References

Anon. 2003. BIO-EARN. Biotechnology for development. A presentation of the East African Regional Program and Research Network for Biotechnology, Biosafety and Biotechnology Policy Development. Stockholm Environment Institute – SIDA.

Anon. 2000. UNEP/GEF Pilot Biosafety Enabling Activity Project. *Uganda Biosafety Framework,* Uganda National Council for Science and Technology (UNCST).

Atikins, W. S. 2003. Uganda Review of the Proposed Biotechnology Policy and the Implications of this Policy to the Plan for Modernization of Agriculture.

Cartagena Protocol on Biosafety, Status of ratification and entry into force, 2004.

ICAC 2004a. *Report of the Second Expert Panel on Biotechnology of Cotton*. International Cotton Advisory committee, November 2004.

ICAC 2004b. Update on Genetically Engineered Cotton. *The ICAC Recorder*, Vol. XXII, No. 2, June 2004.

ICAC 2002a. *The ICAC Recorder*, Vol. XX, No.3, September 2002.

ICAC 2002b Commonly asked questions about transgenic cotton. *The ICAC Recorder*, Vol. XX, No.2, June 2002.

ICAC 2000. Report of the Expert Panel on Biotechnology in Cotton. International Cotton Advisory committee. November 2000.

ICAC 1999. *The ICAC Recorder*, Vol. XVII, No. 2, March 1999.

Erbisch, F. H. and K. M. Maredia. 2003. Intellectual Property Rights in Agricultural Biotechnology. 2nd Edn. *Biotechnology in Agricultural,* Series No. 28, CABI Publishing ISBN 0-85199-739-2.

Organization of African Unity (OAU 2001). The OAU Draft Model Legislation on Safety in Biotechnology.

Perlak, F. J., R. W. Deaton, T. A. Armstrong, R. L. Fuchs, S. R. Sims, J. T. Greenplate, and D. A. Fischaff, 1990. Insect resistant cotton plants, *Biotechnology*, 8 939 – 943.

Russel, D. 2004. Facilitating Adoption of best agronomic practices by small holders. ICAC 63rd Plenary meeting, Fifth open session, December 2004, Mumbai, India.

Shen, J. L., W. J. Zhen, Y. D. Wu, X. W. Lin, D. F. Zhu, W. J. Zhar, Y. D. Win, and X. F. Zhu. 1998. Early resistance of *Helicoverpa armigera* to Bt and its relation to the effect of transgenic cotton, Acta Entomologica sinica 41, 8– 14.

United Nations. 1992. The United Nations Convention on Biological Diversity (CBD).

Nine Years of Transgenic Cotton in Mexico

Jose L. Martinez-Carrillo, National Institute for Forestry, Agriculture and Livestock Research (INIFAP), Mexico

Introduction

The use of transgenic crops continues to grow worldwide and it is estimated that 67.7 million hectares were planted to biotech varieties in 2004 by an estimated seven million farmers in 18 countries. Almost one-third of the area planted to transgenic crops was located in developing countries. It is also estimated that in the next five years, 10 million growers in 25 countries will grow 100 million hectares of transgenic crops (James, 2003). Mexico has adopted this new technology, and since its release in 1996, Bt cotton has been used by farmers interested in obtaining better yields with reductions in pesticide use and production costs. Nine years after commercial release, biotech cotton reached 61% of 107,346 hectares planted in Mexico in 2004/05. In some states more than 70% of the area was planted to transgenic cotton.

Cotton production in Mexico has been influenced by international cotton prices, drought and high production costs. These factors cause cotton area to fluctuate. In 1993, only 42,539 hectares were planted to cotton, mainly due to whitefly outbreaks observed in the early 1990's (Martinez-Carrillo, 1994). In 1994, 175,375 hectares were planted to cotton, and area reached a peak of 314,776 hectares in 1996. This was mainly due to an increase in prices that reached US$2.04 per kg of lint in 1994. After 1994, cotton area and production in Mexico decreased. By 2001/02 only 40,483 hectares were planted to cotton, a record low. Higher prices in 2003, and better government support stimulated cotton area to 62,892 hectares and the area grew to 107,346 hectares in 2004/05. Good yields and better pest control have motivated growers, and another increase in area is expected for 2005/06.

The main cotton producing states are Chihuahua, Sonora, Baja California, Coahuila, Durango and Tamaulipas in northern Mexico. Cotton is irrigated in all these areas. In 2003/04, Chihuahua planted 49% of the area in Mexico, Sonora, 18%, Baja California 17% and Comarca Lagunera, (a region that includes the states of Coahuila and Durango) 15% (Table 3).

Main Insect Pests

The key insect pests differ in each region. In Chihuahua, pink bollworm, stink bugs, whiteflies, bollworm and tobacco budworm are important pests in the northern part of the state, while boll weevil is the key pest in the rest of the state. In

Table 1. Transgenic Cotton in Mexico

Year	Total Cotton Area* (ha)	Bollgard Cotton** (ha)	BG/SF *** (ha)	% Transgenic Area
1996	314,776	897		0.3
1997	214,378	16,677		7.8
1998	249,602	35,630		14.3
1999	149,299	18,653	25	12.5
2000	80,166	26,300	461	33.4
2001	91,899	23,393	1,819	27.4
2002	40,483	13,960	1,235	37.5
2003	62,892	23,897	2,161	41.4
2004	107,346	47,679	17,327	60.6

* Source: Sagarpa (SIACON) ** Source: Monsanto Commercial S. A, de C.V.

*** Bollgard plus Roundup Ready (known in Mexico as Bollgard Solucion Faena)

2001, a program was initiated to suppress pink bollworm and boll weevil at the state level. This program was started in cooperation with the US Department of Agriculture (USDA). Results are encouraging and sprays for the control of key insect pests have been reduced considerably.

Sonora State has two main cotton producing areas that present different characteristics, the north region, composed of Caborca and Sonoyta, produced cotton with well irrigation, and the area is arid and semiarid. The key insect pests are lygus bugs and whiteflies. The pink bollworm, cotton bollworm and tobacco budworm have been reduced with increased use of Bt cotton. In south Sonora, the climate is semiarid, and cotton is irrigated by water obtained from wells. The key pest is the boll weevil (Anthonomus grandis), followed by a complex of sucking insects such as lygus bugs, cotton fleahopper *Pseudatomoscelis seriatus*, and whitefly *Bemisia argentifolii*. The bollworm and budworm complex, *Helicoverpa zea* and *Heliothis virescens*, are also a problem during fruit formation.

The Mexicali Valley is located in the state of Baja California where pink bollworm *Pectinophora gossypiella*, lygus bugs *Lygus hesperus*, *L. lineolaris* and *L. elisus*, silverleaf whitefly *Bemisia argentifolii*, *Helicoverpa zea* and *Heliothis virescens* are the main pests.

The Comarca Lagunera region integrates parts of the states of Coahuila and Durango. This region used to have a serious problem with pink bollworm, and farmers sprayed up to seven times against this pest. The use of Bt cotton has drastically reduced pink bollworm and other insect pests such as tobacco budworm. Now, the main problems are sucking insects like stink bugs *Chlorochroa ligata* and *Nezara viridula*, whiteflies, aphids and cotton bollworm. However, spraying has been reduced to only two applications per season (Sánchez, 2000; Nava *et al*., 2002).

Cotton is irrigated in the north part of the state of Tamaulipas, whereas in the south part it is rain feed. The key pest is boll weevil, which is sprayed 5 times in the north and 15 times in the south Tamaulipas. Other entomological problems include cotton bollworm, tobacco budworm, beet armyworm, whiteflies and fleahoppers, for which growers spray two or three times during the cotton season.

Transgenic Cotton in Mexico

Bollgard (BG) cotton which contains the Cry 1Ac toxin of Bacillus thuringiensis kurstaki has been used in Mexico since 1996 when 897 hectares were planted in south Tamaulipas. Adoption of Bt varieties has increased because of higher yields, better pest control and a reduction in insecticide applications (Sanchez, 2000; Nava *et al*., 2002). In 1997, 8% of total cotton area was transgenic, 14% in 1998, 13% in 1999, 33% in 2000, 27% in 2001, 38% in 2002, 41% in 2003 and 61% in 2004 (Table 1). A new material that contains the BG traits and a gene that provides resistance to the herbicide glyphosate was introduced in 1999. In Mexico, this product is known as Bollgard "solución Faena" (BG/SF). The area under the stocked gene varieties increased from 25 hectares in 1999 to 17,327 hectares in 2004.

Chihuahua had the most area planted to transgenic cotton in 2003/04, 37,828 hectares of which 11,574 were BG/SF. Comarca Lagunera grew 11,760 hectares of transgenic cotton, 9,898 were BG and 1,862 were BG/SF. Sonora had 11,067 hectares, 8,098 were BG and 2,969 BG/SF. Tamaulipas did not plant transgenic cotton, and only 7 hectares were planted in Sinaloa as an experiment. Chihuahua planted 72% of its area with transgenic cotton, Comarca Lagunera 76%, South Sonora 75, North Sonora 21% and Baja California 25% in 2004/05 (Table 3). Because of the restrictions imposed by the resistance management strategy in Mexico, a maximum of 80% of the area will be planted with transgenic cotton.

Table 2. Adoption of Bollgard and BG/SF Cotton by Region in Mexico in 2003/04

REGION	Bollgard	BG/SF	TOTAL
Baja California	3,429	915	4,344
Sonora North	868	361	1,229
Sonora South	7,230	2,608	9,838
Sinaloa	0	7	7
Chihuahua	26,254	11,574	37,828
Comarca Lagunera	9,898	1,862	11,760
Total	**47,679**	**17,327**	**65,006**

After nine years of transgenic cotton in Mexico, these materials have been accepted and are now required by growers to control insects, especially pink bollworm and the complex of cotton bollworms and tobacco budworm. Boll weevil and a complex of sucking pests such as lygus bugs,

Table 3. Transgenic Cotton Area by Region in Mexico in 2003/04

REGION	Cotton Area (ha)	Percent of Total Area	% Transgenic Area
Tamaulipas	2,043	1.9	0.0
Baja California	17,697	16.5	24.6
Sonora North	5,921	5.5	20.8
Sonora South	13,204	12.3	74.5
Sinaloa	294	0.3	2.0
Chihuahua	52,645	49.0	71.9
Comarca Lagunera	15,542	14.5	75.7

stink bugs, whiteflies and others are still a serious problem. However, in some states as Chihuahua and Sonora an eradication program has been established for boll weevil and pink bollworm that includes transgenic cotton, pheromones, traps and sprays. This program is expected to reduce insect problems in cotton and thus limit production costs. The xxx that cotton will become again an important crop in Mexico again.

Conclusions

The adoption of transgenic crops continues to grow worldwide. Transgenic technology has been accepted in Mexico, and biotech cotton area increased from 0.3% in 1996 to 61% in 2004/05. Since 1999, a new variety has been introduced that contains the Cry 1Ac toxin of *Bacillus thuringiensis*, and *kurstaki*, a gene that codifies for resistance to the herbicide glyphosate. Higher prices and better government support stimulated growers to produce more than 100,000 hectares of cotton in 2004/05. Good yields and better pest control has motivated growers. Consequently, an increase in area, including transgenic cotton, is expected in 2005/06.

References

James, C. 2003. Preview: *Global Status of Commercialized Transgenic Crops*: 2003. ISAAA, Briefs No. 30, ISAAA: Itaca, NY.

Martínez Carrillo, J. L. 1994. Problemática fitosanitaria causada por la mosquita blanca en méxico. In: *Memoria de la Segunda asamblea anual del CONACOFI*, 14-15 de noviembre, pp. 77-88, Montecillo, Edo de México.

Nava, Camberos U., E. Valenzuela Herrera y E. López Ríos. 2002. Efectividad del algodonero transgénico para el manejo integrado del gusano rosado en la Comarca Lagunera. *Entomología Mexicana* ,Vol. 1, 356-361, México.

Sánchez, A. J. 2000. Situación actual de la campaña contra las plagas del algodonero en la Región Lagunera. In: *Memorias de la 7ª. Reunión Anual del CONACOFI*, 24-25 de octubre, Puebla, Pue. pp. 146-147.