips				✓	.50
6/7	Karate	Thrips			✓	✓	.01
6/27	Vydate	Fleahopper		✓			.125
6/27	Karate	Fleahopper			✓	✓	.025
7/19	Karate	Bollworm			(✓)	(✓)	.025
7/19	Pix		✓	✓	✓	✓	4 oz/acre
8/5	Karate	Bollworm		(✓)	(✓)	(✓)	.025
8/12	Provado	Aphid	✓	(✓)	✓	✓	.04
8/20	Larvin	Bollworm		(✓)			.75
8/20	Karate	Bollworm			(✓)	(✓)	.025
8/20	Provado	Aphid	✓	✓	✓	✓	.04
9/2	Larvin	Beet armyworm	✓	✓	✓	✓	.9
10/9	Prep		✓	✓	✓	✓	2 pt/acre
10/9	Ginstar		✓	✓	✓	✓	6 oz/acre

Table 2D. Effect of various spray regimes on boll weight, bolls produced and yield NuCOTN 33B and DP 5690 cotton, Altus Research Station, Summer 1996.

Variety	S/R[1]	Boll weight (oz.) 9/11	Bolls: Bolls/acre 9/23	Bolls: Difference
DP 90	1	.54 a[3]	247,000 c	
N.C. 33B	1	45 cd	362,000 ab	115,000
DP 90	2	.50 ab	281,000c	
N.C. 33B	2	.43 de	368,000 a	87,000
DP 90	3	.53 a	305,000 bc	
N.C. 33B	3	.43 de	369,000 a	64,000
DP 90	4	.49 bc	287,000 c	
N.C. 33B	4	.40 e	374,000 a	87,000

Variety	S/R	Bolls – Difference in spray regimes: 1 vs 2	1 vs 3	1 vs 4
DP 90	1			
N.C. 33B	1			
DP 90	2	34,000		
N.C. 33B	2	6,000		
DP 90	3		58,000	
N.C. 33B	3		7,000	
DP 90	4			40,000
N.C. 33B	4			12,000

Variety	S/R	Yield: Lint (lbs/acre)[2] 10/26	Lint difference
DP 90	1	582.5 d[3]	
N.C. 33B	1	737 bc	155.4
DP 90	2	588.6 d	
N.C. 33B	2	727.0 bc	138.4
DP 90	3	574.4 d	
N.C. 33B	3	774.2 ab	199.8
DP 90	4	629.1 cd	
N.C. 33B	4	881.2 a	252.1

Variety	S/R	Difference in spray regimes: 1 vs 2	1 vs 3	1 vs 4
DP 90	1			
N.C. 33B	1			
DP 90	2	6.1		
N.C. 33B	2	-10.9		
DP 90	3		-8.2	
N.C. 33B	3		36.3	
DP 90	4			46.4
N.C. 33B	4			143.3

[1] S/R - Spray Regime: insecticides applied (#)

	Thrips	Fleahopper	Bollworm
Regime 1	none	none	none
Regime 2	none	Vydate (1)	Karate (1) and Larvin (1)
Regime 3	Karate (1)	Karate (1)	Karate (3)
Regime 4	Temik	Karate (1)	Karate (3)

[2] Hand harvested October 26, 1996.

[3] Means followed by same letter do not significantly differ(P=.05,LSD)

Table 3A. Bollworm populations trends prior to and following treatment at Altus and Tipton, Oklahoma; Altus Research Station and Tipton Research Station, Summer 1996.

Location	Number of first and second instar larvae per 100 plants					
	7/18	7/22	8/2[1]	8/9	8/19[1]	8/23
Altus	8	0	15	0	12	2
	7/16[2]	7/23	8/4	8/9		
Tipton	8	0	6	0		

[1] Plots sprayed by ground delivery with 10 gallons of finish spray per acre on 7/19, 8/5 and 8/20;(see Table 3C).

[2] Plots sprayed by ground delivery with 10 gallons of finish spray per acre on 7/18 and 8/4;(see Table 3C).

Table 3B. Comparison of three cotton varieties plant charactistics[1] and yield, Altus and Tipton Research Stations, Summer 1996.

Variety	Treatment[1]	Plant height (inches)[2]	Node fruiting initiated[2]	% Retained
Altus				
		9/10	9/10	9/10
N.C. 33B	1	42.6 a[3]	7.0 a	86.7 a
HS - 26	2	36.9 b	6.0 b	69.7 c
DP 90	3	44.6 ab	6.3 a	72.3 b
		Boll weight (oz.) 9/10		Bolls/acre 9/13
N.C. 33B	1	.41 b		404,666.7 a
HS - 26	2	.68 a		310,000.0 c
DP 90	3	.52 b		348,666.7 b
		Lint (lbs/acre)[4]		
		10/23	Difference in lint 1 vs 2	1 vs 3
N.C. 33B	1	814.2 a		
HS - 26	2	741.8 ab	72.4	
DP 90	3	608.9 b		205.3
Tipton				
Variety	Treatment[1]	Plant height (inches)[2]	Node fruiting initiated[2]	% Retained[2]
		9/10	9/10	9/10
N.C.33B	1	39.6 a[3]	7.6 a	72.5 a
HS - 26	2	36.9 b	6.2 b	61.5 c
H. 1379	3	31.4 ab	6.2 a	536. b
		Boll weight (oz.) 9/10		Bolls/acre 9/13
N.C. 33B	1	.39 b		156,000.0
HS - 26	2	.65 a		120,000.0
H.1379	3	.63 b		106,000.0
		Lint (lbs/acre)[4]		
		10/23	Difference in lint 1 vs 2	1 vs 3
N.C 33B	1	349.4		
HS - 26	2	317.8	31.6	
H 1379	3	281.8		67.8

[1] Treatment = 1 - no bollworm protection and 2 & 3 - protected from boll worms;(see Table3.)

[2] Average of 10 plants.

[3] Means followed by same letter do not significantly differ (p = .05, LSD)

[4] Hand harvested - Altus October 23, 1996 and Tipton October 15, 1996.

Table 3C. Spray history of Altus and Tipton plots including application date, chemical and active ingredient applied; Altus Research Station and Tipton Research Station, Summer 1996.

Date	Chemical	NuCOTN 33B	DP 90	HS-26	Rate (lbs ai/acre)
Altus					
6/27	Vydate	✓	✓	✓	.125
7/19	Karate		(✓)	(✓)	.03
7/19	Pix	✓	✓	✓	4 oz/acre
8/5	Karate		(✓)	(✓)	.03
8/12	Provado	✓	✓	✓	.04
8/20	Karate		(✓)	(✓)	.03
8/20	Provado	✓	✓	✓	.04
9/2	Larvin	✓	✓	✓	.9
10/9	Prep	✓	✓	✓	2 pt/acre
10/9	Ginstar	✓	✓	✓	6 oz/acre
Tipton					
Date	Chemical	NuCOTN 33B	Holland 1379	HS -26	Rate (lbs ai/acre)
6/28	Vydate	✓	✓	✓	.125
7/18	Karate		(✓)	(✓)	.03
8/4	Karate		(✓)	(✓)	.03
8/4	Vydate	✓	✓	✓	.125
8/12	Vydate	✓	✓	✓	.125
9/24	Prep	✓	✓	✓	2 pt/acre
10/15	Ginstar		✓	✓	12 oz/acre

Table 4A. Bollworm population trends on tagged plants NuCOTN 33B and DP 90 cotton under various spray regimes; Altus Research Station, Summer 1996.

Treatment	Number of first and second instar larvae per 100 plants[1]				
	7/18	7/22	8/2	8/5	8/9
DP 90 - sprayed	15	0	15	19	0
DP 90 - check	15	33	31	21	13
N.C.33B - check	18	0	8	7	0
	8/12	8/16	8/19	8/23	8/26
DP 90 - sprayed	2	1	33	3	0
DP 90 - check	5	1	29	47	38
N.C.33B - check	0	0	48	0	0

[1] Plots sprayed by ground delivery with 10 gallons of finish spray per acre on 7/19, 8/5 and 8/20;(see Table 4B).

Table 4B. Spray history of both NuCOTN 33B and DP 90 tagged plant plots including application date, chemical and active ingredient applied; Altus Research Station, Summer 1996.

Date	Chemical	N.C. 33B check	DP 90 check	DP 90 Sprayed	Rate (lbs ai/acre)
6/27	Vydate	✓	✓	✓	.125
7/19	Karate			(✓)	.03
7/19	Pix	✓	✓	✓	4 oz/acre
8/5	Karate			(✓)	.03
8/12	Provado	✓	✓	✓	.04
8/20	Karate			(✓)	.03
8/20	Provado	✓	✓	✓	.04
9/2	Larvin	✓	✓	✓	.9
10/9	Prep	✓	✓	✓	2 pt/acre
10/9	Ginstar	✓	✓	✓	6 oz/acre

Table 4C. Comparison of NuCOTN 33B and DP 90 plant characteristics[1] under various spray regimes; Altus Research Station, Summer 1996.

Variety	Treatment[1]	Plant height (inches)[2] 8/15	Plant height (inches)[2] 9/13	Node fruiting initiated[2] 8/15	Node fruiting initiated[2] 9/13
N.C. 33B Check	1	34.3[3]	43.7	7.3	8.1
DP 90 Sprayed	2	32.5	42.7	6.7	7.6
DP 90 Check	3	34.3	43.5	6.9	7.3

Variety	Treatment[1]	% Retained[2] 8/15	% Retained[2] 9/13
N.C. 33B Check	1	90.4 a	81.9 a
DP 90 Sprayed	2	78.3 a	76.5 a
DP 90 Check	3	40.5 b	41.9 b

Variety	Treatment[1]	Plants /acre 5/30	Boll weight (oz.) 9/13	Bolls/acre 9/13
N.C. 33B Check	1	36,666.7	.41 b	387,000 a
DP 90 Sprayed	2	27,666.7	.47 a	309,666 b
DP 90 Check	3	27,666.7	.46 a	114,000 c

Variety	Treatment[1]	Lint (lbs/acre)[4] 11/5	Difference in lint 1 vs 2	Difference in lint 1 vs 3
N.C. 33B Check	1	688.3 a		
DP 90 Sprayed	2	546.8 b	144.1	
DP 90 Check	3	241.6 c		446.7

[1] Treatment 1 & 3 - no bollworm protection(see Table 4B).
[2] Average of 10 plants.
[3] Means followed by same letter do not significantly differ(P=.05,LSD)
[4] Hand harvested on November 5, 1996.

Table 5A. Comparison of three sampling methods to assess bollworm population trends prior to and following insecticide treatment, Murray Williams" "Gentry", Summer 1996.

Treatment	Number of first and second instar larvae per 100 plants[1] Terminal	Squares	Blooms	Bollworm eggs/100 plants
7/15				
N.C. 33B Check	2	0	na	30
DP 5690 Sprayed	2	0	na	24
7/22				
N.C. 33B Check	0	0	4	6
DP 5690 Sprayed	6	6	4	28
8/2				
N.C. 33B Check	4	4	2	24
DP 5690 Sprayed	6	6	4	28
8/5				
N.C. 33B Check	10	10	0	4
DP 5690 Sprayed	4	8	0	0
8/19				
N.C. 33B Check	8	10	28	68
DP 5690 Sprayed	10	10	24	72
8/23				
N.C.33B Check	2	2	8	30
DP 5690 Sprayed	0	4	2	24

[1] Plots sprayed on 7/19, 8/3 and 8/19; (see Table 5B).

Table 5B. Spray history of both 33B and DP 5690 cotton plots including application date, chemical and active ingredient applied; Murray Williams' "Gentry", Summer 1996.

Date	Chemical	Target Insect	N.C. 33B	DP 5690	Rate (lbs ai/acre)
6/26	Vydate	Boll weevil	✓	✓	.125
7/2	Vydate	Boll weevil	✓	✓	.125
7/19	Baythroid	Bollworm		✓	.033
7/25	Pix		✓	(✓)	6 oz
7/25	Vydate	Boll weevil	✓	✓	.125
8/3	Asana	Bollworm		✓	.0375
8/3	Pix		✓	(✓)	6 oz
8/12	Furadan	Aphid	✓	✓	..25
8/19	Asana	Bollworm		(✓)	.0375
8/26	Furadan	Aphid	✓	✓	..25
9/2	Larvin	Beet armyworm	✓	✓	.8

Table 5C. Comparison of NuCOTN 33 B and DP 5690 cotton plant characteristics[1] ; Murray Williams' "Gentry" , Summer 1996.

Variety	Plant height[1] (inches)		Node fruiting initiated		% Retained	
	8/15	9/13	8/15	9/13	8/15	9/13
N.C. 33B Check	35.6	38.0	8.4	8.4	85.8	76.0
DP 5690 Sprayed	32.9	34.6	7.0	8.6	76.4	57.7

Variety	Boll weight (oz.)	Boll/acre	Lint (lbs/acre)[2]	
	9/13	9/13	10/19	Difference in lint
N.C. 33B Check	.64	409,500	825.0	
DP 5690 Sprayed	.68	385,500	675.0	150.0

[1] Average of 10 plants.
[2] Hand harvested on October 19, 1996.

Table 6A. Comparison of three sampling methods to assess bollworm population trends prior to and following insecticide treatment (unsprayed NuCOTN 33B), Danny Robbins" "Rogers", Summer 1996.

	Number of first and second instar larvae per 100 plants[1]			Bollworm eggs/100 plants
	Terminal	Squares	Blooms	
	7/29			
N.C. 33B	2	0	4	36
	8/5			
N.C. 33B	0	4	4	12
	8/26			
N.C. 33B	4	0	8	8
	9/3			
N.C. 33B-	4	0	8	8

[1] Plots sprayed on 7/30 and 8/29;(see Table 6B).

Table 6B. Spray history of NuCOTN 33B (sprayed and unsprayed) including application date, chemical and active ingredient applied; Danny Robbins' "Rogers", Summer 1996.

Date	Chemical	Target Insect	Check	Sprayed	Rate (lbs ai/acre)
6/22	Vydate	Boll	✓	✓	.125
7/4	Vydate	Boll	✓	✓	.125
7/27	Pix		✓	✓	8 oz/acre
7/30	Fury	Bollworm		(✓)	.04
8/9	Furadan	Aphid	✓	✓	.25
8/9	Pix		✓	✓	6 oz/acre
8/29	Fury	Bollworm		(✓)	.04
8/29	Furadan	Aphid	✓	✓	.25
9/3	Malathion	Boll weevil	✓	✓	.50

Table 6C. Comparison of NuCOTN 33B under different spray regimes plant characteristics[1] ; Danny Robbins' "Rogers", Summer 1996.

Treatment	Plant height (inches)	Node fruiting initiated	% Retained
	9/17	9/17	9/17
Check	35.6	8.1	65.7
Sprayed	31.5	7.5	65.3

Treatment	Bolls/acre	Lint (lbs/acre)	
	9/20	10/22	Difference in lint
Check	482,000	896.3	
Sprayed	407,000	874.5	21.8

[1] Average of 10 plants.
[2] Hand harvested on October 22,1996.