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Contents

Introduction

Chemical agriculture is almost 100 years old, and pesticides have a relatively short history of almost six decades. The effects of insecticides on the environment, including the resurgence of secondary pests, residual effects on crops, high risks of contamination and impacts on non-target insects are some of the most important concerns, still, insecticides are needed. However, the trend in use is changing toward use only as a last resort. It is estimated that pesticides worth US$32.4 billion were consumed in the world in 2004. Almost 9% of pesticide, and 19% of all insecticide sales in 2004 were used on cotton. The pesticides industry is consolidating and six large companies accounted for 77% of pesticide sales in 2004. Pesticide companies are promoting the agrochemical industry as plant sciences, or crop sciences industry. Biotechnology has become an integral component of the strategies of all six of the big companies. Consequently, more and more agrochemical companies are getting involved in the planting seed business. More details about pesticides, including classification from different angles, are included in the first article.

Contamination, which is different from trash, is a serious problem that affects everyone in the cotton chain. Farmers get lower price for producing contaminated cotton, it costs more to gin contaminated cotton, merchants get more disputes with contaminated cotton, spinners have to first eliminate contaminants when opening cotton, and the textile industry suffer losses due to contaminated fabric. The latest report from the International Textile Manufacturers Federation (ITMF), indicates that 22% of all cotton in 2004/05 was contaminated. 15% had a moderate lower of contamination, while 7% had a serious contamination problem. Two years ago, 26% of the samples tested had contamination, with 8% having a serious contamination problem. Cotton is not contaminated on the plant, but as soon as it is harvested, the contamination process begins and ends only after it has been opened at a mill. Seedcotton picking, handling at the farm, transportation to smaller storage areas, storage at homes, transportation to gins, storage at gins, ginning and bale packing are the stages where contamination is added to cotton. Most contamination can be easily avoided if the actual origination points for each contaminant are established and appropriate measures are taken. Some suggestions and examples to produce least-contaminated cotton are given in the second article.

The third article is on a newer technology to control lepidopterans utilizing Bt genes. The U.S. Environmental Protection Agency (EPA) awarded full registration to WideStrike™ cotton in September 2004, and 2005/06 was the first year of commercial production of WideStrike™ varieties. WideStrike™ is a dual-action insect resistant cotton with an additional benefit of controlling non-heliothines in cotton. No synergistic effects or increase in non-target host range were seen as a result of combining these two proteins in the same product. The trials conducted for many years prior to the approval and commercial planting in 2005 showed that the protein efficacy decreases with the age of tissues, which is also true for other Bt gene biotech cottons. The performance of WideStrike™ in 2005/06 showed that it is as good as Bollgard II for controlling many bollworms, with both WideStrike™ and Bollgard II, additional spraying may be required to control secondary pests depending on pest pressure.

World Cotton Research Conference-4

The World Cotton Research Conference-4 will be held in Lubbock, Texas, USA from September 10-14, 2007. The theme of the conference is 'Nature's High-Tech Fiber.' As of mid March 2006, 413 researchers have pre-registered for the conference. Free online pre-registration is available at <http://www.icac.org/>. The full registration package, along with more details on the program and hotel booking, will be available by July 2006. Full registration will be provided to those who have pre-registered for the conference. Most information on the conference is available on the ICAC web page and, additional information can be obtained from:

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Insecticides and Their Use on Cotton

According to the revised International Code of Conduct on the Distribution and Use of Pesticides, adopted by the Food and Agriculture Organization of the United Nations (FAO) in November 2002, pesticides are ‘any substances or mixtures of substances intended for preventing, destroying or controlling any pest, including vectors of human or animal disease, unwanted species of plants or animals causing harm during or otherwise interfering with the production, processing, storage, transport or marketing of food, agricultural commodities, wood and wood products or animal feedstuffs, or substances which may be administered to animals for the control of insects, arachnids or other pests in or on their bodies.’ Pesticides include substances intended for use as a plant growth regulator, defoliant, desiccant or agent for thinning fruit or preventing the premature fall of fruit, and substances applied to crops either before or after harvest to protect a commodity from deterioration during storage and transport. Pesticides, and more particularly insecticides, have become an integral component of cotton production systems. Data from the USA show that agriculture accounts for 72% of pesticide use, industry and government 21%, and home and garden 7%. The share of pesticide use in agriculture is probably higher in most other countries. This is evident from the fact that 85% of the American households use some kind of pesticide. Without attempting to reason how and why this came about, the fact stands that pesticides have both positive and negative effects. The nature of these effects can be further defined as short-term and long-term. Insecticides are not a technology, as such, but a series of compounds used to perform a specific function or functions inside the host or the pest that is causing or will ultimately be causing damage to the host or its enabling environment. Experience shows that the arsenal of insecticide compounds available for use on cotton and other crops is limited because of effects on the environment, the potential resurgence of secondary pests, residual effects, high risks of contamination and collateral impacts on natural enemies of the target pest.

Nomenclature and Historical Developments

Each pesticide usually has three names: the common name that is popular among farmers, the trade name used by companies dealing in pesticides and the chemical name that is important for product development. For example, Carbaryl, Sevin and 1-naphthyl N-methylcarbamate are names for the same product. More than one manufacturer may hold a patent on an insecticide, and therefore there may be more than one trade name for the same chemical. A single product or trade name may have a different common name in different countries. Pesticides are the chemicals or compounds used to control insects, weeds and diseases. However, insecticides are chemicals used to control insects and constitute only one fourth of pesticides. They are followed by various other kinds of compounds including miticides (against mites), fungicides (against fungi), bactericides (against bacteria), algaecides (against algae), insect attractants (pheromones), insect repellents, rodenticides (against rats and mice), acaricides (against ticks and mites), virucides (against viruses), nematicides (against nematodes), ovicides (against the eggs of insects and mites), avicides (against birds) and antifeedants. Insecticides are used to control insects but, incorrectly, in popular parlance they are also considered to include acaricides, fungicides, nematicides and others. Herbicides or weedicides are usually considered separate from insecticides.

There are many different types of chemicals used for insect control. Chronologically, insecticides were developed in the following order:

1. Inorganic insecticides
2. Botanical insecticides
3. Modern synthetic chemicals
   A: Chlorinated hydrocarbons
   B: Organophosphates
   C: Carbamates
   D: Pyrethroids
   E: Insect growth regulators
   F: Formamidine insecticides

Synthetic insecticides have a fairly short history of just less than sixty years. These sixty years can be divided into three periods based on the chemicals used to control insects. The first period started with the launch of "chlorinated hydrocarbon" insecticides immediately after World War II and lasted until the mid-1960s when Dichloro-Diphenyl-Trichloroethane (DDT) and organochlorines were found to have widespread deleterious effects on the environment and on human and animal health. DDT was a nerve poison that acted on contact and in the stomach and had a long residual effect. DDT was ultimately banned in 1972, and by then researchers had realized the need to balance the benefits of pesticides with their impacts on human health and the environment. The second period began with organophosphate compounds, starting with the arrival of parathion in 1944. This was the period when most developing countries started to use insecticides. The third period started with the introduction of synthetic pyrethroids in the late 1970s. The transitions from the first period to the second and from second to the third were characterized by widespread concerns over resistance development and effects on non-target species. Resistance to pyrethroids has once again become a problem, and the history of agricultural insecticides may be entering its fourth stage. As of today, the ultimate goal of insecticide use, which is to obtain maximum benefits with minimal risk, has been only partially achieved.

Classification of Insecticides

Insecticides may be classified in many ways, including: mode of action, toxicity, structure or chemical makeup, origin and method of discovery.

Classification of Insecticides by Mode of Action

Contact Insecticides

Contact insecticides enter the insect's body when they are directly sprayed on the insect or when the insect comes into contact with the treated surface of the plant. The insecticide need not be ingested by the insect, but the insect must come in contact with the insecticide for the compound to begin its lethal action.

Systemic insecticides

The target insect must ingest the systemic insecticide for it to achieve the desired results. Contact insecticides are sprayed on the plant and then travel through the tissues to reach its various parts. When the insect feeds on the poisoned plant tissue, it ingests the poison along with plant material. Systemic insecticides may also have contact action and work simultaneously against sucking insects and bollworms in cotton.

Fumigant insecticides

Fumigants are applied in gaseous form, usually in an enclosed area. Fumigant insecticides act more quickly than contact and systemic insecticides because their attack point is the tracheal system. However, the insect must be exposed to the fumes. Fumigants are also applied to the soil for disinfection against specific pathogens.

Classification of Insecticides by Toxicity

All insecticides are toxic to humans. However, the level of toxicity varies from one to another. Some insecticides may be highly toxic while others may be less toxic. The World Health Organization (WHO) classifies pesticides on the basis of their toxicity. This classification is as follows:

WHO Classification: LD_{50} for Rats (mg/kg Body Weight)

WHO Class	Oral		Dermal	
	Solids	Liquids	Solids	Liquids
Ia Extremely hazardous	5 or less	20 or less	10 or less	40 or less
Ib Highly hazardous	5-50	20-200	10-100	40-400
II Moderately hazardous	50-500	200-2000	100-1000	400-4000
III Slightly hazardous	Over 500	Over 2000	Over 1000	Over 4000

LD_{50}: Statistical estimate of the number of milligrams of toxicant per kilogram of body weight needed to kill 50% of a large population of test animals.
The terms "solids" and "liquids" refer to the physical state of the active ingredient being classified.

There is a fifth group of chemicals, which is considered safe.

Insecticide Classification by Chemical Composition

Inorganic or Naturally Occurring Chemicals

Insects had been a threat to agriculture for a long time before synthetic insecticides were finally developed and recognized as a strong pest control measure. Material like salts, ashes, soot, dust and sulfur and some plant extracts have been used for pest control for hundreds of years. Even salts of mercury and lead were used for pest control. During the 1600s, arsenic and honey were used as a stomach poison for ants. Between the 1920s and the 1940s, calcium arsenate was used as a stomach poison that inhibited the respiratory enzymes. Methyl bromide is still used in fumigation when cotton is shipped across country borders, though requirements for such a treatment vary depending upon the country of origin and destination. However, the use of inorganic/naturally occurring chemicals led to numerous problems. Aerial dusting to control the boll weevil, for example, resulted in outbreaks of secondary pests due to the destruction of natural enemies, while arsenic in the soil led to low yields in arsenic-sensitive crops like soybeans.

Organic Chemicals

Organic chemicals form the main group of insecticides currently used in agriculture. Carbon forms the backbone of these compounds. These products may be

a. Botanical- plant derived,
b. Synthetic- man-made, or
c. Oils – mineral and vegetable

Botanical insecticides like nicotine, a water extract of tobacco, have been in use since 1763. Nicotine worked as a contact nerve poison, as an antagonist of nicotinic acetylcholine receptors, but the major drawback has been the high number of human fatalities. Pyrethrum, which is extracted from chrysanthemum flowers, is a contact nerve poison that disrupts the sodium channel function. It had a fast knockdown effect but was highly photosensitive and biodegradable. Pyrethrum was used extensively during the 1800s.

Synthetic insecticides were introduced after World War II. They are organic chemicals developed for specific objectives and manufactured in factories. Based on their chemical compositions and mode of action on the plant, synthetic organic insecticides may be differentiated into various groups. The major groups are: chlorinated hydrocarbons, organophosphates, carbamates, pyrethroids, insect growth regulators and formamidine insecticides.

Oils had been used as insecticides before the introduction of organic synthetic insecticides. Mineral oil is a by-product of the distillation of petroleum to produce gasoline (petrol). Vegetable oils are extracted from many plants including cotton. Vegetable oils have been used more commonly than mineral oils, which are generally used as lubricants. Vegetable oils are heterogeneous mixtures whose compositions vary between and within kinds and among manufacturers. The performance of vegetable oils as insecticides depends on their formulations and application methods because the insects must come in contact with the products for the oils to start their bioactivities. Not much serious research has been done into the use of oils as insecticides. There is a broad margin for manufacturers to improve formulation preparations, determine phytotoxicity and improve stability and sprayability of oils. With funding from the Common Fund for Commodities, the ICAC sponsored a five-year project in Egypt, Ethiopia, Israel and Zimbabwe. The project ended in 2000 and concluded that two formulations from castor and cottonseed oil can be safely used to control whitefly and aphids in cotton. The project also experimented with seven other oils and concluded that coconut oil had a high phytotoxic effect while castor oil was the safest to use on cotton (ICAC, 2000).

Insecticide Classification by Chemical Structure

Synaptic Poisons

The synapse is the junction between a neuron and a muscle, gland, sensory receptor or another neuron. In the nervous system, a chemical called acetylcholine, transmits a nerve impulse across the synapse (gap) between cells. This compound must be broken down to acetic acid and choline in the presence of acetylcholinesterase (AChE) in order for a nerve impulse to stop and allow the muscle or neuron to rest. ACHesterase clears the system so another nerve transmission event can occur (Peterson, 2001). Organophosphate and carbamate are synaptic poisons that interfere with normal synaptic transmission in the nervous system of insects.

Axonic Poisons

Axonic poisons interrupt normal axonic transmission in the nervous system by affecting the transmission of nerve impulses along axons. Axonic poisons bind to a protein in nerves called the voltage-gated sodium channel. Normally, this protein opens to allow stimulation of the nerve and closes to terminate the nerve signal. Chemicals can bind to this gate and prevent it from closing normally, which results in continuous nerve stimulation. This explains the tremors exhibited by poisoned insects (Valles and Koehler, 1997). They lose control of their nervous system and are unable to produce coordinated movement. Chlorinated hydrocarbons and pyrethroids belong to this group.

Nicotinic Acetylcholine Agonist

Nicotinic acetylcholine agonists cause nicotinic receptors to continue firing until the insect dies. These insecticides have relatively low mammalian toxicity and are comparatively less harmful to the environment. These nicotinic agonists can be synthetically manufactured, like Imidacloprid, or derived from many naturally occurring plants like nicotine from tobacco, pyrethrum from chrysanthemums, neem from azadirachtins, limonene from citrus oil, rotenone from some legume crop roots, Ryania from roots of Ryania species, and sapodilla from the tropical lily, *Schoenocaulon officinale.*

Inorganic Insecticides

Inorganic compounds have already been discussed above. Among the inorganic compounds still in use are: sulfur, sodium fluosilicate, cryolite, diatomaceous earth, silica gels, boric acid, and soaps. These insecticides vary not only in their chemical structure but also in their mode of action.

Insect Growth Regulators

Insect growth regulators interfere with the insect's endocrine system. The endocrine system produces three hormones that initiate and regulate molting and metamorphosis. The hormones are brain hormone, ecdysone and juvenile hormone. A reduction in juvenile hormone concentration leads to incomplete or gradual metamorphosis, which results in subsequent nymphal stages having more and more adult characteristics. Insect larvae with incomplete metamorphosis have a group of undifferentiated cells called imaginal discs which, when they begin to divide, provide the cells that are required for the insect to emerge as an adult. Juvenile hormones inhibit the development of these discs and the insect retains its larval form in subsequent molts. When the larva reaches its full development, juvenile hormone production and concentration in the hemolymph (blood) declines drastically resulting in a molt to the pupal form. If the process continues during the pupal stage, cells in the imaginal discs differentiate and divide resulting in the development of adult tissues, organs and wings. Insect growth regulators may be divided into two broad categories depending on the process they affect, metamorphosis or molting. Juvenile hormones belong to the category of insect growth regulators that affect metamorphosis. The insect growth regulators that affect molting are chemicals that either inhibit chitin synthesis or accelerate the onset of molting, thereby killing the insect.

Microbial Insecticides

Many forms of microbial insecticides have been used for a long time but some bacteria are more common than others. Microbial insecticides are biological control agents available in many forms and their preparation for application is similar to that of conventional insecticides. As soon the larva ingests the compound, the crystalline delta endotoxin quickly dissolves in the midgut of the insect causing gut paralysis. The larvae may be killed immediately or suffer blood disorders leading ultimately to larval death. As far as cotton is concerned, *Bacillus thuringiensis* Kurstaki (B.t.k.) has been used against lepidopterans in many countries.

Spinosad is a natural product of the bacterium *Saccharopoly-*

spora spinosa, which is effective against armyworms, bollworms, loopers, and tobacco budworm in cotton and other pests in vegetables. It is a nicotinic acetylcholine modulator with mammalian and non-target characteristics similar to Bt and performs like a conventional synthetic insecticide.

Insecticide Use Responsibility

The key players in insecticide-based production technology are the insecticide companies, researchers and extension specialists and farmers. Insecticides are developed after extensive research, huge expenditures and many years of hard work. While many products may never reach the market, any product intended for commercial availability has to go through rigorous testing by companies and governments before it is finally cleared for commercial use. In most cases companies have to share the cost of field testing in one way or another. Once a product is approved for commercial use in any country, the company in question has to undertake a promotional campaign to introduce the product to researchers and farmers. There is competition from existing products marketed by other companies and companies also have to promote their new product against their own products already on the market. Researchers and extension workers may have their own views and may or may not be convinced to use a particular product. Major growers may have direct access to information from pesticide companies, but medium and small growers depend mostly on the advice given by extension workers and, at times, directly by researchers. Companies pursue successful use of their products, but preferences may change as products reach researchers who are inclined to assign a high priority to safe use. Researchers must understand the mode of action, mechanism of activation and detoxification of the insecticide for safer and sustained use of products. Farmers have two primary considerations when deciding which insecticides to use: the effectiveness of the product against the target pest or pests in line with their own expectations and the cost of treatment or application. Cotton growers are generally better trained to make insecticide use decisions than non-cotton growers because they use insecticides more than non-cotton growers do. Pesticide companies have many behind-the-scenes players, but marketing people usually target researchers. Marketing people get a lot of feed back from their research teams to be able to deal with well- trained and qualified public sector experts. Public or private sector researchers/extension workers/consultants and farmers have to learn about all the new products themselves. The private sector also resorts to aggressive marketing strategies and invests significant resources in advertising – both in print and on the air. In spite of their best efforts, sometimes even promising pesticides fail to achieve a variable market share or have to be withdrawn because of environmental costs.

Modern Synthetic Insecticides

In their earlier phases, modern synthetic insecticides were broad-spectrum products that destroyed beneficial species along with target species. Products are now developed with specific objectives and targeted to a specific insect – or sometimes to a specific phase of an insect's life cycle. Since cotton farmers are among the major consumers of pesticides, products of every class have been used. Chronologically they are:

Chlorinated hydrocarbons

Chlorinated hydrocarbons are axonic nerve poisons with contact and stomach actions. Their mode of action is the rapid opening of the sodium gates to depolarize the nerve. Pyrethroids also work on the same principle.

Organophosphates

Organophosphates are nerve poisons inhibiting acetylcholinesterase (an enzyme in the nervous system) and their mode of action is contact, stomach, systemic and fumigant. The first organophosphate was developed in 1941; the best known organophosphates are malathion, dimethoate, diazinon, and profenofos. Organophosphates have lower persistence and higher biodegradability than chlorinated hydrocarbons. But they are similar in their effects on the resurgence of target species, damage to beneficial species and development of resistance.

Carbamates

Carbamates are relatively non-persistent and, unlike organochlorines and chlorinated hydrocarbons, they do not bioaccumulate. They are synthetic analogues of plant alkaloid physostigmine and the route of absorption may be ingestion, inhalation and dermal exposure. Carbaryl, a broad spectrum and low mammalian toxicity product, was developed in 1956. Other carbamates include aldicarb, methomyl, thiocarb, propoxur and carbofuran. Their mode of action is similar to that of organophosphates, inhibiting acetylcholinesterase (AChE).

Pyrethroids

Synthetic pyrethroids were developed in 1972. Permethrin (synthetic and photostable) was effective at rates of 10-100 times smaller dosages than organophosphates and chlorinated hydrocarbons. Permethrin was an axonic nerve poison, similar to DDT in its mode of action. Therefore, cross-resistance was a potential problem. Pyrethroids have been extensively used on cotton. Other forms of pyrethroids are fenvalerate, cypermethrin, and bifenthrin.

The Pesticide Industry

The crop protection chemical market is a global market. While these products are used globally - in advanced, developing and underdeveloped countries, they are produced by just a handful of pharmaceutical firms, mostly in developed countries. China is one of the major producers of generic products - chemicals that are no longer protected by patents and thus may be manufactured by anyone with the industrial capability. Given the technical nature of these chemicals, it is necessary to have regimes to govern their standardization. Most of these regimes come within the purview of the UN system, and some of the more important ones are:

1. The WHO Recommended Classification of Pesticides by Hazard
2. International Code of Conduct on the Distribution and Use of Pesticides
3. Guidelines for Packaging and Storage of Pesticides
4. Guidelines on Good Labeling Practices for Pesticides
5. Guidelines for the Disposal of Waste Pesticide and Pesticide Containers on the Farm
6 Stockholm Convention on Persistent Organic Pollutants (POPs)
7. Montreal Protocol

International Code of Conduct on the Distribution and Use of Pesticides

The Food and Agriculture Organization (FAO) of the United Nations started working on international confidence-building measures with regards to the availability, regulation, marketing and use of pesticides for the improvement of agriculture and public health almost 50 years ago. The Panel of Experts on Pesticide Specifications, Registration Requirements, Application Standards and Prior Informed Consent recommended in 1982 that a code of conduct be established for safe export, import and use of pesticides. FAO adopted the first International Code of Conduct on the Distribution and Use of Pesticides in 1985. The code provided general guidelines particularly in the absence of an effective pesticide registration process and a government infrastructure for controlling pesticide handing and use. Most governments have perfected their pesticide handling procedures, and FAO has also revised its code of conduct. The latest version of the International Code of Conduct on the Distribution and Use of Pesticides was approved by FAO in November 2002.

The International Code of Conduct on the Distribution and Use of Pesticides established voluntary standards of conduct for all public and private entities engaged in or associated with the distribution and use of pesticides, particularly where there is inadequate or no national legislation to regulate them. The Code is designed for use within the context of national legislation as a basis whereby government authorities, pesticide manufacturers, those engaged in trade and concerned citizens may judge whether their proposed actions and the actions of others constitute acceptable practices. The Code describes the shared responsibility of all segments of the pesticide industry, from manufacturers to users and governments. Under the Code, governments have the overall responsibility to regulate the availability, distribution and use of pesticides in their countries and to ensure allocation of adequate resources to enforce this mandate. The Code provides that governments should make concerted efforts to develop and promote the use of integrated pest management (IPM). Lending institutions, donor agencies and governments should support the development of national IPM policies and improved IPM concepts and practices. The objective of such a recommendation is of course to encourage judicious use of pesticides. Regulatory and technical requirements, quality control, reduction of health and environmental risks, distribution and trade, information sharing, labeling, packaging, storage and disposal and advertising are extensively covered in the Code.

The Pesticide Market

According to Cropnosis (A private company dealing with crop protection and biotechnology sectors), pesticides valued at $32.35 billion were used in the world in 2004. The value of sales of pesticide was static for almost two decades until 2003, increasing almost at the same rate as inflation. The reasons for the stagnation are: lower consumption, lower cost of herbicides as a result of older products emerging from their patent-protected period, lower commodity prices, increased use of lower-cost generic pesticides and lately, the use of insect-resistant biotech cotton. Pesticide sales increased by 13% in 2004 compared to 2003. Most of the increase came in Latin American countries where sales increased by 26%. Despite the fact that the region has an active generic pesticide industry, sales still increased significantly in Argentina and Brazil. North America accounted for 27%, Western Europe 24%, Asia Pacific 25%, Latin America 14% and the rest of the world 10% of all pesticide sales. Herbicides accounted for 45.9% of the pesticide market, followed by insecticides (26.7%), fungicides (22.6%) and other products including growth regulators and crop desiccants (4.9%). The share of herbicides is increasing due to high labor costs and the reduce use of insecticides.

Plant Protection Chemical Use in the World (Sale in Million US$)

Chemical Group	2000	2001	2002	2003	2004
All Crops					
Herbicides	13,796	13,386	12,475	13,348	14,849
Insecticides	8,206	7,744	7,314	7,738	8,635
Fungicides	5,818	5,467	5,450	6,055	7,296
Others	1,364	1,347	1,322	1,374	1,569
Total:	29,184	27,944	26,561	28,515	32,349
Cotton					
Herbicides	675	740	685	673	777
Insecticides	1,548	1,467	1,351	1,423	1,618
Fungicides	57	58	57	60	70
Others	282	266	254	252	280
Total:	2,562	2,531	2,347	2,408	2,745

Source: Cropnosis, Limited, Edinburgh, UK.

Pesticide Market Concentration 1994-2004

Beginning 1994	By 1997	By 1999	2000-2004
BASF (EU-G)	BASF	BASF	BASF
Cynamid (US) [took over Shell Agri (UK/Dutch) in 1993]	Cyanamid bought by AHP, 1994 (US)	Cyanamid (US) purchase completed in 2000	
Bayer (EU-G)	Bayer	Bayer	Bayer (EU-G)
Hoechst (EU-G)	AgrEvo		
Schering (EU-G)		Aventis	
Rhône-Poulenc (EU-Fr)	Rhône-Poulenc (EU-Fr)		
DowElanco (US)–incorporating Eli Lilly	DowElanco (US)–incorporating Eli Lilly	Dow AgroSciences	Dow AgroSciences
Rohm & Haas (US)	Rohm & Haas	Rohm & Haas	
DuPont (US)	DuPont	DuPont	DuPont Crop Protection
Monsanto (US)	Monsanto	Monsanto	Monsanto
Ciba Geigy (Swiss)	Novartis (Swiss, merger 1996) (Acquired Merck)	Novartis	
Sandoz (Swiss)			Syngenta AG (Swiss) formed in 2000
Zeneca (ex-ICI)(EU-UK)	Zeneca	Zeneca (UK-Swedish) (1999)	

Source: Dinham, Barbara, 2005

Six large companies dominate the pesticide market and accounted for 77% of all pesticide sales in 2004. The six companies accounted for 73% of sales in 2002 and 81% in 2003. The pesticide industry has experienced increased concentration, and the number of major pesticide companies was reduced by half between 1984 and 2003.Above, the industry concentration over the last ten years is shwon above.

It is estimated by Cropnosis (2005) that 8.5% of all herbicides, insecticides, fungicides and other chemicals used in agriculture by value in 2004 were used on cotton. Fruit and vegetables consumed almost 29% of all chemicals (by value) followed by cereals with 16%. Cotton accounted for almost 19% of all insecticides used in 2004.

Use of Generics in Cotton

Generic insecticides are used in all major cotton producing countries including Australia, China (Mainland), India, Pakistan and USA. Generic insecticides make up almost 35% of all insecticides used in Australia. Similar levels are probably valid for the USA, but data are not available. Pakistan is one of the largest, if not the largest, consumer of generic insecticides in the world for use on cotton. It is estimated that generics accounted for almost half of the insecticides used on cotton in Pakistan in 2005/06. Generics made up 40% of all the insecticides consumed in Pakistan in 2004. The share of generics has continued to increase since they were approved for commercial use in 1993. Generics were introduced in Pakistan in an effort to control the leaf curl virus when the struggle against whitefly was at its peak. The major reason for generics becoming popular in Pakistan was that they cost less than brand name insecticides, as is the case in every country. In February 2005, the Government of Pakistan put 34 branded pesticides on the list of generics that can be imported into Pakistan. Once again, the objective was to reduce pesticide prices to affordable levels for the benefit of growers. Pakistan imports insecticides worth approximately $170 million every year.

Latest Trends in the Pesticide Industry

Governments and researchers together promoted the use of insecticides for many years thus facilitating the development of chemical-dependent production systems. The agrochemical industry took the early initiative in educating dealers, extension workers and farmers in the safe and effective use of insecticides. The motive behind the industry-led initiative was to achieve sustained use of their product or products in what is a tough competitive market in most countries, as well as to prolong the commercial life of their products through proper use. This became necessary because of the high cost of product development, coupled with the danger of the development of resistance to a product by target insects. Product development costs were a reason for pesticide industry consolidation. The pesticide industry worked aggressively and complemented the activities of governments and researchers. Consequently, there were many significant research and development breakthroughs in the agrochemical industry. Companies were more aggressive in education in the beginning, but slowly these programs tapered off as companies became aware of the need for additional resources to diversify their activities. The trend is now shifting toward a seed- and biotechnology-driven crop protection market. Biotechnology has affected the agrochemical industry and the development of new chemical technologies seems to have slowed in favor of biotechnology. Companies are adopting a common approach to promote the agrochemical industry as a plant science or crop sciences industry. Biotechnology is now an integral part of the strategies of all the six major companies.

Plant protection has changed from a chemical- based (insecticide use) system to more of a seed- and genomics-dependent research and development field. As seed companies moved forward to understand and use newer technologies, the pesticide companies also developed an interest in seed- based protection systems and now operate their own seed companies. Biotech varieties developed by Dow AgroSciences and Syngenta are already on the market and close to commercial utilization respectively. Monsanto, the largest biotechnology company in the world, also owns seed companies.

There may be a lessened demand for new products, and research and development resources have to be shared with other development lines. This results in the slower release of new products. Companies are also aggressively reducing the number of active products they have on the market, and many have cut their product portfolios to less than half in the last 10 years.

In a way, biotechnology is directly competing against insecticides by providing less expensive, environmentally safe and easy to use alternate technologies. The pesticide industry has to reorient their product development chain and make it competitive against alternate technologies. The new chemicals are more target- specific; they break down quickly (safer for the environment) and are available at lower prices than before.

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Cotton Contamination and its Elimination: Status Report

Cotton contamination is a serious issue, and efforts must be made to avoid contamination during picking, handling and processing. Once cotton is contaminated, it is difficult to clean. Ginning breaks contaminants into smaller pieces that are automatically spread throughout a much larger volume of cotton. Some contaminants are white in color and are so similar to cotton lint that neither machines nor the human eye can identify them. Field and handling practices should be designed to ensure that cotton does not come in contact with polypropylene, plastic, grease, oil, sand/dust, human hair, bird feathers and stamp color which are some of the world's most common cotton contaminants. None of these materials are present in the cotton before picking, but they are added at various stages from picking until the lint reaches a spinning mill.

However, some contaminants originate within the plant material. Three such contaminants are: seedcoat fragments, motes (unfertilized ovules, aborted seeds and undeveloped seeds) and neps. While motes are variety and agronomy dependent, neps are mostly determined by fiber length, fiber maturity and processing. Fibers that are less mature, tend to make more neps, and some varieties may always produce less-mature fibers. Fibers get tangled during processing, thus forming neps. Processing also creates neps because fibers are stretched and then suddenly released. The released end may twist around itself or around other fibers to form a loose nep. During later stretching loose neps may entangle and become real neps. Machine picking usually produces 30% more neps than hand picking. After picking, each successive operation including, drying, cleaning, ginning, post cleaning and carding, increases the number of neps. The only source of seedcoat fragments is poor ginning, where some motes may be crushed to form seedcoat fragments or some hard seedcoats may break up into smaller pieces as a result of a direct hit against saw teeth. In the present article, however, contaminants other than plant material, such as honeydew, neps, seedcoat fragments and motes are the primary focus.

ITMF Survey

The International Textile Manufacturers Federation (ITMF) undertakes a survey of cotton contamination every two years. The latest report was published in August 2005 based on production during 2004/05. 716 samples from 249 growths were analyzed by 152 responding mills. Survey questionnaires were sent to the mills asking if they had consumed particular cotton of specific origin. The respondents were asked to specify if the cotton of a particular origin was contaminated and, if so, whether the contamination was moderate or serious. Respondents were also asked to report if they found stickiness and seedcoat contamination in the cotton they consumed. The ITMF survey is not statistically designed to analyze representative and exact numbers of samples from each country. However, the ITMF data is the only source of information on cotton contamination at the international level.

The 2005 report showed that 22% of the all cotton analyzed in the survey had at least some kind of contamination: 15% had moderate contamination while 7% had a serious contamination problem. The prior report, which appeared two years earlier, found that 26% of the samples tested had contamination, 8% of it serious contamination. Since the ITMF started these surveys in 1983, 2005 was the first time that the contamination percentage was lower than in a previous survey. Contaminants included fabrics and strings made of woven plastic, plastic film, jute/hessian and cotton, organic matter (leaves, feathers, paper, leather, etc), inorganic matter (sand/dust, rust and metal/wire) and oily substances like grease oil, rubber, stamp color and tar.

The survey also showed that 17% of the 716 samples had some level of stickiness. The data from 1989 onward show that stickiness is on the decline. Stickiness is caused by aphids and whiteflies, and these pests are better controlled now than they were ten years ago. However, seedcoat contamination, which is related to poor ginning and seed maturity, is still a serious problem in cotton as indicated by the fact that 37% of the samples were found to contain seedcoat fragments. The problems with contamination, stickiness and seedcoat fragment are specific to some countries. Some countries produce cotton that is clean, free of stickiness and sparse seedcoat fragments, others need to take measures to avoid discounts due to contamination.

Contamination Studies in Indonesia

A textile mill in Indonesia that consumes cotton from many origins has found an increasing trend in cotton contamination (Vijayshankar and Sukarmadji, 2005). Spinners have to make extraordinary efforts to get rid of contaminants. They have to install additional equipment in the blow room and in the winding process. Work is under way to develop devices capable of detecting contamination at carding, in the draw frame and in following operations. These devices can remove the bulk of foreign matter, albeit at an additional cost, but there is no device that can get rid of all contaminants. Seed coat fragments, for example, become so entangled with fibers that they are very difficult to remove, and stickiness is simply impossible to remove. The sugar particles responsible for stickiness are so firmly attached to the fiber surface that it is impossible to get rid of them without chemical treatments or washing. Both of these operations not only add to cost but also have their own consequences. Thus, the goal of all spinning mills is to detect and eliminate contaminants as thoroughly as possible and at as the lowest possible cost.

Manual labor has been tried in Indonesia and India, but it is very expensive to clean 100-125 tons of lint a day at a spinning mill. However, PT Apac Inti Corpora has installed consummate contamination removal lines that are designed to ensure that few undesirable particles escape detection by workers (Vijayshankar and Sukarmadji, 2005). According to Vijayshankar and Sukarmadji (2005) the tables used by workers at PT Apac Inti Corpora, Indonesia for cleaning cotton use a wire mesh to sift out everything they can by shaking the cotton. Another part of the table has a white surface to make it possible to detect colored contaminants. It is estimated that up to 98% of contaminants can be removed by this method. Cotton is cleaned and stored for later use. According to Vijayshankar and Sukurmadji (2005) of the PT Apac Inti Corpora, the cost of manual cleaning is 1.4 to 2.0 cents per pound, depending on the degree of contamination. The cost of cleaning increases with the degree of contamination. The mill started using manual cleaning seven years ago, and their experience over the last seven years shows that no cotton was found to be free of contamination. There was wide variation in contamination among shipments coming from the same country of origin. Cottons from different countries differ in the degree of contamination, but the nature of the contaminants is similar among countries (if cotton is hand picked).

Vijayshankar and Sukarmadji (2005) classify contaminants into two categories. The first comprises materials such as human hair, animal hair, bird feathers, yarn fragments, polypropylene fiber, jute/hessian and others that are broken up into small pieces and difficult to identify and eliminate. The other category comprises material that does not break into tiny pieces and often gets into the cotton after ginning and during baling or handling of lint. Vijayshankar and Sukurmadji (2005) found some unusual items in this category such as currency notes, cold drink cans, metal pieces, etc. However, it is easier to identify and remove this material.

Electronic instruments to detect and eliminate contaminants in the blow room and during winding are expensive. Furthermore, such devices are unable to identify contaminants smaller than 1 cm sq, and by these stages most contaminants have already been reduced to a smaller size. Vijayshankar and Sukurmadji (2005) estimated that 60-65% of contaminants can be eliminated by electronic instruments in the blow room. Human hair, feathers and small pieces of polypropylene escape detection and are not eliminated. An additional 20% of contaminants can be eliminated during winding, bringing the total to 80-85%, which is satisfactory. The problem arises when the electronic equipment fails to detect contaminants due to a loss of the contaminant identification capability. Cleaning in the blow room does not entail any difficulties, but cleaning during winding may affect speed and the yarn quality. There is a high likelihood of leaving hairs and other smaller pieces of contaminants in the cotton and having them show up in the yarn.

It is not easy to establish acceptable limits for contamination. However, based on their seven years experience, Vijayshankar and Sukurmadji (2005) found that reducing contamination to less than one gram per ton of lint helps to minimize the number of complaints. They strongly recommend using cotton cloth for wrapping bales, but if polypropylene has to be used it should be thick transparent polypropylene.

Contamination Studies in Pakistan

Cotton is all hand picked using family and contracted labor in Pakistan. Material for picking is provided by farmers, usually polypropylene or polyethylene. Discarded fertilizer bags are common. Farmers store cotton for short periods and old and torn jute and polypropylene bags are often used for this purpose. Thus, material used to pick and handle cotton becomes a source of contamination. According to a local study undertaken in Pakistan, the country is losing approximately 10-15%of the export value of its raw cotton, mostly due to contamination. The following is a listing of contaminants and the average amount of each per 175-kg bale of lint:

Contamination	Grams/bale
Jute/hessian	12.00
Polypropylene	2.80
Polyethylene	1.78
Colored cloth	0.80
Others	2.00
Total:	19.38

Contamination in Pakistan at 0.01% by weight is far higher than in many other countries, and Pakistan is losing millions of dollars due to this factor. With an estimated annual loss of 10 %, the income lost to the country comes to over $500 million per year. Realizing that the contamination problem starts at the farm, the government decided to intervene to reduce contamination at the farm, market and ginning levels. The Agriculture Department of the government of the province of Punjab, started a pilot project in the district of Rahim Yar Khan in 2001/02 to attempt to improve the situation.

- Farmers in the project area were taught techniques of clean picking. Cloth bags were provided, and farmers were advised to pick cotton using only cloth bags. They were trained in proper storage, the elimination of extraneous matter and safe transportation of seedcotton in cotton bags or covered trolleys. Farmers in non-project areas transported loose cotton in open trolleys.
- At the market level, traders were trained to have separate elevated platforms for cotton storage, proper protection against dust and other foreign matter and to eliminate the use of jute bags and jute twine.
- At the ginning stage, the emphasis was on teaching operators to maintain clean platforms, pick foreign matter manually at various ginning stages and wrap bales in cotton cloth.

These efforts succeeded in reducing contamination from 19.4 gm to 1.8 gm per bale (175 kg lint). Farmers received a premium of Rs.20 to Rs.50 per 37.32 kg (one maund) of seedcotton (30 to 80 cents/37.32 kg of seedcotton) as a reward for producing cleaner cotton. The Government of the Punjab is considering launching a full-scale project throughout the province covering about three million hectares. Unfortunately, a decision has not been made to implement this project, although the government has already passed a law on this subject. One important clause of the law, known as the Cotton Control Act, is a follows:

> Section 17: Punishment for admixture, adulteration, contamination and watering cotton
>
> (1) Any occupier of a factory or any other person.
>
> (a) Who handles or facilitates handling cotton in any cloth made of other than cotton fiber, uses twines made of any fiber other than cotton, waters seed cotton or lint beyond specified limits (more than 10%) allows any foreign substance i.e., jute fiber, jute twines, polypropylene bags, human/animal hair, confectionery wrappers etc; gins or presses or allows such cotton to be ginned or pressed in such factory: or
>
> (b) Who, in any area specified in the notification under section 16, gins or presses or allows to be ginned or pressed any cotton which he knows or has reasons to believe to contain an admixture of different varieties of cotton;
>
> Shall be punishable with imprisonment, which may extend to six months and with fine, which shall not be less than fifteen thousand rupees ($250).
>
> (2) Any owner of cotton who knowingly waters or causes to be watered any cotton to be ginned, or which being already ginned and is intended to be pressed in a factory or mixes or causes to be mixed other varieties, seed, foreign substance or cotton waste with such cotton, or who abets or knowingly allows or connives at any such act, shall be punishable with imprisonment which may extend to six months and with fine which may extend to fifteen thousand rupees ($250).

The Trading Corporation of Pakistan is a public sector body responsible for the implementation of the minimum price support system for various agricultural commodities in the country. If the market price for seedcotton starts dropping below the minimum support price fixed by the government, the Corporation is supposed to start buying cotton off the market reducing the supply and thus pushing prices above the target/threshold price. The following is a clipping from a local newspaper, *The Nation,* published on July 26, 2005. *"The corporation would procure 100,000 bales of cotton (20,000 bales from each district). If in this cotton, the contamination level were 1.5 grams per bale (of 170 kg) the premium would be Rs.150 per maund (US$70/ton of seedcotton), in case of 2.5g contamination the premium would be Rs.75 (US$35/ton) and 3g contamination the premium would be Rs.50 per maund (US$23.3/ton of seedcotton)."* The issue here is not the price support system nor the quantity of cotton purchased by the Corporation, but the incentive to produce uncontaminated cotton.

Contamination Studies in India

The work done in India has been of a practical nature, including extensive analysis of cotton, communication of information to cotton suppliers and education of the firms and persons involved in producing contaminated cotton. The work was undertaken by one of the largest groups of companies in the textile industry in India. Patodia (2003) reported at the 62nd Plenary Meeting of the International Cotton Advisory Committee in 2003 that equipment worth roughly $200 million had been installed in spinning mills around the world to identify and eliminate contamination. Efforts were made to detect contamination at the blow room stage and to remove it with the help of equipment like the Jossi Vision-Shield, Barco, Loptex, Tatsumi, Securomat, Vetal, Sieger, etc. The company, GTN, manually analyzed cotton of Indian and foreign origin and found that white polypropylene thread and fabric, together with bits of alkathene constituted 40% of all contamination; colored polypropylene thread and fabric, along with hair accounted for 30% of contamination; while colored cotton yarn, fabric and fibers, coir, feathers and oily cotton made up 20% of all the contamination. All other contaminants were responsible for only 10% of total contamination.

It is not possible to check every bale of cotton that is consumed by GTN at its four textile units, comprising 165,000 spindles. So GTN randomly selected two bales from each lot of 50 bales of both Indian and foreign cotton. The company developed a contamination index for various grades of cotton and found that not only do Indian and foreign cottons differ in contamination among themselves, but varieties also differ among themselves in levels of contamination. Certain varieties are always more contaminated. GTN noted that in India, independently of the variety, new production areas delivered the least contaminated cotton. GTN undertook the following actions to achieve a long-term solution to the contamination problem:

- GTN bought cotton from many source, and kept records of suppliers who were consistently supplying contaminated cotton. Suppliers were informed about levels of contamination.
- Suppliers were educated about the consequences of processing contaminated cotton. According to Patodia (2003), suppliers were called in for quality discussions over a ten-year period, and taught to buy the least contaminated cotton available.
- Suppliers that failed to improve were eliminated from the supplier list.
- Suppliers that improved in supplying least-contaminated cotton were rewarded with premiums.
- GTN identified their cotton producers and ginners through their suppliers. The company then showed the producers and ginners' samples of fabric made with contaminated cotton. At the same time they instructed them in methods that can help them produce least contaminated cotton.

The following data was presented by Patodia (2003) at the meeting as proof of the success of their approach in reducing contamination.

Cotton Contamination in Guntur Variety

Supplier	Contamination Index 2001/02	2002/03
Supplier 1	7.9	4.3
Supplier 2	8.4	4.7
Supplier 3	6.8	4.0
Supplier 4	8.1	6.7
Average:	7.8	4.9

The self-imposed GTN standards are as follows:

GTN Standards of Contamination

Rating	Contamination A+B+C	D
Excellent	0.0	1.0
Good	< 0.5	1.5
Fair	< 1.0	2.0
Average:	1.0-2.0	2.0-3.0
Poor	2.0-3.0	3.0-4.0
Reject	> 3.0	> 4.0

A=White polypropylene fabric
B=Colored polypropylene string
C=Colored cotton
D=Jute twines

An Approach to Preventing Contamination in the USA

Cotton in the USA is picked by machines, thus minimizing the chances of introducing most kinds of contamination. Still some cotton is contaminated, and at least one-third of the contamination is from plastic. Apparel fibers are also found in US cotton with almost the same frequency. Plastic irrigation ditch liners, road trash, rust, picker heads, module covers and tie-down materials on modules are some of the other common sources of contamination of cotton in the USA. It is evident that the sources of contamination in hand picked cotton and machine picked cotton are different. In machine picked cotton, the level of contamination could be much lower if it were not irrigated and the cotton were not stored in modules. In most cases it is the cotton grower who contaminates the cotton although some contamination is added at gins. People working at gins should keep clothing, hats, gloves, tools and plastic trash away from seedcotton and gin machinery. Oil and grease can also contaminate cotton if proper care is not taken in the field and at gins when lubricating harvesting machines and gin parts. Rubber contamination comes from the picking machine doffers.

Since the cotton industry in the USA is relatively cohesive, contamination complaints are directly and effectively communicated to producers and ginners through a common platform, the National Cotton Council of America. The approach followed in the USA, as in other countries, is prevention. Honeydew contamination is not discussed here, and it is common wherever whitefly and aphids are a problem, particularly when insect pressure is serious at and after boll opening. Grease and oil contamination, most of which is transmitted from fiber to yarn, cannot be eliminated by scouring or bleaching. This is also true for module marking sprays. The National Cotton Council is the lead organization in the fight against the contamination problem. The Council receives feedback from spinners, weavers and end users and produced a video highlighting the consequences of contamination and suggesting recommendations. There are almost 25,000 cotton growers and 976 ginneries. The video is distributed free to ginneries, which then pass on the message to growers. The main recommendations are as follows:

- Vigilance is the key and farmers and ginners must use good house keeping practices in fields, gins, warehouses and around transportation equipment.
- Watch the fields and remove any foreign material that blows or is carried into the fields from roads and highways.
- Modules should be built on ground free of contaminating material.
- Module covers should be properly repaired and when there is a suspicion that they are contaminating the cotton they should be replaced.
- Do not use plastic twine or cord for module tie downs.
- Use only non-contaminating module marking sprays.
- Use only water or wetting agents approved by the picker manufacturer when moistening harvesters; never use motor or diesel oil in moistening systems.
- Clean picker heads and assemblies at least once a week to remove lubricant build-up. Keep pickers and strippers in good mechanical repair.
- Insist on non-contaminating doffer and moistener pads - never use black doffers.
- Use only approved packaging materials and keep bales fully covered during storage.

Elimination of Contamination

The basic approach should be to keep cotton from getting contaminated. Kiechl (2004) reported on the elimination of larger pieces (at least 10x10 cm) of cotton, plastic or polypropylene fabric just before ginning and between the inclined cleaner, the stick machines and green leaf extractors. The cleaning device was first installed after the last cleaning and just before ginning. It was found that large pieces were shredded by the time the seedcotton arrived at the gin-stand. Thus, the device was repositioned between the inclined cleaner and stick machine and green leaf extractor machines, where it could eliminate large pieces of contamination material, whether they are cotton fabric or polypropylene. The large pieces of contaminants wrap themselves around the cleaning cylinders and are ultimately shredded into many smaller pieces. Kiechl (2004) suggested leaving other smaller contaminants to be eliminated later.

According to Langenhove and Kiekens (2000), contamination can be detected and eliminated at the mill at any stage from the bale to yarn. However, each detection and elimination stage has its own benefits and limitations in terms of efficiency, reliability and impact. The best time to eliminate contamination is during the bale opening stage when contaminants are minimal in number and maximum in size. A gripper system can be attached to the detacher arm of the bale opener that moves along the bale continuously and provides an appropriate base for the motion of the detector system. The process is simple and will not interfere with the production speed. But, uneven bale surfaces and the location of contaminants deep inside a bale limit the effectiveness of this option.

Detection and elimination of contamination during opening and cleaning is popular because the installation of a detection system is simple and contaminants have still not been shredded into smaller pieces. An air stream carries off foreign matter, but this system also creates limitations to the adequate detection of contaminants. A complex set of parameters related to airflow and the target objects determines their behavior. Though most fibers will be traveling at almost the same speed, different contaminants or objects may be traveling at different speeds, thus making accurate separation difficult. There is also a possibility that cotton fibers will be carried away along with the contaminants, and transparent material may not be properly detected.

Cotton is in a perfect state at the carding web for the detection of the greatest amount of contamination, even though foreign material may already have been shredded. According to Langenhove and Kiekens (2000), the reduction in size is largely off set by the increase in visibility. A great many more interventions are needed to eliminate the same foreign matter that could have been eliminated more effectively from the bale or during opening and cleaning. The drawback involved in contamination elimination at the card web is the disturbance it produces in the card web itself, which cannot be avoided.

By the time a contaminant reaches the sliver stage it has been distributed evenly in tiny pieces throughout the sliver. Although machines have been developed to extract contaminants from sliver, the fact that the spinning process has to be stopped constitutes a severe limitation to the extensive use of this approach.

Contaminants can also be detected during yarn formation or in the winding stage. Such machines are available, but again, stopping the spindle to get rid of contaminants affects process efficiency. Optical sensors are used to detect contamination at any stage; none of the existing processes can guarantee 100% detection and elimination.

Strolz (2004) reported to the 27th International Cotton Conference, held in Bremen, Germany in March 2004 that almost 1,200 opening lines at spinning mills have some sort of electronic equipment capable of detecting and eliminating contamination. He estimated that approximately five million tons or almost 25% of world production is processed electronically to eliminate contamination. Additionally, some cotton is also scanned for contamination at winding. So, in total almost 30-35% of world cotton consumption is processed to detect and eliminate contamination. Most of this equipment has been installed in the last ten years.

The Root Cause and the Way Forward

Some organic material will inevitably be mixed with the cotton during picking, but most contamination can be easily avoided if the actual origination points for each contaminant are identified and the appropriate measures are taken in a timely manner. Cotton is not contaminated on the plant, but as soon as it is removed from the plant the contamination process begins and it ends only after the cotton has been packed in bales and is ready to be shipped to the mill for spinning. The stages where contamination occurs are: the seedcotton picking operation, handling at the farm, transportation to smaller storage facilities, storage at homes, transportation to gins, storage at gins, ginning and bale packing. All these processes should be made safe enough to avoid contamination. Cotton should be picked in cotton cloth bags instead of bags made of any other material; seedcotton should be placed on a cotton cloth in the field to avoid contamination with dust or sand. Seedcotton should be stored at home and transported in such a way that the known contaminants are not allowed to come close.

Cotton cannot be delivered free of contamination, but there is no standard for what is an acceptable level of contamination. Even when cotton is picked in cotton cloth bags, only cotton fabric is used to transport cotton, cotton is wrapped in cotton fabric after ginning and all other efforts are made to keep contaminants out, there is still the possibility that lint may be contaminated with cotton fibers, cotton strings or yarn or even fabric. Cotton contaminants are the least damaging as they will be dyed along with the production material, but contamination with cotton fibers, strings and fabric may become a problem if the fabric produced is white. The most damaging contamination is the one that creates neps and does not dye similarly to cotton.

The textile industry is affected adversely by contamination, and that is why textile manufacturers have raised the issue of contamination to the highest level. Machinery manufacturers discovered that contamination detection and elimination devices could become a new and lucrative business (Schoeller and Blum, 2000). Efforts have been made to convey the message about contaminants to producers and ginners, but not enough steps have been taken to improve the situation. The way forward requires that producers and ginners recognize that they are responsible for contamination and they must take measures to prevent it. Their efforts will need to be rewarded with better prices for producing least-contaminated cotton. Everything that needs to be done to produce clean cotton is known. Now producers and ginners have to take up the challenge of producing least-contaminated cotton. To achieve this objective, pilot projects must be started in countries known to produce contaminated cotton, and these projects should ultimately be expanded into national programs.

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The First Year Commercial Performance of WideStrike™ Biotech Cotton

Only four types of insect-resistant biotech cottons have been commercialized as of early 2006. Three of them are Bollgard (Cry1Ac), Bollgard II (Cry1Ac+Cry2Ab) and WideStrike™ (Cry1Ac+Cry1F). The fourth type of insect-resistant cotton was developed by the Chinese Academy of Agricultural Sciences and carries the Cry1A gene. It is called 'Guokang' and its use is limited exclusively to China (Mainland). Both the Bollgard and Guokang biotech varieties have been commercialized in China (Mainland), but more than 3 million hectares were planted to Guokang-type varieties, out of approximately 3.5 million hectares planted to biotech cotton in 2005/06. While Bollgard cotton was commercialized in 1996 and Bollgard II toward the end of 2002, 2005/06 was the first year when WideStrike™ went into commercial production.

There are two reasons why researchers/companies pursue new genes. First, target pests can develop resistance to existing toxins, and secondly there is a need to expand the spectrum of pests controlled by biotech cotton and to increase efficacy against pests already controlled. The development of WideStrike™ is in line with both objectives, although the Chinese Academy of Agriculture Sciences and Monsanto claim that a resistance management program is not necessary in China (Mainland) due to the rapid development and replacement of Bt genes, as well as the farming systems used in the country. China (Mainland) has a small-scale farming system and there are plenty of alternate host crops that are grown at the same time that cotton is in the field.

Approval of WideStrike™ for Commercial Production

The Dow AgroSciences LLC tested WideStrike™ varieties in field trials for more than three years. WideStrike™ was also tested under the Environmental Protection Agency's Experimental Use Permits in 2003 and 2004. The insect resistant character of WideStrike™ received full registration from the U.S. Environmental Protection Agency on September 30, 2004 for commercial production in 2005/06. The dual action of WideStrike™ comes from the two genes that have been isolated from the soil bacterium *Bacillus thuringienesis* (Bt). The Cry1F gene provided an additional tool for farmers and researchers to continue delaying the development of resistance to the Bt toxins expressed in insect resistant biotech varieties. Prior to planting for the 2005/06 crop, Dow AgroSciences LLC announced that the novel insect resistant genes would only be available in varieties developed by the PhytoGen Seed Company in the USA. Only three such varieties were available for commercial cultivation in 2005/06, including PHY 440 W, PHY 470 WR and PHY 480 WR. The first variety contains only WideStrike™ genes while the other two also have the Roundup Ready herbicide resistant gene. WideStrike™ is still approved only in the USA.

Mode of Action of WideStrike™

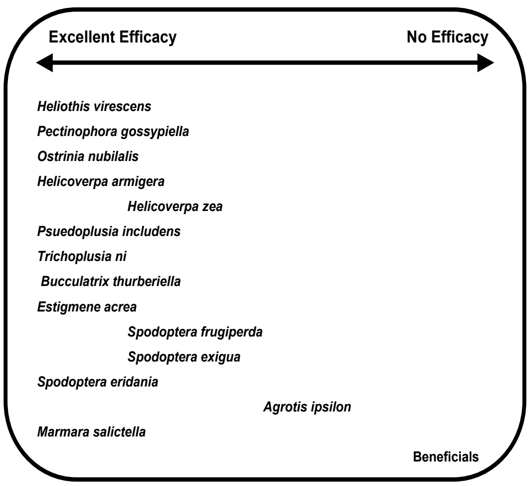
WideStrike™ is most effective against four key pests: tobacco budworm *Heliothis virescens*, the American bollworm *Helicoverpa armigera,* pink bollworm *Pectinophora gossypiella* and the cotton bollworm *Helicoverpa zea*. In addition, WideStrike™ has the potential to control several other lepidopteran pests, both heliothine and non-heliothine. Cry1Ac and Cry1F bind to specific receptor molecules on the midgut epithelial cells of the target pests. The receptor causes pores in the midgut cells leading to lysis, cessation of feeding and ultimately death of the pest. The overlap among receptors is incomplete. Cry1Ac binds to at least three receptors while Cry1F binds to at least two receptors in the tobacco budworm. In the cotton bollworm, Cry1Ac and Cry1F each bind to at least four receptors, of which two are shared. Data submitted by Dow AgroSciences to the US Environmental Protection Agency for approval of WideStrike™ reported that in cotton bollworm approximately 60% of Cry1Ac binding takes place on receptors that also bind with Cry1F, while the remaining 40% of Cry1Ac binding is to receptors that do not bind with Cry1F. Incomplete shared binding is expected to delay cross-resistance when resistance is mediated by receptor changes. The US Environmental Protection Agency examined the effects of the Cry1F and Cry1Ac proteins separately and in combination to detect any synergistic effects on non-target wildlife. No synergistic effects or increase in the non-target host range were found to be the result of combining these two proteins in the same product.

The effectiveness of Cry1Ac and Cry1F together was found between good and excellent against tobacco bollworm *Heliothis virescens*, cotton bollworm *Helicoverpa zea*, the American bollworm *Heliothis armigera,* pink bollworm *Pectinophora gossypiella*, cabbage looper *Trichoplusia ni,* soybean looper *Pseudoplusia includens*, saltmarsh caterpillar *Estigmene acrea*, European corn borer *Ostrinia nubilalis,* beet armyworm *Spodoptera exigua*, fall armyworm *Spodoptera frugiperda* and southern armyworm *Spodoptera eridania.* Their effectiveness against black cutworm *Agrotis ipsilon* was found to be moderate (Haile *et al*., 2004).

WideStrike™ Activity Against Non-Heliothines

WideStrike™ is effective against heliothine lepidopterans because it carries the Cry1Ac gene that has proved effective in the form of Bollgard cotton. Haile *et al*. (2004) studied the effect of Cry1Ac and Cry1F proteins again non-heliothine insects and concluded that WideStrike™ is quite effective against many non-heliothines. Studies compared populations of non-heliothines on a WideStrike™ variety versus a conventional variety. In cases where the field population of the target insects was not large enough, additional populations of the target insects were released in the field. Field and bioassay studies over three years, from 2001 to 2003, found that WideStrike™ was highly effective against the pink bollworm, cabbage looper, soybean looper, salt marsh caterpillar, and European corn borer, and that its effectiveness against spodopterans, including beet armyworm, fall armyworm and southern armyworm, was good. WideStrike™ also provided moderate control of the black cutworm, which is almost equivalent to conventional insecticide control. WideStrike™ activity against heliothine and non-heliothines may be calculated as follows:

WideStrike™ Efficacy Against Lepidopterans



One of the most significant additional advantages of Cry1F is that it provides protection against *Spodoptera* spp. Historically the fall armyworm, *Spodoptera frugiperda* was not a consistent pest on cotton in the USA, but whenever it appears in significant population densities it is capable of causing significant losses in yield. Tindall *et al*. (2006) conducted field and lab trials and observed that WideStrike™ is quite effective against the fall armyworm and may eliminate the need to spray insecticides against this pest. They artificially reared the pest, and then they infested the ten first position white flowers twice with ten 2-day old larvae. Five-day old larvae were released three times on flowers of similar positions. Flowers were covered with nylon mesh and the damage was estimated after seven days. Data showed that in comparison to a conventional variety, fewer fall armyworm infested bolls abscised on WideStrike™ plants. Damage to the flower bracts of a biotech and a conventional variety was the same with 2-day-old larvae, while almost 50% fewer bolls were penetrated by the fall armyworm on the WideStrike™ variety as compared to a conventional variety. Results were similar with the 5-day-old larvae, except that the percentage of damaged bracts was 60% lower in the WideStrike™ variety.

Tindall *et al*. (2006) conducted lab experiments using two colonies, the second being more aggressive than the one used in the field. Both colonies were exposed to squares and small bolls (when squares were not available) of a WideStrike™ and non-biotech variety. Squares were placed in plastic cups in the lab, and one larva was released per square. Mortality was recorded daily after infestation. The lab experiment also showed that larval mortality was higher on WideStrike™ than on the non-biotech variety throughout the season. On average, the larval mortality time was 2.5 days after infestation and all larvae were killed within seven days after infestation.

WideStrike™ Versus Bollgard II

The addition of the Cry2Ab endotoxin to the Bollgard II cotton increased its efficacy against the cotton bollworm, *Helicoverpa zea*, compared with the single gene Bollgard cotton (Jackson *et al*., 2003). Jackson and his colleagues also compared various Bt genes in 2004, and in 2005 conducted comparative field studies in North Carolina and Virginia matching WideStrike™ against Bollgard II. They tested the two Bt technologies against each other and against non-Bt cotton grown under insecticide sprayed and non-sprayed regimes. The five varieties included in the tests were PHY 475WRF (WideStrike™+Roundup Ready Flex), PHY 470WR (WideStrike™+Roundup Ready), PHY 440W (WideStrike™), PHY 410R (Roundup Ready non-Bt) and DP 42BGII/RR (Bollgard II+Roundup Ready). The North Carolina trial included all the combinations, while the trial in Virginia included only WideStrike™ and non-Bt genotypes. Temik was applied to control early season sucking insects, and mid-season plant bugs and stinkbugs were also chemically controlled. In North Carolina, the insecticide-treated plots were initially treated on the basis of a larval threshold and then sprayed weekly for four weeks to achieve perfect control of the insects. On the other hand, the early sprays in Virginia were based on egg count. Weed control, fertilization, application of growth regulators and defoliants were conducted as recommended (by the respective universities) for each location. Each plot comprised four rows, each of them 12.2 meters long (40 feet). Rows were spaced 0.9 meter apart and only the two central rows were used for assessing yield.

The data from the Jackson *et al*. (2006) trial conducted in North Carolina showed that the un-sprayed non-Bt variety PHY 410R suffered significantly higher bollworm damage on all the three dates. The sprayed non-Bt variety PHY 410R was found to have suffered insignificantly different bollworm damage as compared to all biotech varieties carrying either of the two Bt genes. All Bt-gene varieties showed insignificant differences in bollworm attack, whether they were sprayed or not. However, non-sprayed PHY 440W and PHY 470WR and PHY 475WRF showed numerically greater bollworm damage on the three dates as compared to their sprayed regimes. Similarly, WideStrike™ varieties suffered greater bollworm damage than the Bollgard II varieties, which might be due to the enhanced bollworm efficacy of Cry2Ab over Cry1F. All biotech varieties, independently of the Bt gene, had zero bollworm-damaged bolls on all dates. Seedcotton yield in the non-Bt varieties dropped significantly if they were

Performance of Various Varieties and Bt Technologies Under Sprayed and Un-sprayed Conditions in North Carolina, USA

Variety	Insecticides	Bollworm Damage			Seedcotton Yield
		August 18	August 25	September 1	Kg/ha
PHY 410R	No	12.5 a	24.0 a	33.5 a	2,513 cd
PHY 410R	Yes	0.5 b	0.5 b	2.5 b	3,357 a
PHY 440W	No	1.0 b	2.5 b	4.5 b	3,057 ab
PHY 440W	Yes	0.0 b	0.0 b	0.0 b	3,097 ab
PHY 470WR	No	0.5 b	3.0 b	3.0 b	2,854 bc
PHY 470WR	Yes	0.0 b	0.0 b	0.0 b	3,000 ab
PHY 475WRF	No	0.5 b	2.5 b	2.5 b	2,355 d
PHY 475WRF	Yes	0.0 b	0.0 b	0.0 b	2,492 cd
DP 424BGII/RR	No	0.0 b	1.5 b	0.0 c	3,113 ab
DP 424BGII/RR	Yes	0.0 b	0.0 b	0.0 b	3,306 a

Source: Jackson *et al*., 2006

not sprayed with insecticides. Spraying of biotech varieties showed insignificant differences in yield when compared to their respective varieties. However, yield differences among varieties (all of them together) are significant. This might be due to the genetic background or the ability of varieties to perform differently under different production conditions. The data from the Virginia site was not conclusive because the heliothine population in the trial was insufficient. Jackson *et al*. (2006) concluded from the trials in North Carolina that, WideStrike™ provided a high level of bollworm control; however, Bollgard II was more effective against bollworms than WideStrike™ in conditions of moderate bollworm population. According to Jackson *et al*. (2006), their results also indicated that under certain environmental conditions WideStrike™ varieties would likely require supplemental insecticide sprays for adequate bollworm control in the presence of moderate to high bollworm populations. The difference in the effectiveness of the two types of biotech cottons could be reduced if the target pest pressure is low or in areas where the non-target pest insecticide applications are made.

WideStrike™ has the additional advantage of protecting against non-heliothine lepidopterans that cause significant losses to cotton by feeding on the foliage in addition to the fruiting forms. In many cases non-heliothines may be only secondary pests but the losses they produce may be huge, as is the case of the black cutworm *Agrotis ipsilon* (Hufnagel) that can affect plant stand. Willrich *et al*. (2005) observed that plant stands improved significantly when WideStrike™ varieties were planted alone or in combination with a conventional insecticide treatment program, compared to non-Bt varieties treated for the control of black cutworm in artificial infestation conditions.

In contrast, no significant difference was found in the stand reduction resulting from a natural black cutworm infestation in non-treated WideStrike™ and non-treated conventional varieties. According to Willrich *et al*. (2005) the data suggests that WideStrike™ cotton can provide low-level control of the black cutworm. Furthermore, that control may be as good as or better than an insecticide regime. However, planting cotton late into an existing infestation of late-instar black cutworm may result in unacceptable control, and supplemental insecticide applications may become necessary.

Studies have shown that effectiveness of all the “cry” proteins commercialized in cotton so far is influenced by many factors, including location of the target tissue on the plant, type of plant part (leaf, bud, flower, etc) and the age of the tissue. It is also know that bollworms prefer bolls that are not located on the terminal part of the plant but rather in the vicinity of comparatively older leaves. Older plant parts tend to show lower concentrations of “cry” proteins. This is also true for WideStrike™.

Effect of Insecticide Applications on WideStrike™ Cotton

Yield is an outcome of many interactions. When different genotypes are compared under similar growing conditions, even the timing of input applications can make a difference and give the advantage to one variety over another. No extensive data are available on the yield performance of WideStrike™ versus other transgenic insect resistant varieties because regulations prohibit direct comparisons among Bollgard, Bollgard II and WideStrike™ varieties. Both limitations make it difficult to have extensive head-to-head comparisons and conclude that differences in yield are due only to the relative effectiveness of particular biotech cottons in controlling target insects.

In this case the data from a single variety is reported taking into account where it was grown, whether it was in sprayed or unsprayed conditions and in its conventional and transgenic forms. Langston *et al*. (2004) tested WideStrike™ variety PHY 440W against its non-transgenic parental line PSC 355, used as a recurrent parent in developing PHY 440W, under insecticide-treated and untreated conditions. Trials were conducted over a period of three years, from 2001 to 2003, at various locations. The data showed that when grown under un-sprayed conditions, PSC 355 gave only 73% of the seedcotton yield compared with PHY 440W under the same conditions. Under sprayed conditions, the yield performance of PSC 355 was equal to that of PHY 440W, whether sprayed or unsprayed. The key conclusion is that the WideStrike™ variety PHY 440W produced the same yield independently of whether it was grown in insecticide-treated or unsprayed conditions. The yield data in the table below shows that applications of insecticides on PHY 440W provide no economic benefits, considering that an additional 96 kg of seedcotton per hectare may not be enough to cover the cost of sprays.

Seedcotton Yield (Kg/ha) from 2001-2003

Variety/Treatment	Mean Yield of 13 Locations
PSC 355 (Conventional, unsprayed)	1,744

PHY 440W (WideStrike™, unsprayed)	2,397
PSC 355 (Conventional, sprayed)	2,412
PHY 440W (WideStrike™, sprayed)	2,493

The trials conducted by Huckaba *et al*. (2005) showed why insecticide applications increased yield in a WideStrike™ variety. They compared PHY 440W or PHY 470WR to a non-Bt variety, PHY 410R, at a number of locations throughout the USA under sprayed and unsprayed conditions. Bollworm infestation varied from low to moderate to high, depending on the location, although heliothines were the number one pest at most locations.

The pest level was generally high in the southeastern states and decreased in the direction of the southwestern states to Texas. Data on damage to squares and bolls and yield for two locations out of 17 are given in the table. Bollworm infestation was high at both locations, but the WideStrike™ varieties proved to have excellent control of the pests at both locations compared with he non-WideStrike™ variety, whether sprayed or un-sprayed. The percentage of damaged squares and bolls was extremely low in WideStrike™ independently of whether it was sprayed with insecticides to control lepidopterans or not sprayed. One of the locations exhibited higher square and boll damage, possibly due to the extremely high pest pressure it suffered as compared to the other. The yield data indicates that despite the lower level of damage to squares and bolls in WideStrike™ varieties, it did have an impact on yield.

Square and boll damage to WideStrike™ varieties decreased under insecticide application conditions, and consequently, yield also improved at both locations. The data show that insecticide applications on WideStrike™ cotton does improve yield, but the significance of that yield increase on economic performance has yet to be proved. It seems that at some locations where the bollworm population is excessively high, insecticide applications to control lepidopterans may have an additional economic advantage; in others, like Blackville (table below), that advantage may not exist.

Comparison of WideStrike™ and Non-Bt Cottons at Two Locations

Variety	Insecticides	Percent Damaged Squares		Percent Damaged Bolls		Lint Yield	
		Blackville, SC	Elko, SC	Blackville, SC	Elko, SC	Blackville, SC	Elko, SC
Unsprayed	PHY 440W	3.0 c	8.1 b	2.0 c	10.6 b	1626 a	1465 b
	PHY 470WR	2.0 c	7.5 bc	0.0 c	8.1 bc	1755 a	1258 c
	PHY 410R	42.0 a	59.0 a	34.0 a	40.6 a	639 c	549 d
Sprayed	PHY 440W	1.0 c	0.0 c	3.0 c	0.0 c	1727 a	1779 a
	PHY 470WR	1.0 c	0.0 c	0.0 c	0.6 bc	1900 a	1707 a
	PHY 410R	25.0 b	0.0 c	19.0 b	0.6 bc	1187 b	1761 a

Source: Huckaba *et al*., 2005

Refuge Requirements

Planting of a refuge crop is mandatory in most countries for growers who choose to plant biotech varieties. Approval by the US Environmental Protection Agency of WideStrike™ for commercial cultivation carried the same refuge requirements as for Bollgard and Bollgard II varieties. The objective was to maintain consistency in the field and extend the effectiveness of Bt genes against target pests. Options available for refuge crop are as follows:

- **Embedded un-sprayed refuge**. Five hectares of unsprayed conventional cotton must be planted with every 95 hectares of WideStrike™ cotton. Pure herbicide-resistant biotech cotton can be planted as a refuge crop for insect resistant biotech cotton. If the fields are very big, all WideStrike™ cotton fields must be within 2.5 kilometers of the refuge and the refuge must be at least 40 meters wide. The 5% embedded refuge may be sprayed against sucking insects. However, the embedded 5% refuge may not be treated with any anti-lepidopteran products unless the WideStrike™ field is treated with the same product or a similar one. The embedded refuge cannot be treated with foliar Bt.
- **20% external sprayable refuge**. Twenty percent of the cotton area must be planted to non-WideStrike™ and non-Bollgard/Bollgard II cotton but this area may be treated with anti-lepidopteran insecticides (or another control technology except for microbial Bt formulations). The refuge must be within 1.6 kilometers of the WideStrike™ cotton fields.
- **5% external, unsprayed refuge**. At least 5 hectares of non-Bt cotton (refuge cotton) must be planted for every 95 hectares of WideStrike™ cotton. The size of the refuge must be at least 45.7 meters wide, but preferably 91.5 meters wide. This refuge may not be treated with sterile insects, pheromone, or any insecticide labeled for the control of tobacco budworm, cotton bollworm, or pink bollworm. At the pre-squaring cotton stage only, the refuge may be treated with any anti-lepidopteran insecticide to control foliage-feeding caterpillars. The refuge may be treated with acephate or methyl parathion at rates which will not control tobacco budworm or the cotton bollworm i.e. equal to or less than 0.56 kg active ingredient per hectare). The variety of cotton planted in the refuge must be comparable to WideStrike™ cotton, especially in the maturity date, and the refuge must be managed (e.g., planting time, use of fertilizer, weed control, irrigation, termination, and management of other pests) in a manner similar to the WideStrike™ cotton.
- **Community refuge plan**. The community refuge plan is useful for small growers or special field configurations where neither the 5% un-sprayed nor the 20% sprayed options can be applied. A larger area bounding the entire group of farms would form a geographic 'community' and the refuge requirements would apply to the community of growers and the geographic community exactly as they apply to a single grower. The 5% embedded refuge option may not be used with the community refuge.

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Short Notes

• A New Biotype of Whitefly Detected in the USA

Whitefly is one of the most widespread pests on cotton in the world. It is notorious because it quickly develops resistance to insecticides and, it causes stickiness. The two best known species are *Bemisia tabaci* and *Bemisia argentifolii*. Both are known to exist on cotton, vegetables and ornamental plants in the USA. A new biotype 'Q' was found for the first time in the USA in March 2005. Biotype Q was independently identified in Arizona and California, and more recently it has been detected in northern Georgia. Other reports show that the survey undertaken in 2005 detected biotype Q in 17 states in the USA and one location each in Guatemala and Mexico. The Q biotype of *Bemisia tabaci* (Genn.) was discovered for the first time on commercial poinsettia plants in retail markets in Tucson, Arizona during the winter of 2004/05. The Q biotype is thought to have originated in the Mediterranean region, but it is now the dominant biotype in Europe. It is also reported in China (Mainland), Egypt, France, Israel, Japan, Morocco, the Netherlands and Spain. The Q biotype is physically indistinguishable from the other two biotypes, so high population counts and rapid development of resistance are the two important indicators that the Q biotype may be in a population.

Biotype B was described as a separate species *Bemisia argentifolii* in 1994. Currently, this new species designation is under some dispute with taxonomists who consider it as a synonym of *Bemisia tabaci*. Biotype Q whitefly reproduce and develop more rapidly than biotype B, and Q is better capable of transmitting diseases caused by Gemini viruses and has a wider range of host plants than B. It is alarming that a new pest has been identified with a potential to become a major pest and the new pest has already built resistance to most insecticides. The work done during the last year shows that unlike the silverleaf whitefly *Bemisia argentifolii*, resistance in the Q biotype is stable, and does not diminish over time. The other two biotypes have been controlled successfully in the USA for over a decade, and now it is a challenge for researchers to deal with a new biotype. When there was resistance problem in the past, it took long time for entomologists to formulate recommendations and for the industry to come up with new insecticides. However, the Q biotype has been detected in the early stages of its spread and a lot is already known about this biotype, so effective control maybe developed quickly. Still, a lot more needs to be done to understand how wide spread it is and how to stop it from becoming a major sucking pest in the USA.

• Tolerance Limits for Fiber Quality Testing in Australia

It is very important that a fiber quality testing instrument, whether it is a rapid instrument system or a stand-alone instrument, is properly calibrated. Instruments will produce data that are not repeatable if they are not regularly and properly calibrated. Greater accuracy in measurements has advantages, including higher confidence among parties, fewer chances for disputes and optimum utilization of fiber value. No rapid instrument-testing machine can be expected to perform normally if the relative humidity (65±2%) and temperature ($21^0C±1^0C$ or $70^0F±2^0F$) of samples are not maintained consistently. Proper calibration and optimum conditions become useless if samples are not properly conditioned before testing, so that moisture content ranges from 6.75 to 8.25%. Rapid conditioning is used in the USA, but in most test centers, the desirable conditioning time is 48 hours. It is not desirable to have samples conditioned in sacks, wrappers or other coverings. Samples should be conditioned in a single layer of trays, which allow free circulation of air through each sample. Thus, the three most important conditions for reliable instrument results are sample conditioning, instrument calibration and maintenance of proper humidity and temperature in the lab where testing is done. One cannot compensate for the other.

The hygroscopic nature of cotton fiber, its sensitivity to ambient conditions and natural variations among fibers, still leaves chances for variation in test results. That is why the cotton industry, including instruments manufacturers, fix calibration limits/ranges for various fiber quality characters. It is assumed that if a value ranges within a certain limit for the same cotton sample tested again and again, the reading is correct or the instrument is properly calibrated for testing cotton. It is almost impossible to remain within this limit for the same sample if samples are not conditioned or humidity and temperature are not maintained at 65±2% and $21^0C±1^0C$ or $70^0F±2^0F$ respectively.

Australia has 26 rapid instrument testing machines in use testing cotton. Unlike the USA where the US Department of Agriculture is responsible for cotton classing, cotton classing in Australia is in the private sector. Classers in Australia formed the Cotton Classers Association of Australia, which is an important component of the Australian Cotton Industry Council. The Cotton Classers Association of Australia endeavors to bring harmony among cotton classing labs in the country and to improve confidence in classing data. Confidence in the data is very important in Australia because almost all cotton is exported. The Cotton Classers Association of Australia has a check test program where by two samples are taken from each classing facility at random from a bale or gin on weekly basis for both classing subjective and objective testing. The purpose of check testing is the reproducibility of cotton test results. Each classing office is notified if its instruments are found out of tolerance limits. Accordingly, the classing office takes appropriate measures to bring machine readings within tolerance limits. The tolerance limits recommended by the Cotton Classers Association of Australia are slightly tighter than limits adopted internationally:

Length	±0.02 inches
Uniformity index	±1.0 percent
Micronaire	±0.1 units
Strength	±1.5 gram per tex
Rd	±1.0 units
+b	±0.5 units

• Efficacy of Transgenic Bt Cotton for Resistance to the Asian Corn Borer *Ostrinia furnacalis*

Two types of biotech cottons are grown in China (Mainland) on a commercial scale. Monsanto varieties carrying the Cry1Ac gene were introduced in 1998/99. A locally developed biotech cotton called 'Guokang' carrying the Bt gene Cry1A was introduced and planted on a limited area in 1999/00. However, the area under Cry1A gene varieties has been increasing, and it is estimated that in 2005/06 close to 90% of the total biotech cotton area was planted to varieties carrying the locally developed Cry1A gene. Researchers from the Institute of Plant Protection in Beijing and the Dryland Farming Institute at Hengshui in the Hebei Province compared the efficacy of Cry1Ac (Monsanto) and Cry1A (local gene) against the Asian corn borer, *Ostrinia furnacalis* (Guenée). The Asian corn borer is an important component of the lepidopteron pest complex on cotton in China (Mainland). Researchers planted variety NC 33B (Cry1Ac) and Chinese transgenic variety GK-2 (Cry1A) under field conditions and infested them artificially with the Asian corn borer at different crop stages coinciding with the natural occurrence of the Asian corn borer in the field. Researchers discovered that the damage by the Asian corn borer in the transgenic varieties was much lower than in their respective non-biotech varieties DP 5415 and Simian 3 and a major conventional variety Shiyuan 321. However, the percentage of plants stem-bored and the mean number of tunnels per plant were significantly higher on GK-2 than on NC 33B in the second generation. Laboratory studies on tissue assays using leaves, floral buds, squares and flowers showed that much lower numbers of larvae survived on biotech varieties compared to tissues taken from non-biotech varieties. Studies also concluded that survival was higher on the late-season biotech tissues compared to early-season biotech tissues. In addition, higher larval survival was observed on GK-2 than NC 33B in assays with the late season tissues. This may be associated with lower levels of the available toxin in GK-2 that was further reduced in the older tissues. Both laboratory and field studies showed that Cry1Ac and Cry1A are effective against the Asian corn borer and offer season long control, but the efficacy of each, is different and the efficacy of both declined in older plant tissues.

(Full paper Efficacy of transgenic Bt cotton for resistance to the Asian corn borer (Lepidoptera: Crambidae) was published in Crop Protection, Volume 25, Issue 2, February 2006, Pages 167-173.)