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FACTORS INFLUENCING THE USE OF PESTICIDES IN COTTON IN BRAZIL

1. Cotton Pests in Brazil

Cotton, a plant of the Malvaceae family, is cultivated today in Brazil in three macro regions: the North-Northeast (the states of Tocantins, Maranhão, Piauí, Ceará, Rio Grande do Norte, Paraíba, Pernambuco, Alagoas and Bahia); the Midwest (the states of Mato Grosso, Mato Grosso do Sul and Goiás); and the Southeast (the states of São Paulo, Paraná and Minas Gerais). In all these states all the different production systems are found, from very small family farming units of <4 ha, small farming units of <100 ha, and large farming units of >1,000 ha. The larger cotton growers tend to use a higher level of technology; work health and safety monitoring; BMP (best management practices); IPM (insect pest management); and a better level of environmental monitoring.

Of the five countries involved in the study, Brazil is the only one with true tropical production systems, and today more than 90% of cotton area in Brazil is a true tropical agricultural area.

Cotton production during the 1970s and 1980s was concentrated in the northeast, mainly in the states of Piauí, Ceará, Rio Grande do Norte, Paraíba, Pernambuco, Alagoas and Bahia; and in the south-eastern states of Parana and Sao Paulo. This situation started to phase out in the 1980s and early 1990s. The north-eastern region in Brazil was literally taken over by the boll weevil, and the small farming units were unable to control the pest due to a number of factors, including problems created because a large volume of the cotton cultivated was perennial. The south-eastern states lost their importance as a result of competition from sugarcane as well as a series of external economic factors. In the eighties and nineties the textile industry imported an enormous amount of cheap cotton that drove growers away from the activity. Brazil became a major importer of cotton in the mid-nineties, reaching a level of over 400,000 tons per year. The new era of cotton production that has tripled its output in less than 15 years is the result of more technology and capital investment in the sector. The importance of cotton production has always been acknowledged by recent governments and, as a result, production levels have remained stable since the beginning of this century.

Modern production of cotton in Brazil today requires a very high level of knowledge and capital elements, trained labour, financial resources and organization. This situation is required due to the fact that there are very few natural elements to help control pests, such as cold, frost, and extreme drought. The dryland/upland cotton production helps to make this unique situation a major challenge for the success of future production and long-term stability of the Brazilian cotton industry. There are numerous efforts being made to establish new and better best management practices (BMP) and integrated pest management (IPM) practices, but in the last ten years the economic climate has not allowed growers to dedicate financial resources into this effort. In the last few years, the boll weevil has become a major threat to the success of Brazilian cotton production with, in some cases, an excess of 12 applications needed to control the pest. Cotton producers realize that the increase in pesticide use is the result of this pest and, as a consequence, are taking measures to effectively establish a control/eradication program. This will be achieved through ABRAPA, the Brazilian cotton producers association, and the state producer associations, together with the state governments and the Ministry of Agriculture and, hopefully, part of the funds from the WTO dispute settlement.

There are numerous pests that attack the cotton plant. These can be divided in two groups: a) pests which attack the plant during the establishment phase, (root borers, thrips, stem borers, stink bugs, aphids, leaf sucking insects), and b) pests that occur at flowering and boll forming. (Alabama, whitefly, various types of caterpillar, mites, and boll weevils). The most logical method to control these pests is through IPM practices, such as destroying crop residues, concentrated planting windows; use of varieties resistant to attacks; crop rotation and complete control of crop border areas where most infestation begins; as well as monitoring, using pheromones, etc.; and localized controls. Chemical control is used in accordance with the monitoring of the types and specific species of pests. In Brazil, the use of agricultural chemicals requires that prescription and

use be controlled by an agronomist, who will recommend using a systemic, biological or contact product.

1.1 Boll weevil

The “boll weevil” *Anthonomus grandis* Boheman (Coleoptera, Curculionidae) is the most harmful insect pest of cotton in the Americas, causing severe fruit losses and boll damages (Lanteri, 1999). Its original area of distribution, ancestral host plants and pathways of dispersal throughout the continent have been the subject of debate during the last century (Townsend, 1895; Fryxell and Lukefahr, 1967; Burke and Cate, 1979; Burke et al., 1986; Jones and Burke, 1997; Scataglini et al. 2000, 2006).

Some authors have proposed the hypothesis that the boll weevil originated in southern Mexico, from where it spread to the USA together with its wild host plants (Malvaceae of the tribe Gossypieae) probably during the Pleistocene (Burke et al. 1986; Jones, 2001). Once in the USA, *A. grandis* spread out rapidly throughout the Cotton Belt from 1889 to 1916 by the extension of the cotton culture.

There is little information on the appearance and dispersal range of *A. grandis* in South America. On the basis that some boll weevil specimens in South America are morphologically similar to those in southern USA, Burke et al. (1986) proposed the occurrence of multiple introductions from this country associated with commercial exchange. However, genetic studies using Random Amplified Polymorphic DNA markers (RAPD) and a phylogeographic approach based on mitochondrial DNA sequences have given support to a new hypothesis on the origin of South American boll weevils that could change the traditional viewpoints about the evolutionary history of the species (Scataglini et al. 2000,2006; Confalonieri et al. 2003; Lanteri et al. 2003). This novel hypothesis suggests that boll weevil populations in South America can be classified into two types: (i) populations with a single haplotype or very few haplotypes, which are remnants of “bottlenecks” that occurred after colonization and with characteristics of “recent invaders” introduced by trade; and (ii) populations with several highly differentiated haplotypes, which represent an “ancient population” present in the continent before cotton cultivation. The former type is associated to cotton fields and/or nearby areas, and the latter to pristine areas with native forests, such as the Iguazu National Park, Misiones Province, Argentina (Scataglini et al. 2000, 2006). A recent study has confirmed this hypothesis, where data clearly demonstrate that individuals coming from this protected area, with genetic characteristics of ancient lineages, could also be found in neighboring cotton fields (Guzman et al. 2007). This recently found picture is a new scenario for practical actions against such plague since the whole control methodology was not developed for the native *A. grandis* population.

For the first time in Brazil a study was carried out with the objective of showing the diversity and genetic structure of the natural populations of *A. grandis* in Brazil. Twelve populations collected in six Brazilian states, Paraíba, Ceará, Bahia, Pará, Mato Grosso and Goiás, in areas where cotton is grown under both, large farming as well as family farming systems, were evaluated using RAPD, isoenzymas and microsatellites, and concluded that the populations of *A. grandis* in these states showed little genetic diversity when compared to populations in the USA, Mexico and other countries in Latin America, suggesting that the colonization of this insect came about in one or very few areas. The results obtained in relation to the genetic diversity also permit the genetic diversity to be distinguished in regions where there are large farms to regions where there is only family farming. The study also showed that populations in the northeast of Brazil are entering new areas beside areas already identified (Martins, 2006).

The cotton boll weevil was detected in the São Paulo state for the first time in 1983 (Habib & Fernandes, 1983) and at the present time it is considered one of the most important key-pests in Brazilian cotton fields. Many investigations were undertaken to study the population behavior, biological responses and other ecological aspects of this Curculionidae pest in this new habitat, to establish IPM strategies for its control (Fuchs & England, 1989; Gutierrez et al., 1991; Gabriel et al., 1992; Pierozzi Jr. & Habib, 1992a, 1992b, 1993a, 1993b; Ramalho & Silva, 1993; Fernandes et al., 1994; 1996; Araujo & Azevedo, 1997). Many ecological and behavioral differences were observed among boll weevil populations in their new environment in comparison to other cotton agro-ecosystems, mainly in the USA (Pierozzi Jr., 1989).

The first record of the boll weevil in Argentina was reported from Misiones, Iguazu National Park, in 1993, and since then the species has been found over the entire province despite the absence of cotton cultures. This situation may have been due to the migration to Misiones of boll weevils from cotton fields of neighboring areas, and/or from fragments of pristine forests of this province to surrounding disturbed areas. Scataglini et al. (2006).

Cotton is a perennial shrub that may survive for many years in a favorable environment. The perennial nature of cotton allows it to regrow following harvest, producing fruit suitable for boll weevil reproduction in 3-4 weeks. This regrowth potential is of little concern in areas where winter weather kills cotton and prevents boll weevil reproduction, but represents a severe challenge to boll weevil management in tropical regions. Cotton stalk destruction is a primary tool for managing overwintering boll weevils in these regions by reducing or eliminating food and reproductive opportunities. Early destruction of cotton stalks by plowing or burning was among the initial and most significant recommendations for control of the boll weevil (Townsend, 1895; Hinds, 1908). In Brazil, weevils can survive during the winter in bolls of undestroyed stalks in scattered cotton fields. In these unattended fields, cotton produces fruit throughout the winter/off season and, in the spring, weevils from such locations become a serious threat (Bergman et al., 1983), (Summy, 1988).

Among several types of insect adaptations to environmental changes, some serve as protection against the seasonal climatic changes. Periodic migrations, diapauses or dormancy are some of such adaptations. Regarding adults of the cotton boll weevil, since Brazzel Jr. & Newson (1959) described and characterized the diapauses process; many other scientists have studied these adaptation mechanisms and their role in population dynamics. The spark of the diapauses process seems to be associated to the limited availability of square buds for the boll weevil, low temperatures and plant exposition to short day length (Pierozzi Jr., 1989). The utilization of fruit (bolls) for larval boll weevil feeding is also considered an important factor inducing diapauses (Lloyd et al., 1967; Lloyd, 1986). Diapause, as well as dispersion, can be caused by some chemicals present in such fruit. According to Arellano (1995), the decrease in the amount of cotton squares and increase of boll availability can be considered indicators of the winter period proximity and, consequently, the activation of the preparatory metabolism in insect population. Increase of some metabolic rates, accumulation of fat tissues and drastic reduction of sexual and reproductive activities are some of the observed responses.

Facultative diapause occurs among adults of this Curculionidae pest. In the USA, diapause is a survival mechanism of such a pest between cotton seasons. This behavior occurs when the cotton season is completed, and especially when soil moisture decreases inducing plant stress. This phenomenon is observed in Mexican strains as much as in the U.S. southwestern ones. In agreement with Pierozzi Jr. & Habib (1992a), Fernandes et al. (2001) also believe that boll weevils found in Brazil are of the same strain which occurs in Mexico and in southwestern USA. According to Cross (1973), after the migration process, the diapausing weevils, and apparently some non-diapausing ones, disperse into the forest litter for hibernation, and this type of dispersion occurs in regions with wet and cold conditions between-seasons. In other regions with dry and hot conditions during this period, dispersion would normally occur in order to localize an alternative host. Finally, some weevils would survive in old cotton stalks. Some authors consider the possibility that a part of the *A. grandis* population does not accomplish the diapauses process (Palmer & Cate 1992; Fernandes et al., 1994).

While boll weevil growth and reproduction are not so common during the winter seasons of temperate zones and diapause is vital for survival of their populations; in the tropics the climatic conditions, including temperature and photoperiods, are not sufficient to trigger this process. Moreover, several host plants are available during the whole year offering pollen to feed adults (Tauber et al., 1986; Brown & Phillips Jr., 1989; Benedict et al., 1991; Chandler & Wright, 1991; Jones et al., 1992). Habib et al. (1984) captured great amounts of *A. grandis* adults in glandure pheromone traps during winter.

In Paraná state, southern Brazil, the presence of *A. grandis* as a key pest increases cotton production costs year by year due to the number of insecticide applications which have increased from an average of 5.4 to 10.1 applications per season (Morales et al., 1997). According to Mafra-Neto & Bakers (1996), two methods are used to prevent mating using synthetic pheromones: "mating disruption" and "attract-and-kill". In the second method, pheromone sources are mixed with small amounts of insecticide that poison males and females attracted by the pheromone (Fernandes et al., 2001).

In Brazil, cotton stalk destruction is enforced by law as a strategy for effective IPM.

2. Diseases and their control

Brazilian cotton in the midwestern states is grown under a tropical rainfall environment, which requires the control of a number of diseases during the cotton cycle, making it necessary to use fungicides as well. The main diseases are fusarium, verticillium, nematodes, ramulose, and blue disease. Many of the diseases that attack cotton that were secondary years ago are now becoming more prevalent. There has been an enormous effort by ABRAPA, EMBRAPA, state producer foundations, IMA (Mato Grosso Cotton Institute),

and the Mato Grosso Foundation (FMT), in collaboration with private companies, to produce better cultivars for these conditions and new challenges. The better use or more rational use of pesticides will come about in Brazil by an integrated system of the use of BMP, IPM, plant breeding and the integration of biotechnology into cotton production systems. The rational use of pesticides comes through the use of certified seed and better sanitary control of the seed. Seed treatment has proved very effective in the control of diseases that are seed borne, as well as many sucking pests in the early establishment period.

The use of biotechnology for pest control in the Brazilian production system, which started in 2006, is relatively new, and its impact has been very limited. The “Bt” resistant material available to date has not been able to compete in the market place to cause an impact in boll weevil control and in the large increase in the use of pesticides. The future of biotechnology looks very promising as new genes are incorporated into the production system as well as cultivars that have tolerance and resistance to the principal diseases. Chemical control through seed treatment is a major tool in the system today and will continue to be so until we have resistant cultivars. (Fuzatto et. all, 2005).

Pest and disease damage is one of the main constraints to productivity. The group of pests attacking cotton is well known, comprising at least 30 species of insects and three species of mites. The most economically damaging species and the intensity of the damage they cause vary from region to region. Diseases caused by viruses, bacteria and fungi also affect productivity in some regions, and some are transmitted by pests (insects).

Fiber yield and fiber quality are priorities in all breeding programs, in Brazil, however, resistance to diseases is a main focus for all breeding programs. In Brazil, *Meloidogyne incognita* frequently is involved in a cotton disease complex with fusarium wilt that has far more impact on the crop than the nematode or the fungus alone. The primary concern over *Pratylenchus brachyurus* in Brazil is its potential to damage *Zea mays* or *Glycine max* grown in rotation with cotton. Promising seed treatments containing avermectin or harpin proteins have recently become available. Several cultivars resistant to *Meloidogyne incognita* races 3 and 4 have been released. Currently, there is intense research toward the introgression of resistance to *Rotylenchulus reniformis* into upland cotton, *Gossypium hirsutum*, from other *Gossypium* species. During the last two years DNA markers for major genes for resistance to *M.e incognita* and *R. reniformis* have been discovered in upland cotton and offer great potential in the development of resistant cultivars suitable for the wide range of growing conditions where cotton is produced (Robinson, 2007).

The gall or branch nematode and the reniform nematode were responsible for large losses in the states of São Paulo and Paraná, but so far they are not a reason for concern in Mato Grosso, probably because their occurrence is limited and circumscribed. Surveys carried out in Mato Grosso showed that only 4% of the 623 samples collected presented *M. incognita*, in contrast with the 94% of frequency of the nematode for root lesions (Silva et al., 2003). The scenario in Mato Grosso do Sul shows an expressive presence of nematodes in branches and the reniform nematode, with a predominance of the lesion nematode (29%, 19% and 59% frequency of *M. incognita*, *R. reniformis* and *P. brachyurus*, respectively, in 104 samples) (Comunello and Asmus, 2003).

2.1 Control

- Following with successive plowing, and removal and elimination of crop residues for the three phytonematodes is an efficient control practice, mainly for *P. brachyurus*.
- Resistant cultivars: most of the cotton cultivars present great susceptibility to the three phytonematodes. Cultivar IAC-22 shows a behavior of resistance to *M. incognita* and to *P. brachyurus* (Gielfi, 2001; Goulart et al., 1997).
- Cleaning of machines and agricultural tools: strong water jets are sufficient to remove the soil that has adhered to machine parts and to agricultural tools.
- Nematicides: products based on the active ingredients carbofuran, aldicarbe, fenamifos and terbufos are registered by the Ministry of Agriculture for cotton crops with the aim of controlling *M. incognita* and/or *R. reniformis*. Only the commercial products Furadan 50 and Ralzer 50 GR are recommended for the two phytonematodes. The use of nematicides is quite frequent in cotton growing areas, mainly due to the monoculture that is carried out in many areas year after year, stimulating a considerable increase in the nematode population.

- Antagonist plants: green composting with *Crotalaria spectabilis*, *C. grantiana*, *C. mucronata*, mucuna-aterrina, mucuna-cinereum or wild turnip also contribute to reducing the population density of *M. incognita*. *Crotalaria breviflora*, *C. spectabilis* and *C. juncea* are indicated for the control of *P. brachyruves* *R. reniformis* (Motta; Machado; Inomoto, 2006; Silva *et al.*, 1989).

- Crop rotation: with gramineous plants such as rice, sugarcane and *Digitaria decumbens* have a resistance behavior to the reniform nematode. The search for soybean cultivars that are resistant to the reniform nematode and the root lesion nematode is being initiated. In a paper by Asmus (2006), commercial soybean cultivars M-SOY 8001, CD 202 and CD 201 stood out as being resistant to the reniform nematode.

For *M. incognita*, the use of resistant soybean cultivars is the most efficient means of control and the most appropriate one in a crop rotation situation. Information on these resistant cultivars can be obtained by consulting EMBRAPA's annual publication that deals with Production Technologies for Soybean in the Central Region of Brazil. *Brachiaria brizantha*, *B. decumbens* and *Panicum maximum* cv. Guiné can be recommended for the control of this phytonematode. Peanuts and hybrids of resistant maize (P30F80, BRS 2114, AG9090 and others) can also be used.

- Weeds are excellent host plants for gall nematodes, reniform nematodes and root lesion nematodes. Therefore, avoiding their presence in the crop is of great importance to prevent their increase during and between cropping seasons, so as not to have an impact on the success of crop rotation (Santos, S.D.).

On average, farmers spray the cotton crop around 20 times during the growing season, many times with mixtures of products. Sprays including fungicides are applied from three to six times during the growing season. Growth regulators are used an average of four times per season, and insecticides may be used up to 15 times per season. In the area where cotton is grown in Brazil, precipitation, temperature and air humidity are ideal for fungal development. Until recent years, viruses were a large problem, demanding 5-6 sprays for rigorous aphid control until recent years. The newest locally bred cultivars are resistant to most viruses, which allows for a more relaxed aphid control regime. A significant amount of resources are spent on disease control; consequently disease resistance is one of the priorities in breeding (Uitdewilligen, 2007).

Diseases constitute one of the main sources of loss in the cotton crop, mostly in high productivity areas. One of the diseases of great economic importance in cotton in Brazil is commonly called cotton blue disease (CBD). It was first described in 1962, in the town of Ribeirão Bonito SP (EMBRAPA, 2001), as a particularly virulent type of veinal mosaic, capable of inflicting significant damage.

The disease is transmitted by the cotton aphid *Aphis gossypii* Glover, a highly polyphagous and cosmopolitan species, which has over 80 host plant species (Ebert & Cartwright, 1997). The virus transmission by *A. gossypii* is of a persistent type (Costa *et al.*, 1997; Santos, 2001).

It was recently proved that the pathogen is a virus of the Luteoviridae family and it was confirmed, for the first time, that it is in fact a new virus of the *Polevirus* genus, named "Cotton leaf roll dwarf virus" (CLRDV) (Corrêa *et al.*, 2005). When inoculated into a plant, symptoms develop in 9 to 28 days (Cauquil & Vaissayre, 1971; Cauquil & Follin, 1983).

Ramulosis is also an important disease caused by *Colletotrichum gossypii* (South) var. *cephalosporioides* (A. S. Costa) and occurs throughout Brazil, Venezuela, and Paraguay. Ramulosis, also known as witches'-broom, is currently considered the most important disease of cotton in some regions of Brazil. Without an effective fungicide spray program, severe yield losses may occur (Cia & Fuzatti, 1999; Paiva *et al.*, 2001; Silva-mann *et al.* 2002). Dispersal of *C. gossypii* var. *cephalosporioides* is typically via seeds that are contaminated externally by conidia or internally by dormant mycelia. The pathogen can also survive several years in contaminated soil (Watkins, 1981). Fungicide sprays are a necessary part of ramulosis management because most producers plant susceptible cultivars due to market demand for them (Cia & Fuzatti, 1999).

Grey mildew, caused by the fungus *Ramularia gossypii* (Speg.) Cif. is the most important foliar spot disease in Brazilian cotton. There are a few products available to growers to manage this disease, among them the fungicides tryazol and strobilurine (Aquino *et al.*, 2008). Recent studies have shown that the pathogen has low genetic variability and there are a number of sources of genetic resistance, which suggests, that durable resistance may be achieved in a few years through conventional breeding techniques (Lucena, 2007).

3. BMP/IPM

In cotton production systems, sampling is carried out to detect the presence of insects and damage to the plants by them; however, the number of plants examined and the frequency of this sampling process varies greatly. Uttrel et al. (1994), showed that under the Australian system the sampling of 60 plants in every 100 hectares two or three times a week is recommended. On the other hand, in the USA, most of the fields are sampled once or twice a week, sampling 100 fruits and flowers in every 20 to 30 hectares, whereas in Brazil the recommendations are made on the historical observations and presence of the insects in the region. Busoli (1991) recommends that in cotton fields monitored under IPM the sampling be carried out once a week. Fernandes et al (2002) recommend the same practices with 80–100 plants per hectare sampled on a random basis. EMBRAPA (2003) recommends that samples be made on a five day interval, picking 100 plants on a random basis in a field of up to a 100 hectares and that sampling be conducted on a zigzag basis within the field.

Failure to destroy the cotton crop residue or the use of non-adequate methods, not only causes financial losses to the farmer, but could cause non repairable financial loss to the whole region. The practice of eliminating all crop residue should be carried out by all farmers within the shortest post harvest interval. (EMBRAPA, 2007).

Frequent studies show that the elimination of cotton crop stubbles will bring about a reduction of up to 70% in insect populations. Without crop residue destruction those insects that are in the quiescence state will survive the inter-crop period, and consequently will infest crops the following year. This technique is also valid for the control of those diseases that reduce the Brazilian production of cotton, ramulose, leaf spots, and blue disease.

“ The practice of destroying the cotton stubble is not only important for the benefit of the farmer, but for the region as a whole, and today there are laws that oblige cotton growers to carry out this practice in all the cotton producing states. In the case where a cotton farmer does not destroy the crop stubble, he is subject to penalties as well as losing tax incentives at the time of selling his cotton.” Comments observed by researcher Odilon Ribeiro at EMBRAPA Algodão.

Mechanical control continues to be a significant means for destroying stalks. Stalks are typically shredded after harvest to reduce stalk size so that plows can easily kill the roots. After shredding, a disk is often used to flatten beds to allow deep tillage operations for breaking hardpan. Stubble stalk pullers also are used to uproot the stalks (Lemon, 2003). These mechanical methods are generally successful, but some stalks may survive these operations. However, in order to adopt BMP, cotton producers are increasingly adopting conservation tillage, a system antithetical to mechanical operations. Adverse weather conditions can also impede immediate and complete stalk destruction using typical tool implements. Thus, there is a need for alternative stalk control methods (Greenberg et al., 2007).

The success of the boll weevil management and control process will be dependent on thorough stalk destruction following harvest. It is anticipated that effective cotton stalk destruction can be achieved by chemical crop termination. Producers' attempts at chemical stalk control have relied heavily on herbicides containing 2,4-D, and have had variable degrees of success, which may be influenced by both harvest and post-harvest activities. Potential harvest and post-harvest practices that may influence chemical stalk destruction include the type of harvester used (picker versus stripper harvest), whether stalks are shredded after harvest or not and whether herbicides are applied immediately after harvest or after a period of cotton re-growth. Still, there is little information about herbicide effects on shredded and standing cotton stalks (Greenberg et al, 2007).

Stalk destruction is the main control method used, but other strategies have also been used in Brazil to help control boll weevil. Chemical insecticide is the control mechanism mostly used, but the effective control and monitoring of this pest can only be achieved from a series of strategies like using sentry plots planted with early season cotton varieties and the use of traps and pheromone tubes. A series of research and pilot projects have already been initiated in Mato Grosso and Goiás in order to define an appropriate system for the boll weevil suppression plan to be implemented by ABRAPA in the coming year.

EMBRAPA has conducted research to develop a gene for boll weevil resistance that is under continuing study. Crucial information that is still missing is about a good promoter gene that can be “turned-on” in the right tissue when it is attacked by boll weevil in cotton.

The IPM practice of cotton stalk destruction is enforced by law in Brazil. Each state has its own regulation about the appropriate deadline for cotton stalk destruction each year. If destruction is not carried out by this deadline, the producer can receive a fine of up to 5% of the predicted income generated in the area, and also lose the credential to access agricultural finance.

Producers associations (such as AMPA, the association of cotton producers in Mato Grosso) have invested in technical teams to help producers monitor and control the boll weevil to avoid the spread into uninfected areas. Activities include training, field visits, monitoring, and even spraying and destruction of isolated plants along public roads and highways, as well as around gins.

4. Pesticide Registration

There is a common conclusion that all the problems associated with pesticides are the result of their improper use. The rigid and dynamic legislation that involves the use and registration of these products ensures that all the pesticides made available in the market are safe if used within the specifications of their registration. The arguments that make only the use and the user of these products responsible are inconsistent with reality, as discussed in detail by Garcia (2001).

The importance of legislation and the control of dangerous substances are beyond question. In Brazil, all chemical substances used in agriculture to control pests and diseases are controlled by the law on pesticides ("Lei dos Agrotóxicos no 7.802/ 89") passed in 1989. That law is very important, since the previous law that regulated the sector dated back 55 years (o Decree number 24.114,2 of 14th April 1934) and at that time the organic-synthetic pesticides, widely used today, were not available for use in agriculture (Garcia et al, 2005).

In Brazil the registration of pesticides dates back well before the new law, (Gelmini, 1987) but the "Lei dos Agrotóxicos" was considered a major advance from a public health and environmental point of view because any new product with the same characteristic as a previously registered product can only be registered if its toxicity is less than the previously registered product.

Among the 863 registered commercial products in 2000, 46.6% were already registered before the pesticide law. Among the 461 commercial products registered after the law, 59.2% were derivatives of active ingredients registered before the law, and 41.4% were classified as highly hazardous (classes I and II of the Brazilian toxicological classification). No significant differences in toxicological classification profile were identified between the group of pesticides derived from active ingredients registered before the law and the group derived from active ingredients registered after the law ($p < 0.0859$). Ten years after the pesticide law came into effect, no significant improvement had been observed in the toxicological classification profile of registered pesticides. This was due especially to the continuing presence of products registered before the law and the registration of new commercial products derived from "old" active ingredients. There were still a high proportion of registrations in the most hazardous classes. It is recommended that compulsory periodic reevaluation of all registered pesticides should be reestablished (Garcia et al, 2005).

5. Biotech Cotton

Since 1996, when the USA and Australia initiated the commercial use of *Bt* cotton, a number of countries have adopted biotech technology in the production of cotton, and this area has increased on an annual basis. Today a total of nine million hectares are planted throughout the world. The acceptance of this technology by farmers has resulted in a series of social, economic and environmental benefits that have been crucial with respect to the adoption of the biotech technology. (Sá et al, 2005).

In Brazil, cotton farmers have a number of traits available, including insect resistance and control, herbicide tolerant varieties, glifosate RR and caterpillar control with the use of insect control traits, (Bollgard®). The use of biotech varieties has not reduced the use of insecticides because there is no trait or technology available to control the boll weevil, which is the major pest controlled by insecticides in the production of cotton. It has not been shown to date in Brazil that the adoption of this technology has reduced the use of insecticides in cotton. Today, growers have been unable to see any cost benefit, as the seed, including the technology fee for insect resistance traits, is much more expensive than chemical control, due to the number of insecticide applications made to control boll weevil. (Sá et al, 2005).

6. Discussion

The rapid agricultural development of the "Cerrado" region led to an increased use of pesticides in Brazil, which now ranks among the five largest agrochemical markets in the world (Racke et al., 1997). The intensive

use of pesticides in agriculture may cause contamination of ground water due to their leaching through the soil into aquifer regions. Ground water pollution by pesticides has been extensively studied in temperate regions (reviewed by van den Berg and van der Linden, 1994; Ritter, 1990), whereas data from tropical areas are lacking almost completely. Recent results of Lanchote et al. (2000) and Li et al. (2001) proved the contamination of ground water in the tropics with triazines, which underlines the fact that nonpoint pollution of ground water may be of concern in tropical regions, too.

To assess the risk of ground water contamination by pesticides, their persistence and mobility in soil need to be determined (Roberts, 1996). Laboratory studies are often not adequate to this aim, because variable climatic conditions and processes like volatilization, UV oxidation, leaching, and pronounced preferential flow transport may influence pesticide persistence and mobility under outdoor conditions (Beulke et al., 2000; Flury, 1996). In temperate regions, many studies were conducted to assess the leaching potential of pesticides in field experiments and to evaluate the influence of soil properties, soil management, and application mode on pesticide output from soils (e.g., Bowman, 1990; Gish et al., 1995; Johnson and Pepperman, 1995). However, relatively few data were reported so far on pesticide persistence under the specific climatic and pedological conditions in the tropics (reviewed by Racke et al., 1997). Recently, LAABS et al. (2000) reported in a comparative study of field dissipation half-lives of pesticides and a moderate short-term leaching of polar herbicides to the subsoil of one Ustox in tropical Brazil. Other study performed by LAABS et al. (2002), evaluating pesticide dissipation in Brazilian Ustox and Psamments soils demonstrated that their persistence was mostly greater in clay than in sandy soils. In comparison with temperate regions, dissipation of pesticides was five to ten times faster, except for alachlor, deltamethrin, and cyhalothrin, which exhibited a less reduced persistence than under temperate conditions. However, in comparison with ranking lists of pesticides according to their leaching properties in temperate regions, observed leaching rates of pesticides in this study differed in their relative order and in absolute values. According to this author, long-term leaching studies (2-3 yrs) and surveys of ground water contamination in agricultural regions of the tropics were needed to establish a list of priority pollutants for these climates. It still remains to be proven if pesticide leaching in soils under tropical conditions is generally reduced in comparison with temperate regions. Data on medium to long-term leaching of pesticides in tropical soils are very inconclusive.

7. Cotton in the tropical region of Brazil: Conclusions

1) Rain grown cotton with high vegetative capacity and insect pressure, requires special attention in tropical areas, a different analysis than cotton in a temperate region.

2) Over 99 % of all cotton in Brazil is rain-grown, and studies have been done to monitor water quality and the effects on the environment. This is a plus for Brazilian growers as the biomass capacity in the tropics means that the half life of these chemicals is much shorter, as described above from a series of research data.

References

- AQUINO, L. A. de et al. Controle alternativo da mancha de Ramularia do algodoeiro. Summa phytopathology. Botucatu, v. 34, n. 2, June 2008 .
- BENEDICT, J.H.; WOLFENBARGER, D.A.; BRYANT JR., V.M.; GEORGE, D.M. Pollens ingested by boll weevils (Coleoptera: Curculionidae) in Southern Texas and Northeastern Mexico. Journal of Economic Entomology, v.84, p.126-131, 1991.
- BERGMAN D, HENNEBERRY TJ AND BARIOLA LA. Overwintering boll weevil populations in southwestern Arizona cultivated cotton. Proc Beltwide Cotton Prod Res Conf, National Cotton Council, Memphis, TN, pp. 182–185 (1983).
- BEULKE, S., I.G. DUBUS, C.D. BROWN, AND B. GOTTESBU. 2000. Simulation of pesticide persistence in the field on the basis of laboratory data—A review. J. Environ. Qual. 29:1371–1379.
- BOWMAN, B. 1990. Mobility and persistence of alachlor, atrazine and metolachlor in Plainfield Sand, and atrazine and isazofos in Hon- eywood Silt Loam, using field lysimeters. Environ. Toxicol. Chem. 9:453–461.
- BROWN, C.M.; PHILLIPS JR., S.A. Weeping love-grass as an overwintering habitat for the boll weevil (Coleoptera: Curculionidae). Journal of Economic Entomology, v.82, p.799-802, 1989.
- BURKE HR, CATE JR (1979). A new species of Mexican Anthon- omus related to the boll weevil (Coleoptera: Curculionidae). Ann Entomol Soc Am 72:189–192
- BURKE HR, CLARK WE, CATE JR, FRYXELL PA (1986) Origin and dispersal of the boll weevil. Bull Entomol Soc Am 32:228–238
- BUSOLI, A.C. Práticas culturais, reguladores de crescimento, controle químico e feromônios no Manejo Integrado de Pragas do algodoeiro. In: DEGRANDE, P.E. (ed.), Bicudo do algodoeiro: Manejo Integrado. Dourados: UFMS/EMBRAPA-UEPAE Dourados, 1991. p. 29-52.
- CAUQUIL, J.; FOLLIN, J.C. Les maladies du cotonnier attribuées à des virus ou à des mycoplasmes en Afrique au Sud Sahara et dans le reste du monde. Coton et Fibres Tropicales, v.38, p.293-308, 1983. [[Links](#)]
- CAUQUIL, J.; VAISSAYRE, M. La "maladie bleue" du cotonnier en Afrique: transmission de cotonnier à cotonnier par *Aphis Gossypii* Glover. Coton et Fibres Tropicales, v.6, p.463-466, 1971.
- CHANDLER, L.D.; WRIGHT, J.E. Longevity of the boll weevil (Coleoptera: Curculionidae) on cotton and alternate feeding sources under various temperature regimes in the laboratory. Journal of Economic Entomology, v.84, p.1699-1704, 1991.
- CIA, E., and FUZZATTO, M. G. 1999. Cotton disease management. Pages 121- 131 in: The Cotton Crop. E. Cia, E. C. Freire, and W. J. Santos, eds. Piracicaba, Potafos, SP, Brazil.
- CONFALONIERI, VA., SCATAGLINI MA., LANTERI AA. (2003) Origen de las poblaciones del picudo del algodón en Argentina, Brasil y Paraguay: una hipótesis basada en el estudio de genes mitocondriales. Proceedings Cotton in the Southern Cone. Project Integrated Pest Management of the Cotton Boll Weevil in Argentina, Brazil and Paraguay. CFC/ICAC/ 04. Final Workshop Part I: 29–39. Argentina
- COPPLESTONE JF. The development of the WHO Recommended Classification of Pesticides by Hazard. Bull World Health Organ 1988;66:545-51.
- CORRÊA, R.L.; SILVA, T.F.; SIMÕES-ARAÚJO, J.L.; BARROSO, P.A.V.; VIDAL, M.S.; VASLIN, M.F.S. Molecular characterization of a virus from the family *Luteoviridae* associated with cotton blue disease. Archives of Virology, v.150, p.1357-1367, 2005.
- COSTA, A.S.; JULIATTI, F.C.; RUANO, O. Algodão (*Gossypium hirsutum* L.): doenças causadas por vírus. In: VALE, F.X.R.; ZAMBOLIM, L. (Ed.). Controle de doenças de plantas: grandes culturas. Viçosa: UFV, 1997. p.571-582.
- CROSS, W. H. Biology, control and eradication of the boll weevil. Annual Review of Entomology, v.18, p.17-46, 1973.
- Decreto no 24.114, de 14 de abril de 1934. Aprova o regulamento de defesa sanitária vegetal. In: Gelmini GA, Novo JPS. Defensivos agrícolas: informações básicas e legislação. Campinas: Fundação Cargill; 1987. p. 416-23.

Decreto no 4.074, de 4 de janeiro de 2002. Regulamenta a Lei no 7.802, de 11 de julho de 1989, que dispõe sobre a pesquisa, a experimentação, a produção, a embalagem e rotulagem, o transporte, o armazenamento, a comercialização, a propaganda comercial, a utilização, a importação, a exportação, o destino final dos resíduos e embalagens, o registro, a classificação, o controle, a inspeção e a fiscalização de agrotóxicos, seus componentes e afins, e dá outras providências [documento on-line]. Diário Oficial da União; 8 jan 2002. Disponível em URL: <http://e-legis.bvs.br/leisref/public/showAct.php?id=2848> [2004 abr 30]

Decreto no 98.816, de 11 de janeiro de 1990. Regulamenta a Lei 7.802, de 11 de julho de 1989, que dispõe sobre a pesquisa, a produção, a embalagem e rotulagem, o transporte, o armazenamento, a comercialização, a propaganda comercial, a utilização, a importação, a exportação, o destino final dos resíduos e embalagens, o registro, a classificação, o controle, a inspeção e a fiscalização de agrotóxicos, seus componentes e afins, e dá outras providências. In: Legislação federal de agrotóxicos e afins. Brasília (DF): Ministério da Agricultura e do Abastecimento; 1998. p. 15-53.

Decreto no 991, de 24 de novembro de 1993. Altera o Decreto no 98.816, de 11/01/1990. In: Legislação federal de agrotóxicos e afins. Brasília (DF): Ministério da Agricultura e do Abastecimento; 1998. p. 57-9.

EBERT, T.A.; CARTWRIGHT, B. Biology and ecology of *Aphis gossypii* Glover (Homoptera: Aphididae). Southwestern Entomology, v.22, p.116-153, 1997.

EMBRAPA – Empresa Brasileira de Pesquisa Agropecuária. Soqueira continua sendo problema na pós-colheita do algodão, aponta estudo da Embrapa. 2007. <http://www.embrapa.br/imprensa/noticias/2007/agosto/2a-semana/soqueira-continua-sendo-problema-na-pos-colheita-do-algodao-aponta-estudo-da-embrapa/>

EMBRAPA-ALGODÃO, Sistemas de produção II, 2003. Extraído de <http://sistemasdeproducao.cnptia.embrapa.br/FontesHTML/Algodao/AlgodaoCerrado/pragas.htm>, em 29/5/2010. as 22:38

EMBRAPA. Algodão: tecnologia de produção. Dourados: Embrapa Agropecuária Oeste, 2001. 296p.

FERNANDES, M.G. Distribuição espacial e amostragem seqüencial dos principais noctuídeos do algodoeiro (*Gossypium hirsutum* L.). R. bras. Agrocência, v. 8, n. 3, p. 213-218, set-dez, 2002.

FERNANDES, W.D.; OLIVEIRA, P.S.; CARVALHO, S.L.; HABIB, M.E.M. *Pheidole* ants as potential biological control agents of the boll weevil, *Anthonomus grandis* (Col., Curculionidae), in southeast Brazil. Journal of Applied Entomology, v.118, p.437-441, 1994.

FERNANDES, WD, CARVALHO, SL, HABIB, M. BETWEEN-SEASON ATTRACTION OF COTTON BOLL WEEVIL, *ANTHONOMUS GRANDIS* BOH. (COLEOPTERA: CURCULIONIDAE) ADULTS BY ITS AGGREGATION PHERORMONE. Sci. agric. vol.58 no.2 Piracicaba Apr./June 2001.

FLURY, M. 1996. Experimental evidence of transport of pesticides through field soils—A review. J. Environ. Qual. 25:25–45.

FRYXELL PA, LUKEFAHR MJ (1967) *Hampea* Schlecht: possible primary host of the boll weevil. Science 155:1568–1569

FUZATTO M.G.; CARVALHO LH; CIA E; SILVA NM; CHIAVEGATO EJ; LÜDERS RR Boletim 200. 2005. Acessado através do link: <http://www.iac.sp.gov.br/Tecnologias/Algodao/algodao.htm>

GARCIA EG. Segurança e saúde no trabalho rural: a questão dos agrotóxicos. São Paulo: Fundacentro; 2001.

GISH, T., A. SHIRMOHAMMADI, R. VYRAVIPILLAIAND, AND B. WIENHOLD. 1995. Herbicide leaching under tilled and no-tillage fields. Soil Sci. Soc. Am. J. 59:895–901.

GOULART, A.C.P. Tratamento de sementes com fungicidas. In: EMBRAPA. Centro de Pesquisa Agropecuária do Oeste. Algodão: informações técnicas. Dourados, 1998. p.71-84. (EMBRAPA. CPAO. Circular Técnica, 7).

GUZMAN N. V.;V. V. LIA, A. A. LANTERI, V. A. CONFALONIERI. Population structure of the boll weevil in cotton fields and subtropical forests of South America: a bayesian approach. Genetica (2007) 131:11–20.

HABIB, M. E. M.; FERNANDES, W. D.; FAVARO JR., A.; ANDRADE, C. F. S. Eficiência do feromônio de agregação e inseticidas químicos no combate ao bicudo *Anthonomus grandis* Boheman, 1843 (Coleoptera, Curculionidae). Revista de Agricultura, v.59, p.239-251,1984.

HINDS WE, The first and last essential step in combating the boll weevil. J Econ Entomol 1:233–243 (1908).

IBGE. Dados de Previsão de Safra. Abril de 2010. Acessado através do site: <http://www.sidra.ibge.gov.br/bda/prevsaf/default.asp?t=1&z=t&o=25&u1=1&u2=1&u3=1&u4=1>

JOHNSON, R., AND A. PEPPERMAN. 1995. Soil column mobility of metri- bazine from alginate-encapsulated controlled release formulations. J. Agric. Food Chem. 43:241–246.

JONES RW (2001) Evolution of the host plant association of the *Anthonomus grandis* species group (Coleoptera: Curculionidae): phylogenetic test of various hypothesis. Ann Entomol Soc Am 94(1): 51–58

JONES RW, BURKE HR (1997) New species and host plants of the *Anthonomus grandis* species group (Coleoptera: Curculionidae). Proc Entomol Soc Wash 99(4): 705–719

JONES, R.W.; CATE, J.R.; HERNANDEZ, E.M.; NAVARRO, R.T. Hosts and seasonal activity of the boll weevil (Coleoptera: Curculionidae) in tropical and subtropical habitats of northeastern Mexico. Journal of Economic Entomology, v.85, p.74-82, 1992.

LAABS, V., W. AMELUNG, A. PINTO, A. ALTSTAEDT, AND W. ZECH. 2000. Leaching and degradation of corn and soybean pesticides in an Oxisol of the Brazilian Cerrados. Chemosphere 41:1441–1449.

LANCHOTE, V.L., P.S. BONATO, A.L. CERDEIRA, N.A. SANTOS, D. DE CARVALHO, AND M.A. GOMES. 2000. HPLC screening and GC/MS confirmation of triazine herbicide residues in drinking water from sugar cane area in Brazil. Water Air Soil Pollut. 118:329–337.

LANTERI AA, CONFALONIERI VA, SCATAGLINI MA (2003) El picudo del algodonoero en la Argentina: Principales resultados e implicancias de los estudios moleculares. Rev Soc Entomol Argent 62(3–4): 1–15

LANTERI, A. A. (1999) Aplicacion de tecnicas moleculares en estudios poblacionales y filogeneticos en Curculionidae. Rev Soc Entomol Argent 58(1–2): 161–168.

LEMON R, STICHLER C AND NORMAN J, Cotton stalk destruction with herbicides, Texas Cooperative Extension, Texas A&M University System, 2 pp. (2003).

Li, Q.X., E.-C. Huang, and F. Guo. 2001. Occurrence of herbicides and their degradates in Hawaii's groundwater. Bull. Environ. Contam. Toxicol. 66:653–659.

LUCENA, V. S. CARACTERIZAÇÃO DA RESISTÊNCIA DO ALGODOEIRO A *Ramularia areola* E VARIABILIDADE MOLECULAR DO PATÓGENO. Dissertação. Universidade Federal do Rio Grande do Norte. 60p. 2007.

LUTTRELL, R.G.; FITT, G.P.; RAMALHO, F.S. et al. Cotton pest management: Part 1. A worldwide perspective. Annual Review of Entomology, Palo Alto, v.39, p.517-26, 1994.

MAFRA-NETO, A.; BAKER, T.C. Elevation of pheromone response threshold in almond males pre-exposed to pheromone spray. Physiological Entomology, v.21, p.217-222, 1996.

MARTINS, WFS. Diversidade genética de populações naturais de *Anthonomus grandis* Boheman (Coleoptera: Curculionidae). Universidade Federal de Pernambuco. Tese de Doutorado. Recife, 2006. 127p.

Ministério da Saúde. Secretaria Nacional de Vigilância Sanitária (SNVS). Portaria no 03, de 16 de janeiro de 1992. Ratifica os termos das “Diretrizes e orientações referentes à autorização de registros, renovação de registro e extensão de uso de produtos agrotóxicos e afins - no 1, de 9/12/91”. In: Legislação federal de agrotóxicos e afins. Brasília (DF): Ministério da Agricultura e do Abastecimento; 1998. p. 153-77.

Ministério da Saúde. Secretaria Nacional de Vigilância Sanitária (SNVS). Portaria no 03, de 16 de janeiro de 1992. Ratifica os termos das “Diretrizes e orientações referentes à autorização de registros, renovação de registro e extensão de uso de produtos agrotóxicos e afins - no 1, de 9/12/91”. In: Legislação federal de agrotóxicos e afins. Brasília (DF): Ministério da Agricultura e do Abastecimento; 1998. p. 153-77.

MORALES, L.P.P.; CENA, F.P.; MENDES NETO, S.F.; COSTA, F.; OLIVEIRA, T. Resistência de genótipos de algodoeiro a *Anthonomus grandis* Boh. *Frankliniella* sp. e *Aphis gossypii* Glover. Anais da Sociedade Entomológica do Brasil, v.26, p.93-98, 1997.

PAIVA, F. A., ASMUS, G. L., and ARAÚJO, A. E. 2001 Diseases. Pages 245- 272 in: Cotton: Production Technology. Embrapa Agropecuária Oeste, Brazil.

PALMER, J.O.; CATE, J.R. Over-wintering survival of pre-reproductive and post-reproductive boll weevil (Coleoptera: Curculionidae) in Central Texas. Environment Entomology, v.21, p.117-120, 1992.

PIEROZZI JR., I.; HABIB, M.E.M. Proposta de análise de componentes básicos para um programa de MIP para algodoeiros infestados por *Anthonomus grandis* Boheman, 1843 (Col., Curculionidae), na região de Campinas, SP. Revista de Agricultura, v.67, p.253-269, 1992a.

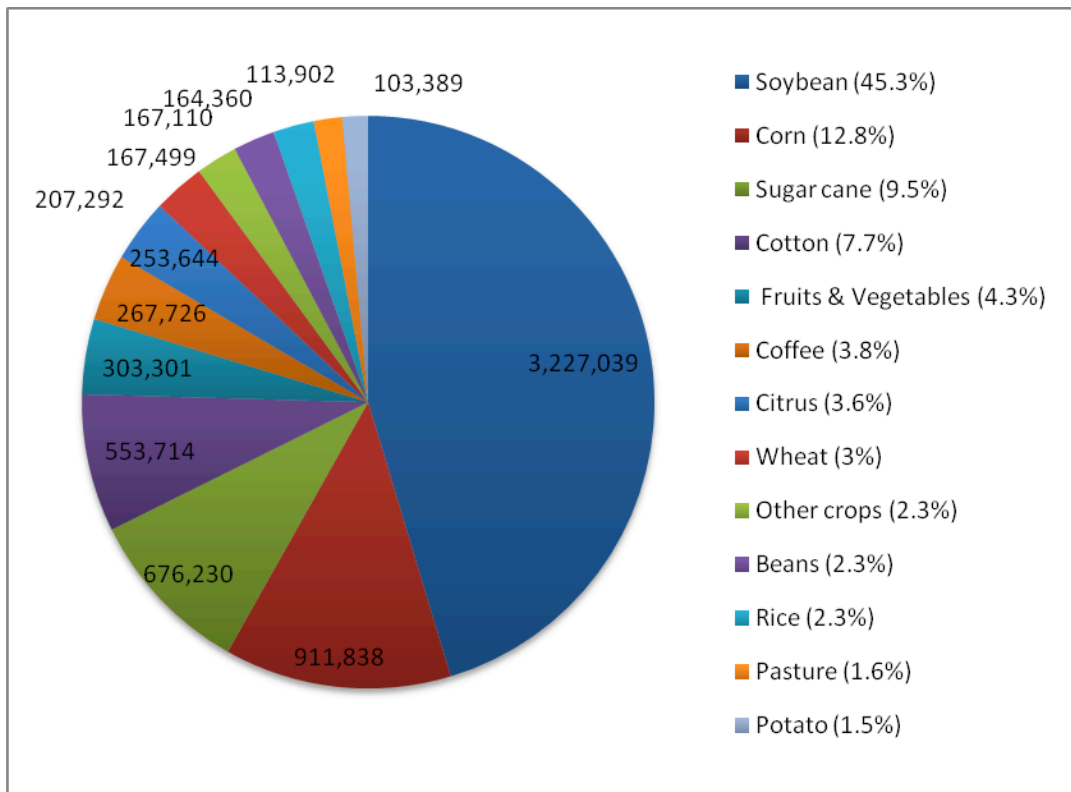
RACKE, K.D., M.W. Skidmore, D.J. Hamilton, J.B. Unsworth, J. Miyamoto, and S.Z. Cohen. 1997. Pesticide

- fate in tropical soils (technical report). Pure Appl. Chem. 69:1349–1371.
- RACKE, K.D., M.W. Skidmore, D.J. Hamilton, J.B. Unsworth, J. Miyamoto, and S.Z. Cohen. 1997. Pesticide fate in tropical soils (technical report). Pure Appl. Chem. 69:1349–1371.
- RITTER, W. 1990. Pesticide contamination of ground water in the United States—A review. J. Environ. Sci. Health B25:1–29.
- ROBERTS, T. 1996. Assessing the environmental fate of agrochemicals. J. Environ. Sci. Health B31:325–335.
- ROBINSON, A. F. Integrated Management and Biocontrol of Vegetable and Grain Crops Nematodes: Nematode Management in Cotton. Volume 2, Netherlands, pag. 149, 2007.
- SANTOS, M. A. dos S.D. Defesa seu algodão. FMC brochure, 4 pages.
- SANTOS, W.J. Identificação, biologia, amostragem e controle das pragas do algodoeiro. In: EMBRAPA. Algodão: tecnologia de produção. Dourados: Embrapa Agropecuária Oeste, 2001. p.181-226.
- SCATAGLINI MA, CONFALONIERI VA, LANTERI AA (2000) Dispersal of the boll weevil (Coleoptera: Curculionidae) in South America: evidence of RAPD analysis. Genetica 108:127–136
- SCATAGLINI MA, LANTERI AA, CONFALONIERI VA (2006) Diversity of boll weevil populations in South America: a phylogeographic approach. Genetica 126:353–362
- SHOIL M GREENBERG, ALTON N SPARKS JR, JOHN W NORMAN JR, RANDY COLEMAN, JOE M BRADFORD, CHENGHAI YANG, THOMAS W SAPPINGTON AND ALLAN SHOWLER. Chemical cotton stalk destruction for maintenance of host-free periods for the control of overwintering boll weevil in tropical and subtropical climates. Pest Manag Sci 63:372–380 (2007).
- SILVA-MANN, R., SALGADO, K. C. C., VIEIRA, M. G. G. C., AND MACHADO, J. C. 2002. Genetic variability of *Colletotrichum* complex associated with cotton seeds, by using molecular markers and plant inoculation. Fitopatol. Bras. 27:27-32.
- SILVA, C. A. D.; ALMEIDA, R. P. Manejo integrado de pragas do algodoeiro no Brasil. Campina Grande: EMBRAPA Algodão, 1998. 65 p. (EMBRAPA-CNPA. Circular Técnica, 27).
- SUMMY KR, HART WW, DAVIS MR, CATE JR, NORMAN JW, WOFFORD CW, et al. Region wide management of boll weevil in southern Texas. Proc Beltwide Cotton Prod Res Conf, National Cotton Council, Memphis, TN, pp. 240–247 (1988).
- TAUBER, M.J.; TAUBER, C.A.; MASAKI, S. Seasonal adaptation of insects. Oxford: University Press, 1986. 411p.
- TOWNSEND CHT (1895) Report of the Mexican boll weevil in Texas (*Anthonomus grandis* Boh.). Insect Life 7:295–309.
- TOWNSEND CHT, Report on the Mexican cotton boll weevil (*Anthonomus grandis* Boh.) in Texas. Insect Life 7:295–309 (1895).
- UITDEWILLIGEN, W. An overview of cotton breeding in Brazil. http://wcrc.confex.com/data/abstract/wcrc/2007/Paper_2254_abstract_2187_0.pdf
- V. LAABS, W. AMELUNG, A. PINTO, AND W. ZECH. Fate of Pesticides in Tropical Soils of Brazil under Field Conditions. Journal of Environment. Qual. 31:256–268 (2002). Pag. 256.
- VAN DEN BERG, R., AND T. VAN DER LINDEN. 1994. Agricultural pesticides and groundwater. p. 293–313. In U. Zoller (ed.) Groundwater contamination and control. Marcel Dekker, New York.
- World Health Organization (WHO), International Programme on Chemical Safety (IPCS). The WHO recommended classification of pesticides by hazard and guidelines to classification 1990-1991 [on-line]. Geneva; 1990. Available from: http://whqlibdoc.who.int/hq/1990/WHO_PCS_90.1_REV.1.pdf [19 Mai 2000]

ANNEX I

A. Use of pesticides in Brazil – 2008

Figure 1. Pesticides Sales (USD 1000) per Crop in Brazil, 2008.



In accordance with the information from SINDAG (Brazilian agricultural chemical association) in 2008, cotton production accounted for 7,8% of the pesticides in Brazil, while this is based on a dollar basis it is a good comparison between crops. Crops such as soy accounted for (45,3%), corn (12,8%) e sugar cane (9,5%) totalling 67,6% in this crop year.

Figure 2. Pesticide Sales (USD 1000) per State in Brazil, 2008.

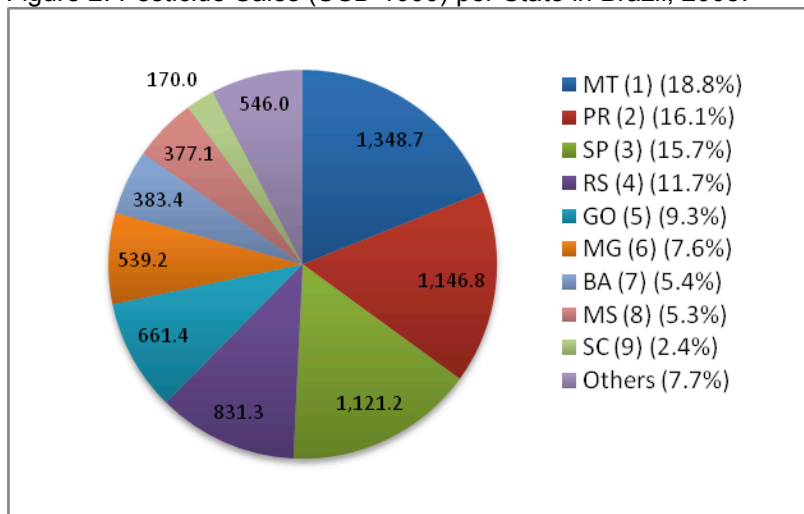
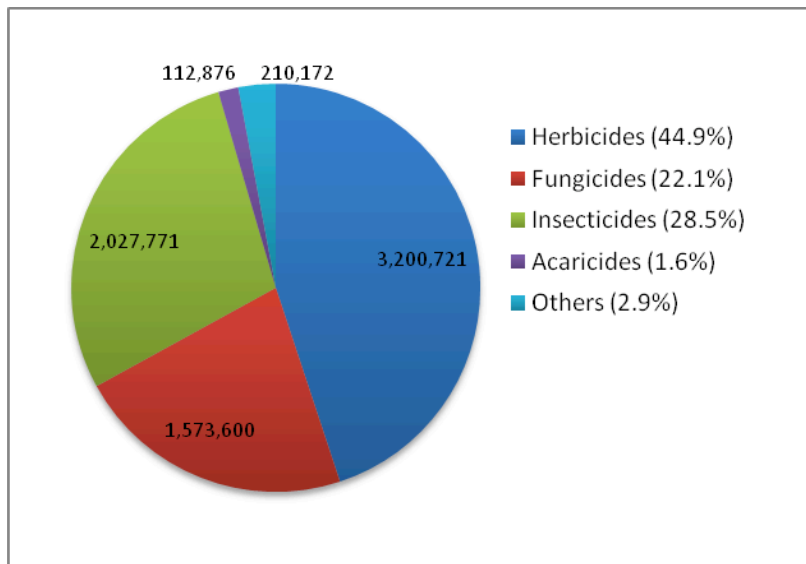


Figure 3. Pesticide Sales (USD 1000) per Class of Product, 2008.



This graph for 2008 shows sales on a state by state basis indicating that most consumption of pesticides is in Mato Grosso, the largest consumer, due to the very large area of soy as well as cotton, whereas the other states that produce cotton are not high in the ranking (Bahia, Goiás, Mato Grosso do Sul, etc). It is important to recognize that soy production is a major factor in pesticide use in Brazil, with the state of Paraná as second in ranking and Rio Grande do Sul as fourth in ranking. The third in ranking is São Paulo, probably as a result of large areas of sugar cane.

B. Pesticides used or recommended in Brazil

EMBRAPA recommends that for the efficient control of pests a system of integrated pest management (IPM) be adopted involving an integrated control strategy. The success of this control strategy is determined by sampling techniques and the action of beneficial insects. Together, a correct diagnosis and sampling will optimize the use of insecticides.

Pesticides registered in Brazil for use in cotton.

Active ingredients: 143

Formulated products: 447

Herbicides: 101

Inseticidas/Acaricidas: 280

Fungicidas: 66

Toxicity Class :

I – 118

II – 107

III – 164

IV – 58

A 2003 study by EMBRAPA showed that the main insecticides used in cotton crops are monocrotofós (Azodrin 400S), carbosulfan (Marshal TS 350); diafenturion, metamidofós, endosulfan (Thiodan 350 CE), dimetoato, triazofós (Hostathion 400 CE), paratiom metil (Folidol 600 CE), thiamethoxan (Cruiser 70 WS), phosmet (Imidan 500 PM); acefate, acetamiprid, abamectin, profenofós, propargite, dimetoato, cipermetrina (Polydial 30UVB, Sherpa 200 CE, Ripcord 100 CE), deltametrina (Decis 25 CE, Decis 4 UVB), metidathion, deltametrina, betacyflutrin, zeta-cypermtrina, diafentiuron, alfacipermetrina, fipronil.

EMBRAPA recommends that chemical control of the main insect pests in cotton should only be carried out when necessary, or when the infestation reaches a level that this form of control is effective in reducing economic losses. When insect pressure reaches levels seen in table 1, then the use of pesticides is recommended. EMBRAPA also recommends that not until the first buds appear (about 70 days) should pyrethroid based insecticides be used.

Table 1. Cotton pests and their chemical control.

Pests & natural enemies	Pest level for control	Active Ingredient	Dose (g.a.i./ha)	Action level
Worms	-	Carbofuran Dissulfanil	3.000,0 4.000,0 16.600,0	a -
Dark Sword-grass <i>Agrotis Ipsilon</i>	-	Carbaril	960,0	-
Thrips	70% of attacked plants	Tiometon Dimetoato Monocrotofos	175,0 126,0 250,0	-
Aphis Gossypii	10% to 70% of attack with colonies, resistant or susceptible for viruses.	Pirimicarb Tiometon Monocrotofos	37,5 a 50,0 65,5 120,0	-
Cotton lacebug (<i>Gargaphia torresi</i>)	53% of plants with colonies.	Tiometon	125,0	-
Cotton Leafworm	22% or 53% of attacked plants.	Diflubenzuron Clofluzuron Tefluazuron Tefubenzozide Endosulfan	12,5 25,0 a 37,5 7,5 300,0 350,0	-
Boll weevil	10% of attack	Endosulfan Phosmet Carbaryl	525,0 750,0 1.400,0	-
Tabacco budworm	13% of plants with worms.	Endosulfan Carbaryl	525,0 a 700,0 1.200,0	-
Spodoptera spp.	13% of plants with worms.	Endosulfan Carbaryl	525,0 a 700,0 1.200,0	-
Pink bollworm	11% of plants with danified bolls.	Carbaryl	1.200,0	-
Mites	40% of plants with colonies.	Abamectin Propargite	7,2 681,0	-
Stink bugs	20% of attacked plants.	Endosulfan Dimetoato	525,0 126,0	-
Whitefly	-	Endosulfan Dimetoato	525,0 a 700,0 126,0	-
Predators and parasitoid	-	-	-	71% plants w/ predators and/or mummies

Source: Adapted from Silva & Almeida (1998)

Observation: The data below are the result of research. While many of these products are applied on a regular basis by cotton producers in the Cerrado region, only carbendazin (Derosal) is registered by the Ministry of Agriculture and Animal Health for spraying in cotton fields.

Table 2. Fungicides used on cotton seed treatment.

Technical name	Comercial Product	Doses for 100 kg of seed	
		Active Ingredint	Commercial product
Captan	Captan 750 TS	120g	160g
Thiran	Rhodiaurum 500 SC	280ml	560ml
Difenoconazole	Spectro	5ml	33,4ml
Tolyfluanid	Euparen 50WS	75g	150g
Pencycuron	Monceren 50PM	150g	300g
Quintozene (PCNB)	Kobuto/Brassicol	300g	400g

Carboxin + Thiran	Vitavax-Thiran SC	200	100 + 100ml	500ml
Benomyl	Benlate 500		100g	200g
Thiadimenol	Baytan FS		30ml	200ml
Carbendazin	Derosal 500 SC		40ml	80ml

Source: Goulart (1998).

Table 3. Fungicides recommended for ramulosis control in cotton.

Technical name	Commercial name	Dose rate of commercial product (kg/ha)
Carbendazin + Trifenil Hidróxido de Estanho	Derosal + Brestanid	0,5 + 0,4
Trifenil Tin Acetate + Tiofanate Metil	Hokko Suzu + Cercobin	1,0 + 0,7
Azoxystrobin	Priori	0,2 a 0,3
Tebuconazole + Tiofanate Metil	Folicur + Support	0,6 + 0,75
Clorothalonyl + Tiofanate Metil	Cerconil	1,5

Source: Goulart (1998)

Table 4. Fungicides recommended for ramularia control in cotton.

Technical name	Commercial name	Dose rate of commercial product (kg/ha)
Azoxystrobyn	Priori	0,2
Trifenil Tin Acetate + Tiofanate Metil	Hokko Suzu + Cercobin	1,0 + 0,7
Carbendazin	Derosal	0,5
Epoxiconazole	Opus	0,15

Source: Goulart (1998)

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