positive transgression for fiber length was observed in F_3, and starting F_4 was stabilized in both 4 species and 5 species hybrids.

12th Meeting of the Southern and Eastern African Cotton Forum

The 12th Meeting of the Southern and Eastern African Cotton Forum (SEACF) will be held in Maputo, Mozambique, from June 17-19, 2014. The Instituto de Algodão de Moçambique (IAM) is the primary host of the meeting. Draft program and registration are available at https://www.icac.org/tech/Regional-Networks/Southern-and-Eastern-African-Cotton-Forum. For additional information contact Dr. Graham Thompson, GThompson@arc.agric.za or Mr. Lawrence Malinga LawrenceM@arc.agric.z.

6th Meeting of the Asian Cotton Research and Development Network

The Ministry of Agriculture of the Government of Bangladesh will host the 6th Meeting of the Asian Cotton Research and Development Network. The meeting will be held in Dhaka, Bangladesh, from June 18-20, 2014. The Cotton Development Board of the Ministry of Agriculture will organize the meeting in collaboration with the Technical Information Section of the ICAC. The meeting is open to all researchers and countries including from the private sector. Last date for registration is April 15, 2014. More information is available at https://www.icac.org/tech/Regional-Networks/Asian-Cotton-Research-and-Development-Network. For additional information contact ICAC at Rafiq@icac.org.

Third Generation Insect Resistant Biotech Cotton

Based on almost two decades of experience since its commercialization, biotech cotton in the form of insect-resistant cotton may rightly be called a success story. Thanks to the resistance management strategies adopted in most biotech cotton-producing countries, development of resistance to *Bacillus thuringiensis* toxins has been avoided or at least greatly delayed. No seriously alarming situation has emerged in any country, although claims of the development of resistance cannot be dismissed outright. Many reports have appeared on the alleged development of resistance by the target lepidopteron larvae, but none of them has led to any sort of panic among biotech cotton producers. Conversely, in the same time frame, resistance to insecticides had already affected cotton yields and distressed researchers and farmers. Many countries, irrespective of the pest pressure affecting them, had to deal with the consequences of development of resistance to insecticides. Many of them resorted to higher doses and more frequent applications, a choice that inadvertently further aggravated the problem. The number of sprays against the target bollworms doubled and even exceeded these amounts in places such as Australia, China, India, Pakistan and many West African countries. The pesticide industry also joined the struggle and came up with resistance management strategies. The strategy measures they proposed required wide-scale adoption of a number of recommendations, irrespective of farming practices. Expert recommendations, in particular spray protocols, were followed in almost every affected country, including West African countries that usually have similar spray regimes across countries. The pesticide industry developed new chemicals and the resistance problem was successfully overcome.

In 1996, when insect-resistant biotech cotton became available for commercial use, the resistance problem was at its peak around the world and most affected countries were devising or implementing programs to deal with the problem of insecticide resistance. Stagnation in yields, the need to deal with the insecticide resistance problem and the ever-increasing cost of insecticides raised great hopes in the new technology in the form of insect-resistant biotech cotton, which was hailed as a single solution to all three problems mentioned above. The consequences of using more and more insecticides, the high cost of these products and the growing awareness of environmental concerns further highlighted the need to give biotech cotton a chance. The Cry1Ac toxin contained singly in Bollgard® cotton proved very effective against insects that had either developed resistance to insecticides or were considered to be the most dangerous pests in a given country. But the cotton industry needed dual-gene action and it was delivered at just the right time. Bollgard® II, which contained the Cry2Ab gene stacked onto the Cry1Ac, further extended the life of insect-resistant biotech cotton. Bollgard® II was commercialized in Australia and the USA in 2003/04, only seven years after the rollout of the first Bollgard® (Ingard in Australia). The cotton industry was expecting similar additions of new genes and, more specifically, genes with different modes of action. But so far, no new insect-resistant gene has been identified that is as effective as Cry1Ac and has a different mode of action. Bollgard® III and WideStrike™ 3, with three stacked insect resistance genes, are expected to be released for commercial use in 2 to 3 years.

Bollgard® III

One of the major benefits of the insect resistant biotech trait is the elimination or minimization of vulnerability to fluctuating levels of bollworm populations. Without biotech genes, higher populations of target pests require more stringent control measures in the form of higher doses of insecticides or shorter intervals between sprays, if insects are to be effectively

Adoption of Insect Resistant Biotech Cotton

Biotech Cotton	Year of Commercial Release
Bollgard® (Cry1Ac)	Argentina (1998/99), Australia (1996/97), Brazil (2005/06), Burkina Faso (2008/09), China (1997/98), Colombia (2004/05), India (2002/03), Indonesia (2002/03), Mexico (1996/97), Myanmar (2010/11), Pakistan (2010/11), Paraguay (2012/13), Sudan (2012/13), South Africa (1998/99), USA (1996/97)
Bollgard® II (Cry1Ac+Cry2Ab)	Australia (2003/04), Brazil (2009/10), Colombia (2007/08), Costa Rica (2009/10), India (2006/07), Mexico (2003/04), South Africa (2006/07), USA (2003/04)
WideStrike™ (Cry1Ac+Cry1F)	Australia (2009/10), Brazil (2009/10), Costa Rica (2009/10), Mexico (2004/05), USA (2005/06)
Guakong (Cry1Ac+Cry1Ab)	China (1997/98), India (2006/07)
Event 1 (Cry1Ac, modified)	India (2006/07)
Cowpea crypsin (CpTi +Cry1Ac)	China (2002/03)
TwinLink® (Cry1Ab+Cry 2Ae)	USA (2010/11)
Bollgard® III (Cry1Ac+Cry2Ab+Vip3A)	Expected in Australia (2014/15) expected in the USA (2014/15)
WideStrike™ (Cry1Ac+Cry1F+Vip3A)	Expected in Australia (2014/15) expected in the USA (2014/15)

controlled. In additional to vulnerability to fluctuating pest populations, conventional cotton is also subject to losses caused by insects before insecticides are sprayed at the threshold level. The cotton sector would like to continue to benefit from biotech developments already in use, but the benefits cannot be taken for granted. The biggest concern linked to sustained use of the insect-resistant trait has been, and will continue to be, how to avoid or delay development of resistance to genes that are used on a commercial scale. This goal cannot be attained unless strong resistance management programs are continuously implemented.

Bollgard® III is a three-gene stacked cotton with Cry1Ac, Cry2Ab and Vip3A. The Cry and the Vegetative Insecticidal Protein (Vip) toxins are produced during different stages of the life cycle of *Bacillus thuringiensis* (Bt), but have similar forms of action against the target insects. While the Cry1Ac and Cry2Ab proteins are produced during the sporulation phase of Bt, Vip proteins are produced during the vegetative state of the bacterium. Results have shown that Vip3A is effective against a range of lepidopteron pests. The toxin is absorbed in the high pH insect gut and quickly becomes active. The toxin or toxins cause(s) holes in the lining of the gut and lead(s) it to rupture. The toxins do not kill the insect immediately but stop it from feeding within a few hours. It may take up to 48 hours before all the insects that ingested the toxins are killed.

In China, the most important bollworm on cotton is *H. armigera*. Researchers screened isofemale families of *H. armigera* with a discriminating concentration of both Cry1Ac- and Vip3A-containing diets. The data on the relative average development rates and percentage of larval weight inhibition of F_1 full-sib families tested simultaneously for the impact of both Cry1Ac and Vip3Aa indicated that responses to Cry1Ac and Vip3Aa were not genetically correlated in field populations of *H. armigera*. Thus, the chances of cross-resistance between Cry1Ac and Vip3A are very low in these populations.

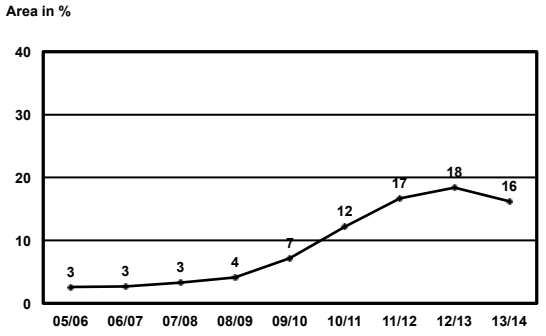
The work done in comparative testing of Bollgard® III and Bollgard® II in comparison with conventional cotton in Australia showed significant differences for boll positions on the plant. Insecticides were not applied to the different cottons, including conventional cotton. The data compiled two days prior to picking showed no difference between the Bollgard® II and Bollgard® III plants in total boll retention, first position boll retention or the distribution of bolls in the plant canopy. Both Bollgard® II and Bollgard® III crops showed higher first position fruit retention, and maintained a greater proportion of fruit away from the canopy as compared to a conventional variety. Further work also demonstrated that the addition of the Vip3A gene contributed to overall efficacy of the plant in controlling *H. armigera* and *H. punctigera*, the two major Lepidopterans affecting cotton in Australia.

It is expected that Bollgard® III biotech cotton will be released first in Australia, where Monsanto has already applied to the Australian Office of the Gene Technology Regulator for commercial release of Bollgard® III as Genuity Bollgard® III and Bollgard® III stacked with Roundup Ready Flex®. It is expected that Genuity Bollgard® III will be released for the crop year 2014/15 or 2015/16.

WideStrike™ 3

The WideStrike™ cotton from the Dow AgroSciences contains Cry1Ac and Cry1F proteins. In cotton, the WideStrike™ technology is available to US cotton growers through Phytogen varieties. In the last few years, Phytogen varieties have become popular in the USA and occupied over

Area Planted to Cry1F+Cry1Ac (WideStrike™) in the USA



Note: The increase in area is not only due to biotech genes. Liking for particular brand varieties and herbicide tolerance also contributed to increase in the area.

16% of the US cotton area in 2013/14, up from 3-4% until five years ago. The Deltapine brand is still on top occupying 33% of the area, followed by the Fibermax brand from Bayer CropScience on 25% of the area planted to cotton in 2013/14. A WideStrike™ Roundup Ready Flex variety was planted on 9.4% of the US cotton acreage in 2013/14, amounting to 300,000 hectares–more than any other variety in the country.

Cry1Ac and Cry1F in stacked form as WideStrike™ have also been approved for field-testing in a number of other countries. Commercialization in Australia and Brazil began in 2009, while Mexico and the US started commercializing Cry1F+Cry1Ac in 2004 and 2005, respectively. The mode of action of Cry1F is similar to that of other cry crystal proteins. Cry1F and Cry1Ac are both endotoxins and must be ingested by the target insect for binding to specific sites. Its broad range of efficacy against various insects is shown in the table below, along with other Bt proteins. Data provided by Dow AgroScienecs to the US Environmental Protection Agency showed that only pollen grains had a lower quantity of Cry1F protein compared to Cry1Ac, 0.06 ng/mg tissue dry weight and 1.45 ng/mg tissue dry weight respectively (Technical Bulletin, Dow AgroSciences). The variation in specific binding between different cry proteins affects the efficacy spectrum and cross-resistance between Bt proteins.

As is the case with other cry proteins, single or stacked, WideStrike™ varieties are also vulnerable to the risk of target pest adaptation to the Cry1Ac/Cry1F proteins, leading to the possibility of reduced efficacy. In order to prolong the effectiveness of WideStrike™ technology, it is important to implement resistance management programs, as with Bollgard® and Bollgard® II. Insect resistance management programs should be adopted in different countries in accordance with their specific production systems, in particular the crops grown when cotton is in the field. Extra close monitoring of the resistance program is necessary when the crops grown during the cotton season are also biotech and carry Cry genes.

The WideStrike™ 3, by Dow AgroSciences, features Cry1Ac, Cry1F proteins and a vegetative insecticidal protein (Vip3A). WideStrike™ 3 is expected to provide superior protection throughout the cotton plant against a wide spectrum of damaging lepidopteron pests, such as the cotton bollworm, and an improved resistance management strategy. Dow AgroSciences received a registration of the trait from the U.S. Environmental Protection Agency in May 2013 and will offer the technology exclusively in Phytogen brand varieties starting in 2014 or 2015. WideStrike™ 3 varieties are expected to be available first in the USA.

Additional Benefits of Double and Triple Gene Insect Resistance

A lot of work has been done on the non-target effects of Bt proteins present in Bollgard® and the combination of Cry1Ac and Cry2Ab. The two genes have been studied not only in cotton but also in other biotech crops, such as maize and soybeans, that share common pests with cotton. The evidence so far has shown that, for Cry1Ac alone and for the combination of Cry1Ac and Cry2Ab, the level of resistance has not reached an alarming stage but must be given serious attention. Once developed, resistance will continue to increase. Unlike with

Spectrum of Activity on Cotton for Various Biotech Genes

Bollgard® Cry1Ac	Bollgard® II Cry1Ac + Cry2Ab	WideStrike™ Cry1Ac + Cry1F	Bollgard® III Cry1Ac + Cry2Ab + Vip3A	WideStrike™ 3 Cry1Ac + Cry1F + Vip3A
Tobacco budworm	Tobacco budworm	Tobacco budworm	Tobacco budworm	Tobacco budworm
Cotton bollworm	Cotton bollworm	Cotton bollworm	Cotton bollworm	Cotton bollworm
Pink bollworm	Pink bollworm	Pink bollworm	Pink bollworm	Pink bollworm
European corn borer	European corn borer	European corn borer	European corn borer	European corn borer
Cabbage looper	Cabbage looper	Cabbage looper	Cabbage looper	Cabbage looper
Cotton leaf perforator	Cotton leaf perforator	Cotton leaf perforator	Cotton leaf perforator	Cotton leaf perforator
Beet armyworm	Beet armyworm	Beet armyworm	Beet armyworm	Beet armyworm
Soybean looper	Soybean looper	Soybean looper	Soybean looper	Soybean looper
Fall armyworm	Fall armyworm	Fall armyworm	Fall armyworm	Fall armyworm
Saltmarsh caterpillar	Saltmarsh caterpillar	Saltmarsh caterpillar	Saltmarsh caterpillar	Saltmarsh caterpillar
Cutworms	Cutworms	Cutworms	Cutworms	Cutworms

Note: Efficacy against a particular insect may also vary depending upon the genotype, position on the plant, plant age, intensity of the pest and abiotic circumstances.

insecticides, the options of rotating products and changing doses are not available. Research has demonstrated that in addition to genetic resistance based on target site mutations (that induce resistance to high toxin concentrations) and other resistance mechanisms, exposure of insect larvae to lower than optimal levels of toxin(s) induces immunity and metabolic responses, resulting in low-level resistance (inducible tolerance). Field experiments conducted with the first insect-resistant biotech cotton showed that cotton leaves exhibited a significantly decreased ability to kill cotton bollworm larvae as compared to the developmental stage of the plant. After bloom/squaring, when the plant reached a peak flowering stage, leaf toxicity to larvae decreased dramatically and stayed low. Greenhouse studies also confirmed these results. The lowered toxicity of leaves was clearly correlated with a decline in the expression of the CrylAc gene and reduced amounts of Bt toxins in leaves.

Similar conclusions have been abundantly reported in connection with lower doses of insecticides. It was strongly recommended that the target bollworms should not be exposed to lower levels of any active ingredient because this simply enhances tolerance to the product. Tolerance to toxins, such as Cry proteins, in insect populations that can be transmitted to offspring by epigenetic inheritance mechanisms (caused by gene and protein regulatory mechanisms) has major ramifications for maintaining the efficacy of biotech cotton.

Research has also shown that the toxin levels vary in different parts of the plant and toxin concentration decreases in the older parts of the plant. Declines in toxin with the age of the crop can expose target insects to lower levels of the toxin, thus accelerating the insects' ability to build up a tolerance mechanism. Biotech cotton with a single Cry gene had a high probability of fostering such occurrences. The dual gene technology reduced chances of letting the toxin to fall below threshold lethality levels. Various insects can have different thresholds for various toxin proteins and the dual gene technology really does have a double action. The first, as explained above, is its higher quantity of toxin, while the second indirect advantage is that it only allows a minimal population of the target insects to reach a development stage where the toxin level is suspected of dropping below the relevant threshold level.

Bommireddy *et al*. (2011) studied the one-to-one effects of the Vip gene on the cotton bollworm *Heliothis zea* and tobacco budworm *Heliothis virescens*. Two biotech cotton lines, one having a single protein (Vip3A), another having a combination of two proteins Vip3A + Cry1Ab (VipCot™), together with a non-biotech variety were tested over three years (2005-2007). Throughout each season, data were recorded on injury to fruiting forms and larval survival with in the cotton bollworm and the tobacco budworm populations. The number of fruiting forms damaged by the two heliothines was significantly higher on non-biotech cotton than on the Vip3A and VipCot cotton lines. The VipCot cotton had significantly fewer heliothine-damaged fruiting forms than the Vip3A cotton. The number of surviving larvae infesting fruiting forms was also significantly higher on non-biotech cotton than on the biotech varieties. In addition, significantly fewer cotton bollworm and tobacco budworm larvae were recovered on VipCot plants than on Vip3A cotton plants. The study proved the usefulness of the Vip gene, but it also showed that Vip3A alone was incapable of controlling the cotton bollworm and the tobacco budworm to the same degree as VipCot.

These studies indicate that the Vip proteins can provide a useful addition to Cry proteins, but given the similar lytic mode of action of Vip3A proteins in the insect midgut, it may entail a similar vulnerability to the development of resistance if used on its own. Pyramiding of the Vip3A trait with other Cry insecticidal proteins appears to be a high priority for achieving sustainable deployment against *H. armigera* or similar susceptible species.

Additional Technologies to Delay Development of Resistance

The hybridization theory of natural crossing between resistant and susceptible populations is working. But, the fact remains that farmers comply with refuge requirements in differing degrees and the very level of refuge implementation varies greatly among countries. Inadequate compliance with the mandatory refuge requirements in itself implies a huge risk, but it is also important to acknowledge that refuge requirements alone cannot be relied upon to delay or preclude the development of resistance. Gene stacking is another option but additional strategies must also be used whenever available. Tabashnik *et al*. (2010) studied a non-traditional alternative technology involving hybridization of a resistant population with sterile moths of the pink bollworm *Pectinophora gossypiella*. A sterile moth technology has been used in the USA on conventional cotton since long before biotech cotton was adopted. Tabashnik and a group of other researchers (2010) used a computer simulation model to show that the sterile moth technology delayed the development of resistance to the Bt toxins. In the simulations, when sufficient numbers of sterile moths were released, pest resistance was held way over a 20-year period. Based on evidence gleaned from experiments to study the pink bollworm's response to Bt cotton, they first modeled recessive inheritance of resistance with a fitness cost and incomplete resistance. The results showed that with no refuges, resistance evolved in three years without the release of sterile moths, but populations did not persist and resistance did not occur with weekly 'low' releases of sterile moths. With refuges accounting for 2 to 20% of the total area planted to cotton, resistance evolved more slowly in response to the release of greater numbers of sterile moths. With 20% of the cotton area planted to non-biotech cotton as a refuge, resistance did not occur in 20 years, even without sterile releases. Because of fitness costs associated with the pink bollworm's resistance to biotech cotton, higher refuge

percentages not only reduced the proportion of population exposed to selection for resistance but also increased selection against resistance. Conversely, in a hypothetical worst-case scenario with dominant inheritance of resistance and no refuges, resistance evolved in a single year.

The sterile moth approach has several advantages over the refuge strategy. Yields are always lower in refuge areas, so farmers can greatly reduce or eliminate planting of refuges by using the sterile moth approach and thus avoid associated complications and consequently cut their yield losses. Secondly, because mating of sterile moths does not produce fertile progeny, this approach is capable of delaying resistance based on either recessive or dominant inheritance. The refuge approach requires the existence of a susceptible population while the sterile moth approach does not require maintenance of susceptible populations. The technology also allows growers to release sterile moths as and when required and also makes it possible to match pink bollworm pressure on the biotech cotton. Researchers believe that the program has benefitted from strong grower commitment, public investment in sterile insect technology, a well-developed infrastructure for monitoring pink bollworm resistance and population densities, virtually 100% efficacy of biotech cotton against the pink bollworm, and this pest's nearly exclusive dependence on cotton.

Some of the requirements mentioned above may not allow replication of the sterile technology in other countries. The pink bollworm may not be surviving exclusively on cotton, as was the case where the technology was tested in the US. But, further exploration of such tactics might help to enhance the sustainability of insect resistant biotech cotton. It may also be possible to release transgenic insects carrying a dominant lethal gene so that they do not produce fertile offspring whenever mating with a susceptible moth.

Sex pheromone confusion technology may also be modified and employed in the same manner as was done on conventional cotton. The limitations of the pheromone technology clearly have to be overcome. Here the approach is to minimize the size of the resistant population that must mate automatically with the susceptible population in the refuge.

Multi-Gene Breeding Challenges

Conventional breeding has its own limitations, the most significant one being the time required to evaluate, confirm and reconfirm results and have them approved (if approval is necessary) for commercial release. Progeny row testing, replicated trials, large-scale trials and farmer field-testing consume the most time. Insertion of biotech genes in the existing genotypes slowed down the variety release process in the US in the early years of biotech cotton because breeders continued devoting their efforts to inserting biotech genes in existing varieties. But the variety development process again picked up when it became normal to have biotech gene(s) in the breeding lines. In some countries the introduction of biotech genes altogether changed the varietal composition because of farmers' inclination toward biotech varieties.

Addition of a large number of non-cotton genome genes in cotton, along with the desirable genes accumulated through conventional breeding, posed a great challenge for breeders. A breeder has to have Cry1Ac in the germplasm to develop and test a Bollgard® II variety before it is released. Bollgard® III must have Cry1Ac and Cry2Ab in the material to add Vip3A. Addition of an herbicide tolerance feature requires a further step. Accumulation of four specific genes certainly requires greater efforts by the breeder to come up with a variety that does not lack yield and quality characteristics. The drive to achieve varieties with a greater number of specific traits inevitably adds to the complexity of the breeding process. Consequently, the price breeders will have to pay will be potentially longer timelines for developing any specific variety. The situation with WideStrike™ 3 varieties will be no different. While the quest for increases in yields and improved quality parameters in any variety is a continuous process and can only grow with the time, development of new biotech genes for additional features/traits will also continue, making conventional breeding more challenging than it was prior to the introduction of biotech genes. Deleterious interactions among transgenes also cannot be ruled out.

What Next?

Since the release of insect resistant biotech cotton in the mid-1990s, the cotton industry has seen only a stacking of genes for the sake of enhancing the effect or the lifespan of insect resistant biotech genes. Expectations were running particularly high during the first 5-8 years of commercialization of insect resistant cotton. The industry was pragmatically waiting for the next new product as if it were only a few years away. The popular notion was that perhaps the next generation biotech traits to be introduced might consist of naturally-colored cotton (yellow or black) or improved fiber quality features. All such hopes have slowly dissipated. Direct yield improvement in the form of higher photosynthesis rates or prolonged photosynthesis activities has almost disappeared from the radar for commercial use at any time soon.

Researchers in the public and private sectors have spent enormous resources to deal with the resistance issue. Mahon *et al.* (2012) stated that lepidoptera are generally only susceptible to toxins in the Cry1 (e.g., Cry1Ac, Cry1Ab, Cry1F) and Cry2 (e.g., Cry2Ab, Cry2Aa, Cry2Ae) classes, several of which are currently being used in existing transgenic crops. Within the Cry1 class, insects that are resistant to one toxin are often, but not always, cross-resistant to others. Less is known about cross resistance within the Cry2 class, although it is known that Cry2Ab-resistant *H. armigera* are resistant to Cry2Aa and that Cry2Ab-resistant *H. armigera* and *H. punctigera* are resistant to Cry2Ae (Mahon *et al*., 2012). *H. punctigera* is common on cotton in Australia. It is, therefore, likely for most systems that if resistance emerges to a toxin in the Cry1

or Cry2 class, there are limited alternative Cry toxins for plant breeders to employ.

Stacking of insect and herbicide resistance genes will surely continue for the sake of saving or adding longevity to the life of the technology, but the two new traits that are on horizon from the research aspect are drought-tolerant and nitrogen-use-efficient cotton. The first generation of drought-tolerant trait in cotton is probably at the top of the list for commercialization in the near future. Most cotton production systems in the world suffer from water deficit, irregular supply and drought. Farmers are able to capitalize on the benefits of biotech traits only if the crop is safe from other natural disasters. Among natural adversities that can harm cotton at its earliest stages is the lack of optimum plant stand resulting from poor germination due to dry conditions. While low soil temperature can affect germination more than high soil temperatures, optimum soil moisture is critical for good germination of certified quality seed. Improved water use through provision of yield stability in environments experiencing occasional or consistent water stress, together with lower water needs in irrigated areas are expected to benefit cotton in general. Indications are that drought tolerant cotton will follow Bollgard® III and WideStrike™ 3. Nitrogen–use-efficient cotton may be next after the drought-tolerant trait.

High registration costs and lack of resources in the public sector are hampering the drive to come up with new traits. Remuneration for the technology developed is vital for the recovery of the resources, without which the private sector cannot broaden its efforts. It is natural for developers to expect to recuperate the high cost of important developments on their registration. Biotech research is expensive and a lot more needs to be done using new genomic approaches to deepen our understanding of plant development or agronomic processes in order to help identify specific genes controlling or impacting specific traits.

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~~Comparison of the Cost of Production Among Countries~~

~~A detailed article entitled 'Long Term Trends in the Cost of Cotton Production' was published in the December 2013 issue of the *ICAC RECORDER*. The article dealt exclusively with world averages for the cost of various inputs and with long-term changes. The source of the information was the ICAC publication *Cost of Production of Raw Cotton*, September 2013, which contains data for the 2012/13 cotton production season. The inputs and operations covered in the survey questionnaire and used to compute net cost of production of cotton were also discussed in terms of world average levels in the December 2013 article to determine general trends. The cost of producing a kilogram of seedcotton and the net cost of producing a kilogram of lint, i.e., total cost minus land rent and the value of commercial seed (seed after ginning), was calculated. Land rent is excluded from the cost per kilogram of seedcotton.~~