WHY SO MUCH USE OF INSECTICIDES IN COTTON PRODUCTION?

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ABSTRACT:

Cotton is a marvelous product. It is natural, renewable, recyclable and biodegradable. Besides the beautiful yarn and oil and protein rich seeds produced by cotton growers, they also generate jobs, profits and social welfare in rural and in urban areas as well. Worldwide cotton is a 12 billion US$ business, generating some 350 million jobs. In 2015, world cotton area contracted by 9%, to 31.1 million hectares, in response to relatively low cotton prices. Adverse weather and increased pest pressure contributed to a decrease in world average yield of 6%, to 723 kg/ha. Brazil ranks fifth in cotton production worldwide, after India, China, the US and Pakistan. In 2015, Brazil grew some 1 million ha of cotton, with an average lint productivity of around 1.6 t/ha.

As good as it is, many insects, spider mites, nematodes and disease causing microorganisms also prefer cotton. For this, it has become the champion on the use of pesticides worldwide. Cotton growers do not spray insecticides and other pesticides to their crops just because they want to pollute the environment, kill wildlife, and intoxicate their neighbors and they themselves. They spray pesticides because they have made quite an investment in land, seeds labor, fertilizers, machinery and bank loan interests. It is just fair that, at the harvest, they have some return from the money they have spent.

How do Brazilian cotton growers decide on when and what to spray? Some rely on their own experience; others take advice from neighbors, extension agents and/or consultants. In very large conglomerates, cotton growers themselves are so busy with other managerial aspects of their businesses that a technician, usually an agronomist, decides on what and when to spray. The decision is based on previous cropping season pest situation, on recommendations by pesticide dealers, on advice by consultants and, even, on the results of pest scouting.

The most important insect pest in Brazil is the cotton boll weevil (*Anthonomus grandis*), firstly detected in 1983, followed by the old world cotton bollworm (*Helicoverpa armigera*), present since the 2013 cropping season. Other secondary pests, created by the overuse of insecticides against the previous two, include whiteflies (*Bemisia tabacci*), aphids (*Aphis gossypii*) and different species of caterpillars, spider mites and bugs. Triggered by the boll weevil, Brazil is experiencing an insecticide treadmill, when more and more insecticides have to be applied to keep from losing everything.

The author discusses cotton pest control situation in Brazil, makes considerations on the development and application of IPM and indicates what Embrapa is doing to lead a way out of present insecticide treadmill situation.

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Cotton, the King

Worldwide cotton is a 12 billion US$ business, generating some 350 million jobs. It is a major agricultural and industrial crop grown in more than 60 countries. Some 35 million ha of cotton are grown every year in all the five continents. Cotton constitutes the economic base for many developing nations and is a major foreign exchange earner. Cotton provides food and fiber and, when it is grown in association or rotation with food crops, it is responsible for the food security of many countries. Cotton has become a migrant crop worldwide due to political unrest, climatic change, soil conditions, water scarcity and, mainly, because of pests. Inevitably, wherever cotton goes, it has to dispute with other crops in order to gain space and to become competitive. Cotton is quite adaptable to different weather and soil types and may tolerate adverse conditions more than any other crop.

The Enemies of Cotton-Insects

As in other parts of the world where cotton is grown, Brazil has its share of insect pests. In the old days of perennial cotton growing in the Northeast, farmers basically had to deal only with the leaf worm (*Alabama argillacea)* and with the root/stem weevil (*Eutinobothrus brasiliensis)* and, every so often, with the pink bollworm (*Pectinophora gossypiella)*. More to the South where upland cotton was grown and the use of insecticides was more frequent, besides the species previously mentioned, cotton was also plagued by aphids (*Aphis gossypii),* different species of true bugs and spider mites and by the most troublesome bollworms (*Helicoverpa zea*) and (*Heliothis virescens*), against which most insecticides were used. These applications preempted the occurrence of secondary pests like spider mites and whiteflies, and made cotton a less viable agricultural option.

In 1983, the worst pest of cotton known as the boll weevil (*Anthonomus grandis*) was detected in Brazil for the first time, most probably introduced from the US. It has changed the address and the owners of cotton in Brazil. From a small holder activity based in hand labor in the Northeast to a big business, fully mechanized operation in the Midwest. The boll weevil made cotton growing an unprofitable activity in the semiarid zones of the Northeast and turned the new production zones of Central Brazil very dependent on the use of insecticides. During the 2013 cotton growing season, another unwanted visitor, the old world cotton bollworm (*Helicoverpa armigera)* arrived to bring more worries to the already much plagued Brazilian cotton sector.

The Friends of the Cotton Grower

Yes, they are definitely natural enemies of the cotton insect pests but I prefer to call them the friends of the farmer, otherwise it will be difficult to convince a grower an enemy is something good that needs to be protected and harnessed. Once I was checking a large cotton field in the State of Mato Grosso for the boll weevil and for natural enemies. As in the words of the grower, the field was “so well taken care” that I was not able to find a single weevil nor a foraging spider.

He kidded me asking what was so important about finding a spider in his field. I told him spiders were his best friends but he could not believe it. As he was going to Australia in the following week, I suggested him to ask one of the CSIRO entomologists to show to him the role of the spiders in cotton IPM programs there. A few weeks later, he called me and said he was committed to give a chance to spiders and other of his friends, in Mato Grosso too.

In order to sell more insecticides, some dealers propose the idea that farmers must spray more chemicals in tropical areas because pests are more numerous for the number of generations in the warmer winter-free weather. Much to the contrary, biodiversity is so greater in the tropics with such a profusion of natural enemies that pests have less chances of survival in larger numbers. The overuse of broad-spectrum insecticides in cotton production in the tropics suppresses the friends of the farmer (predators and parasites), leading to pest resurgence and secondary pest outbreaks. It leads to a pesticide treadmill, when pests also become resistant to available pesticides and more and more chemicals have to be applied to keep farmers from losing everything.

Unfortunately, the need for crop intensification prompted the development of mono-cropping systems, removing food crops from growing in association with cotton. In some areas, not even crop rotation is implemented. Therefore, systems that were very complex in the past become so oversimplified, favoring just a few species, sometimes just the host plant over a very large area and a few herbivores. Natural enemies do not have much chance in these systems, even less when insecticides are used abusively.

Cotton Production in Brazil

Cotton was already produced in Brazil by the indigenous population before the arrival of the Portuguese settlers in the year of 1500. The Jesuit priests were so impressed by the advantages of this local product that they recommended the Portuguese crown to establish a textile industry in that new and vast colony, where “if planted, anything could grow and produce well”, as written back to the King of Portugal at the time of discovery. Using aboriginal or African slave’s forces, a strong textile industry based on cotton developed in several areas of colonial Brazil and became part of its history, economy, and folklore.

Presently, cotton contributes significantly to Brazil’s agricultural output and foreign exchange earnings. In 2013, the value of cotton production reached US$ 4,078 billion, representing 2.2 percent of the country’s total agricultural output (MAPA, 2014). Annually, over 6,800 farms are involved in cotton production on circa 1 million ha (IBGE, 2014). Cotton exports accounted for US$1,902 billion in 2013, representing 1.87% of Brazil’s agricultural exports (CEPEA-USP, 2014). Brazil is also among the world’s largest consumers of cotton fiber, ranking fifth and accounting for about 3.78% of world cotton consumption in 2013 (ICAC, 2014).
Up to the mid-1980s, most of the Brazilian cotton crop situated in the semiarid zones of the Northeastern Region, and was dependent on cotton varieties of the “moco” cotton, quite unique in the world of cotton as it grew for several years before replanting. This type of cotton usually was interplanted with food crops,

with cattle grazing on crop residues after harvesting. Its low yields were associated with ability to survive for long periods of drought. In spite of its high quality fiber, “moco” cotton production was not particularly sensitive to price and had practically no competition as a cash crop, although it played a very important role in the subsistence farming communities and supported the well-known cattle-cotton production binomial. Most producers were crop sharers whom got seeds and some other inputs from the landowners, invariably the owners of the gins, direct major beneficiaries of this quite perverse relationship. Lint productivity was as low as 200 kg/ha, and production used to vary considerably from year to year because of low and erratic rainfall (Agroanalysis, 2000). Parts of the less arid Northeast and in the Southern states of São Paulo and Paraná produced upland varieties but, even there, cotton growing was basically considered a small to middle holder activity with more input use but still with low production costs and with relatively low yields.

The arrival of the cotton boll weevil in 1983, the inaction of governmental plant protection agencies and a series of wrong policies that followed, including lint and cotton fiber import liberalization, made cotton growing almost impossible, forcing a cotton self-sufficient and net exporting nation to become one of the largest cotton importers of the world in the early 1990s. The “moco” cotton production in the semiarid, for its low productivity and perennial nature, could not cope with the new pest that required recurrent insecticide treatments. On the other hand, upland cotton producers in the Northeast and in the states of Paraná and São Paulo, could not stand the increased production costs brought by higher than normal insecticide use and fierce competition with cotton imported from countries with much lower production costs and higher yields (Santos Filho, 1994).

The above mentioned events coincided with major change in the local agriculture. With incentives by the federal government and technologies developed by the Brazilian Agricultural Research Corporation-Embrapa, traditional soybean growers and agricultural entrepreneurs from the South moved to the Midwest to grow grain and to produce beef. They benefitted from low cost and vast flat land to established large and fully mechanized plantations. Soils were very acidic and of low fertility, requiring large doses of lime and fertilizers. Soybeans, maize and pastures quickly covered millions of hectares of land and brought wealth to a previously neglected and unproductive zone.

Cotton was not a traditional crop to the area, it was introduced in rotation with soybeans and soon became a major fully mechanized crop from planting to harvesting. Weeds were controlled by an array of herbicides in pre and post planting sprayings and the minimum tillage system was soon adopted. Farmers took advantage of the absence of the boll weevil and other insect pests at the beginning. Within a few years, however, all the major insect pests became established, demanding escalating insecticide applications. Because the very high rainfall during the growing season many foliar diseases became prevalent and required recurrent fungicide sprayings. To further complicate things the old world cotton bollworm, detected during the 2013 cotton season, brought new worries to cotton growing communities due to increased use of synthetic

insecticides. Cotton growing in Mato Grosso, West Bahia and elsewhere in the cerrado is an extremely high-input activity with the costs to produce one hectare surpassing 2,500 US$. This very high cost of production forced the smaller growers out of production, concentrating the land and the cotton activity in fewer hands.

Present high-input cotton production systems of the cerrado brought many benefits to the Brazilian cotton industry. They have taken away the hardship of hand weeding and harvesting and released labor to higher income activities, such as industry and services. Additionally, it stabilized cotton production because this activity reduced dependency on weather conditions and labor availability. Cotton production clustered in limited area also facilitated processing and marketing. Cotton became an important component of a complex system that includes grains, cattle, and some alternate crops. Modern inputs such as high yielding varieties, extremely efficient machinery, concentrated fertilizers, less toxic and a more degradable pesticides, and technical information contributed to the high productivity and Brazil managed to produce up to two tons of lint per hectare, the world highest rain fed cotton productivity (Freire et al., 1997).

Cotton farming became a big business and stimulated growers to create associations to fight for their rights and to demand more and direct assistance from the governmental authorities in infrastructure, marketing policies and services related to research and development. The fast developing cotton agribusiness gave way to the establishment of networks for machinery supply, fertilizers, pesticides and other inputs and services. Brazil has become one of the world's leading cotton producers and an important competitor for Asian and European cotton markets. This situation has come about because of, among other things, technological improvements, trade liberalization, and structural transformation of the Brazilian economy and the emergence of new cotton producing regions.

The Situation of Pest Control in Brazil

The arrival of cotton to the cerrado areas of Midwest Brazil met with problems not common elsewhere. The very high rainfall of up to 2,000 mm per year generates a very humid condition, leading to the development of many fungal diseases. Farmers make up to 12 sprayings of fungicides per season. Weed control is heavily dependent on the use of herbicides, a must when the very large and fully mechanized fields are established. The use of herbicide resistant cotton varieties brought many benefits and even lowered the overall cost of production. However, as in other cotton growing areas of the world, clear signs that weeds are becoming resistant to some herbicides are demanding more attention of farmers, extension agents and researchers.

In the last few years, mainly due to the exacerbation of the boll weevil infestations and the arrival of the old world boll worm, there has been a sudden increase in the use of insecticides and, consequently, on the cost of pest control in Brazil. The leading cotton producing countries do not have the boll weevil and

they have adopted Bt cottons in most of their areas, drastically reducing the number of sprayings and control costs.

Although quite belatedly, Brazil has also introduced Bt cotton varieties but is not realizing all the benefits of the technology due to the presence of the boll weevil. The required refugees of conventional non-Bt cotton varieties, which should be left unsprayed, would nurture boll weevil populations to infest the whole area. On the other hand, the early application of non-selective insecticides to control the boll weevil eliminates natural enemies of several species of worms and limits the possibilities of using mass produced biological control agents against them.

The consequences of the over use of insecticides are many fold with economic, social and environmental implications. In spite of the very high yields of the Brazilian cotton sector, the always-increasing costs of insecticides and other inputs are a serious threat to competitiveness in a scenario of reducing cotton lint prices in the international markets. Furthermore, by the elimination of their natural enemies, pests become more difficult to control and resurge at higher infestations, as it has happened in many traditional cotton growing areas of the world, like Central Texas, San Joaquin Valley of California, Cañete Valley of Peru, Or Valley of Australia, Central America and in many other places.

IPM-The Way Out

Integrated Pest Management (IPM) has been defined as the optimization of pest control in an economically and environmentally sound manner, accomplished by the coordinated use of multiple tactics to assure stable crop production and to maintain pest damage below the economic injury level while minimizing hazards to humans, animals, plants and the environment (Flint and van den Bosch 1981). Although the term was coined some 50 years ago and widely accepted, the practice of IPM is not yet wide spread with still many cases of pesticide overuse today.

IPM is certainly the way to go but it must be locally developed with the participation of all involved in cotton production. In different parts of the world where the pest syndrome was installed the way out varied but programs had in common an area-wide approach, which required close cooperation among farmers, extension agents, plant protectionists and scientists. Because pests occur in populations that interact with other populations in complex situations, pest control must be grounded in ecology.

Because the uncontrolled high use of modern inputs in cotton growing, considering their side effects on the economy, on human health and on the environment, it may not be sustainable over the long run, caution must be taken against their overuse. What should count in the future is not the number of cotton bales in the barn but the number of dollars in the farmer’s pocket after all the costs are paid for, with due concern to human health and the environment.

In recent years, the advent of transgenic cultivars with resistance to herbicides and with *Bacillus thuringiensis*-BT genes have revolutionized cotton growing in

the major cotton growing areas of the world, bringing a substantial reduction in pesticide use. India, for instance, has experienced a dramatic reduction in the use of insecticides. Although a great technology with very sound scientific base, genetically modified-GM cottons should not be seen as another panacea. Caution should be taken to use GM-cottons properly within an IPM approach in order not to lose them as happened to other technologies of the past.

With the uncertainties on future cotton marketing trends and a growing concern on the consumer's side in relation to the overuse of pesticides, cotton farmers associations, universities, and research & extension systems must joint efforts to develop more benign and more sustainable cotton production methods to guarantee economic, social and environmental sustainability of this very noble activity of cotton production over the years to come. IPM seems to be the way out.

For situations where the boll weevil is the key pest, as in the case of cotton growing in Argentina, Brazil, Colombia, Mexico and Paraguay, IPM programs must be developed based on the knowledge that this pest is monophagous and depends on cotton for its survival between crops seasons. The basic approach must be to remove cotton plants from the field before the weevil population is large enough to cause damage. This is possible by following these relatively simple steps:

- Destroy completely and thoroughly all the rootstalks soon after harvest. Next year's IPM program starts with the rootstalks destruction of this year crop. It is the best investment a farm can do for next year's crop.
- Plant certified seeds of short-season cultivars with concentrate fruiting, either conventional or transgenic.
- Establish area wide uniform dates of planting, with not more than 15 days elapsed between the first and the last planting.
- Scout fields of adult boll weevil, visually or with pheromone traps and spraying insecticides when 5% of the squares (flower bottom) are punctured or when the trap counting indicates five weevils per trap per week.
- Again, complete and thorough rootstalk destruction, which should be made mandatory.

Whatever tools an IPM program uses, the most important and more difficult to achieve part is the integration of people interested in making IPM a reality.

What is Embrapa Doing?

Embrapa was created in 1973 to make Brazil self-sufficient and exporter of food and fiber. Embrapa Cotton became operational in 1975 with the purpose of developing technology for cotton production in Brazil. It is investing to create varieties that will resist present and future biotic and abiotic stresses, including resistance to pests and diseases. Embrapa's breeding program is developing varieties with resistance to herbicides, insect pests, nematodes and multiple pathogens. Future varieties, transgenic or conventional, will also resist to draught, salinity and other stresses caused by climatic change. They also will be able to produce high fiber quality to meet evolving market demands and competing with synthetic fibers. Crop management practices are being

developed with focus on efficiency and minimal impact on human health and environment. These developments will keep cotton production as a viable option to offer jobs, income and dignity to people involved in the cotton chain.

Of top priority is the development of GM-cotton cultivars resistant to the boll weevil. This may take a long time and will require much funding and an orchestrated effort by entomologists, breeders, geneticists, cell biologists and biotechnologists. The foreseen results will lead the way to guarantee sustainability of cotton growing in the cerrados and the return of cotton to the semiarid traditional zones of the Northeast.

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