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Production and Marketing Characteristics of Adopters and Nonadopters of Transgenic Cotton Varieties in California

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This paper analyzes the characteristics of early adopters of transgenic cotton varieties in California and explains the factors driving such early adoption. The research was conducted through the use of a mail survey that was distributed to all California cotton growers during December 2000 and January 2001. A response rate of 16% of the 1,300 cotton growers generated a sample size of 206 California cotton growers.

Key words: cotton, transgenic, adoption, biotechnology, USA, California.

Introduction

The United States (US) is second to China in the production of cotton in the world market. China and the US are followed by India, Pakistan, and Uzbekistan in the world production of cotton. Seventeen states produce cotton within the US. California generates 13% of US cotton production. Cotton is California's largest planted crop, with one million acres in production and 20 million pounds of cottonseed planted annually. The objective of this research is to compare production and marketing characteristics of early adopters and nonadopters of transgenic cotton varieties in California. This research was conducted through the use of a mail survey distributed to all California cotton growers during December 2000 and January 2001. A response rate of 16% of the 1,300 cotton growers generated a sample size of 206 California cotton growers.

Table 1. Adoption levels of transgenic cotton in 2000.

Type of Cotton	Growers Planted	Transgenic Acreage as Percent of Total
Adopted Transgenic	57%	44%
All Nontransgenic	43%	0%
N	200	200

Table 2. Proportion of cotton acreage by variety.

	Adopters	Nonadopters	*t*
This Season			
Pima	7.34%	5.23%	.96
Acala	62.76%	81.38%	-3.69**
Upland	29.89%	13.39%	3.37*
Next Season			
Pima	12.59%	8.06%	1.55
Acala	63.00%	76.45%	-2.61**
Upland	23.71%	15.31%	1.73*
N	114	86	

***Significant difference at the .05 level. *Significant difference at the .10 level.*

Transgenic Cotton Planted and Planned

The results of this research indicate that 57% of growers planted transgenic cotton in 2000. On average, 44% of the total acreage of adopters of transgenic varieties was devoted to such varieties (Table 1).

There are three varieties of cotton that are planted in California. Upland variety cotton is used for basic clothing products, such as jeans or sweatshirts. Acala is a specific variety of Upland that must be approved and is grown in the San Joaquin Valley in California. Pima variety is premium cotton that is used to make expensive clothing, sheets, and so forth.

The most planted variety among respondents was the Acala variety. However, adopters of transgenic varieties had a lower proportion of acreage planted with Acala and a higher proportion planted with Upland. A similar relationship holds for the expected plantings for next season (Table 2).

Plantings of transgenic varieties were expected to increase in the following year. The mean proportion of acreage planted among last year's adopters would increase from 44% to 48%. Further, there was a planned increase in planting of transgenic varieties (from 0% to 17%) by those that did not plant it in the previous year (Table 3).

Less than 5% of the early adopters intended to disadopt. The early adopters that planned to continue use of transgenic varieties indicated intentions to increase the

Table 3. Planting intentions for transgenic varieties in 2001.

	Adopters	Nonadopters	*t*
Percent of Acreage in Transgenic Varieties Last Year	43.96%	0%	13.44**
Percent of Acreage in Transgenic Varieties Next Year	47.84%	16.57%	6.59**
N	114	86	

*** Significant difference at the .05 level.*

Table 4. Proportion of transgenic acreage based on adoption of transgenic varieties last year.

	Transgenic Last Year and Next Year	Will Not Plant Transgenic Next Year	Independent *t*
Percentage Last Year	37.46%	4.78%	8.58**
Percentage Next Year	53.94%	0%	18.47**
N	124	71	

*** Significant difference at the .05 level.*

proportion of their total acres devoted to transgenic varieties from 37% to 54% (Table 4).

Transgenic Acreage, Tech Fee, Profit, and Production Costs

The increase in the anticipated acreage of transgenic varieties is likely the result of the growers' recovering increased expenses (e.g., technology for transgenic varieties) and their expectations that transgenic varieties generate more profit per acre. When increased expenses are recovered, the propensity to continue or increase adoption increases as well. On average, 80.9% of all early adopters recovered the tech fee. The proportion of early adopters who planned continuing adoption, however, was 88%.

Similarly, when early adopters expect increased profitability from transgenic varieties, their propensity to continue or increase adoption also increases. On average, 76% of early adopters indicated that they believe transgenic varieties to be more profitable than nontransgenic varieties; 48% of nonadopters also had similar expectations (Table 5). As this expectation increases, so does the propensity to continue adoption. 87.6% of early adopters who believed transgenic varieties to be more profitable planned to continue using transgenic varieties in the next year.

On the other hand, poor performance of the new transgenic varieties in the field discouraged continuing adoption. Only 13% of growers that did not plan to use transgenic varieties next year were early adopters of transgenic varieties. Most of these growers (64.3%) did not recover their tech fee. Furthermore, a majority of growers that did not plan to repeat planting with transgenic varieties (92.9%) did not experience higher profit per acre from their transgenic varieties (Table 6).

Where does increased profitability from transgenic varieties come from? Users of transgenic cotton varieties have indicated experiencing lower fuel and labor costs per acre (Table 7). Given typical reductions in the number of sprays for pests expected in the case of transgenic varieties, lower fuel and labor costs are reasonable.

Table 5. Transgenic varieties generate more profit per acre than nontransgenic varieties.

	Adopters	Nonadopters	χ^2
Transgenic Varieties Generate More Profit Per Acre Than Nontransgenic	76.0%	48.1%	12.335**
N	104	54	

*** Significant difference at the .05 level.*

Table 6. Transgenic varieties last year compared to next year.

	Will Plant Transgenic Next Year	Will Not Plant Transgenic Next Year	χ^2
Planted Transgenic Last Year	87.5%	12.5%	64.97**
Did Not Plant Transgenic Last Year	31.3%	68.7%	
N	112	83	

*** Significant difference at the .05 level.*

Table 7. Production costs where significant differences exist among adopters and nonadopters.

	Adopters	Nonadopters	*t*
Fuel Cost/Acre	$38.56 (N=58)	$52.17 (N=41)	-1.998*
Labor Cost/Acre	$81.22 (N=64)	$104.71 (N=45)	-2.54**

*** Significant difference at the .05 level. *Significant difference at the .10 level.*

Cottonseed Purchasing Behavior

California cotton growers were most likely to purchase their seed from ginners or seed distributors. However, early adopters of transgenic varieties were more likely to purchase seed from a chemical distributor. Indeed, almost half of respondents who used transgenic cotton had bought their seed from a chemical supplier. In contrast, only 16% of nonadopters had purchased their seed from such distributors (Table 8).

The primary source of technical information about seed is seed companies. However, the transgenic users were also very likely to use a pest control advisor (PCA) for technical information about seed. Furthermore, 22% of early adopters got their technical information from

Table 8. Types of seed supplier.

	Adopters	Nonadopters	χ^2
Ginners	67.5%	64.0%	.282
Chemical Supplier	46.5%	16.3%	20.085**
Seed Distributor	43.0%	34.9%	1.345
Seed Producer	11.4%	10.5%	.044
All-service Farm Supply	6.1%	4.7%	.209
Other	2.6%	1.2%	.540
N	114	86	

*** Significant difference at the .05 level.*

Table 9. Sources of technical information about cottonseed.

	Adopters	Nonadopters	χ^2
Seed Producer	71.1%	60.5%	2.467
PCA	64%	45.3%	6.947**
Farm Advisor	51.3%	44.2%	.997
Another Grower	49.1%	53.5%	.374
UC-Davis IPM Website	21.9%	11.6%	3.603*
Other	20.2%	29.4%	2.270
N	114	86	

*** Significant difference at the .05 level. *Significant difference at the .10 level.*

Table 10. Purchase seed from more than one seed supplier.

	Adopters	Nonadopters	χ^2
Yes	49.1%	17.6%	
No	50.9%	82.4%	21.021**
N	114	85	

*** Significant difference at the .05 level.*

the University of California-Davis integrated pest management (IPM) website, while only 11.6% of nonadopters received information from the same source (Table 9).

63% of growers surveyed indicated that they purchased from only one supplier. However, a comparison of early adopters and nonadopters of transgenic varieties shows that adopters were less likely to use only one supplier. Only half of early adopters purchased from one supplier, while 82.4% of nonadopters purchased seed from only a single supplier of seed (Table 10).

Therefore, it is not surprising that nonadopters believed that finding a "single" supplier is an important consideration in their seed purchasing decision. However, the most important factors to both groups when evaluating a seed supplier were product availability and product delivery, followed by technical support and communication. Nonadopters indicated that marketing and internet support are more important when evaluating a seed supplier than did early adopters of transgenic varieties (Table 11).

Table 11. Factors used when evaluating a seed supplier.

	Adopters	Nonadopters	χ^2
Product Availability	76.1%	73.3%	.211
Product Delivery	71.9%	69.8%	.111
Technical Support	58.8%	47.7%	2.430
Communication	47.4%	43.0%	.373
Informational Grower Meetings	39.5%	48.8%	1.749
Sales People	35.4%	25.6%	2.194
One Source Supplier	23.7%	34.9%	3.017*
Marketing Support	11.4%	21.2%	3.536*
Internet Support (crop information)	3.5%	14.0%	7.266**
N	114	86	

*** Significant difference at the .05 level. *Significant difference at the .10 level.*

Table 12. Factors influencing decision on variety to plant.

	Adopters	Nonadopters	χ^2
Competitive Trial Results	91.2%	82.6%	3.369*
Neighbors	65.8%	61.6%	.368
Industry Field Days	57.0%	46.5%	2.170
Farm Advisor	55.3%	47.7%	1.131
Farm Publications	38.9%	27.9%	2.642
Distributor	28.1%	34.9%	1.064
Seed Breeders	26.5%	26.7%	.001
Seed Salesman	22.1%	20.9%	.041
Trade Journals	21.1%	19.8%	.050
Other	18.4%	23.3%	.703
N	114	86	

**Significant difference at the .10 level.*

The most important factor in the decision on variety to plant for both groups was yield trial results. However, 91.2% of early adopters relied on the results of competitive field trials when deciding which variety to plant—significantly more than nonadopters. This is a reasonable result, as growers are attempting to evaluate the performance of the new transgenic varieties. The next most important factors in the decision on variety to plant for both groups were neighbors, industrial field days, and the farm advisor (Table 12).

Both transgenic users and nonusers used pay net 30 days and no pay until harvest plans for their seed. Fur-

Table 13. Current payment programs for cottonseed purchases.

	Adopters	Nonadopters	χ^2
Pay Upon Delivery	1.8%	5.9%	4.814
Pay Net 30 Days	36.8%	44.7%	
Pay Net 60 Days	14.0%	9.4%	
Pay Net 90 Days	14.9%	11.8%	
No Pay Until Harvest	27.2%	22.4%	
Other	5.3%	5.9%	
N	114	85	

Table 14. Payment programs liked to see from a seed supplier.

	Adopters	Nonadopters	χ^2
Pay Upon Delivery	1.8%	1.3%	7.090
Pay Net 30 Days	10.9%	16.7%	
Pay Net 60 Days	6.4%	9.0%	
Pay Net 90 Days	11.8%	21.8%	
No Pay Until Harvest	61.8%	47.4%	
Other	7.3%	3.8%	
N	110	78	

Table 15. Importance of seed return policies in purchasing decision.

	Adopters	Nonadopters	χ^2
1 (very important)	51.8%	43.5%	3.146
2	26.8%	24.7%	
3	12.5%	20.0%	
4	7.1%	8.2%	
5 (not at all important)	1.8%	3.5%	
N	112	85	

ther, both groups preferred the no pay until harvest plan (Tables 13 & 14).

Both groups agreed that return policies are very or extremely important in the purchase decision for seed. As expected, it is somewhat more important for early adopters, since they are confronted with increased uncertainty about the performance of the new varieties (Table 15).

Both groups of respondents agreed that if specific varieties are in short supply they should be allotted by past business relationships and historical purchases (Table 16).

Newsletters and field days were the most preferred methods for presenting results of competitive trials to both groups. However, 64% of early adopters felt that results from competitive trials should be made accessible online to the growers for the most benefit (Table 17). Again, such response is reasonable, as early adopters attempt to find alternative strategies to mitigate risk and uncertainty on the performance of the new varieties.

Table 16. Allocations of specific varieties in short supply.

	Adopters	Nonadopters	χ^2
Allotted by Past Business Relationship and Historical Purchases	47.7%	51.9%	.596
Allotted by Equal Percentage to Each Grower	40.5%	39.5%	
Allotted by Volume of Current Purchase	11.7%	8.6%	
N	111	81	

Table 17. How results from competitive trials should be presented to growers for the most benefit.

	Adopters	Nonadopters	χ^2
Newsletter Mailings	88.6%	87.2%	.089
Field Day	69.3%	77.9%	2.358
Accessible Online	64.0%	44.2%	7.820**
Trade Journal	48.2%	52.3%	.326
Other	3.5%	7.1%	1.286
N	114	86	

*** Significant difference at the .05 level.*

Table 18. Bed spacing.

	Adopters	Nonadopters	χ^2
30 Inches	28.6%	16.3%	4.541
38 Inches	50.9%	59.3%	
40 Inches	16.1%	20.9%	
Other	4.5%	3.5%	
N	112	86	

Growing and Business Practices

The growing practices of the early adopters and nonadopters were similar with respect to bed spacing and plant populations per acre. Approximately one half of both transgenic respondents and nontransgenic respondents used 38 inches for bed spacing (Table 18). In addition, most growers used plant populations of 40,000 to 54,999 plants per acre (Table 19).

Record keeping was the leading use of computers among all growers surveyed. However, early adopters of transgenic varieties were more advanced computer users than nonadopters. They indicated that computers are used in their businesses for financial records, research, marketing/futures markets, inter-company communication (email), and internet sales at higher levels than those of nonadopters (Table 20).

Table 19. Plant populations used per acre.

	Adopters	Nonadopters	χ^2
30,000-34,999	3.6%	7.3%	1.955
35,000-39,999	9.1%	8.5%	
40,000-44,999	27.3%	29.3%	
45,000-49,999	27.3%	23.2%	
50,000-54,999	20.0%	17.1%	
55,000 and Greater	12.7%	14.6%	
N	110	82	

Table 20. Amount business is aided through use of computers.

	Adopters	Nonadopters	χ^2
Record Keeping	77.9%	68.7%	2.105
Financial Records	73.7%	59.0%	4.699**
Research	43.0%	26.5%	5.656**
Marketing/Futures Markets	36.8%	24.1%	3.618*
Inter-company Communication (email)	24.6%	14.5%	3.030*
Business-to-business Communication	21.9%	13.3%	2.421
Internet Sales (any type of product)	10.5%	2.4%	4.793**
N	114	83	

***Significant difference at the .05 level. *Significant difference at the .10 level.*

Growers of transgenic varieties were more likely to be in Tulare and King Counties and less likely to be in Fresno, Merced, and Madera Counties (Table 21).

Summary and Conclusions

The results of this research indicate that 57% of California growers planted transgenic cotton in 2000. Most respondents that planted transgenic varieties in the previous year indicated that they would plant transgenic cotton the following year. Almost a third of nonadopters indicated that they expected to begin adoption the following year. The mean proportion of cotton acreage planned for the following year among early adopters increased significantly from 37% to 54% of total acreage. This increase in acreage planted in transgenic varieties is attributed to increased profitability. Not all early adopters experienced increased profits, however. 12.5% of early adopters did not plan to plant transgenic varieties next year. Over 90% of those who planned to discontinue adoption indicated that they did not consider transgenic varieties more profitable than nontransgenic varieties.

Table 21. County/counties cotton farmed.

	Adopters	Nonadopters	χ^2
Fresno	23.2%	29.4%	14.616*
Tulare	22.3%	18.8%	
Kern	18.8%	18.8%	
King	14.3%	5.9%	
Merced	7.1%	14.1%	
Riverside	4.5%	—	
Madera	4.5%	10.6%	
Imperial	3.6%	2.4%	
Glen	1.8%	—	
N	112	85	

**Significant difference at the .10 level.*

Early adopters experienced a lower cost of fuel per acre and a lower labor cost per acre than nonadopters, pointing to some potential sources of efficiencies from transgenic varieties.

Uncertain performance of new varieties is a key source of risk in the early stages of market introduction. Accordingly, sources of information and other strategies that mitigate such risk seem to be important to early adopters. Respondents indicated that seed producers and PCAs were their top two sources for technical information about seed, while the UC-Davis IPM website was the least-used source for technical information about seed. However, PCAs and the IPM website were more likely to be used by early adopters. Most respondents indicated that newsletter mailings and field days should be used to present results from competitive trials. However, early adopters were more likely to indicate that internet access to competitive trials was important.

Early adopters were more likely to indicate that their businesses were aided through the use of computers. Computers were more likely to aid their businesses in the following ways: financial records, inter-company communication through email, internet sales, marketing and futures markets, and research. This result suggests that early adopters might be more progressive growers.

Overall, the results suggest that economics drive adoption of cotton transgenic varieties in California. This research indicates that the use of transgenic varieties of cotton in California is expected to increase among current users and new users. The increase in adoption of transgenic cotton varieties is related to a higher level of profit per acre. Adopters of transgenic varieties are more likely to use computers and the internet in their business activities. Further, competitive trial results are important

to them in their decision of which variety to plant. However, due to the decrease in the price of cotton and the decline in planting since this survey was administered, additional research is needed to examine the impact of transgenics in this changed market environment.

When this research was conducted (December, 2000) the price of cotton was approximately $64 and has since plummeted to approximately $35 (National Cotton Council of America, 2002). The price of cotton in 2002 is currently at a 20- to 30-year low. This price reduction, which can be attributed to an increase in world supply, is leading to an overall decrease in the quantity of cotton planned in the US. According to the US Department of Agriculture, there will be a 17.8% reduction in the quantity planted in the US from 2002 to 2003 (United States Department of Agriculture Economic Research Service, 2002). It is expected, however, that adoption of transgenic varieties might be accelerated by the more difficult economic conditions confronted by California cotton growers. Due to the change in the world supply and price of cotton, additional research will be needed to examine the impact of the cotton price decline on the adoption of transgenic seed varieties.

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