RESULTS OF THE BWACT IN BOLL WEEVIL CONTROL, PREVENTION, SUPPRESSION AND ERADICATION PROGRAMS IN THE AMERICAS

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Abstract

The use of attract and control technologies in boll weevil (*Anthonomus grandis Boh*.) control, prevention, suppression and eradication has made substantial progress in area wide programs in Argentina, Bolivia, Brazil, Colombia, Paraguay and the USA.

Early discoveries by scientists, as reported in the literature and a USDA-ARS monograph (Agriculture Handbook Number 589, Ridgeway et al., 1983), led to the isolation, identification and synthesis of Grandlure, an aggregation and sexual pheromone for both sexes of the boll weevil and the subsequent design and production of effective boll weevil traps. In the 1980s, the traps as designed by Dr. Dick Hardee and Dr. Bill Dickerson evolved into commercial production for use in early Boll Weevil Eradication Programs (BWEPs) in the Southeast USA and early IPM programs. Several years of wide-scale use demonstrated that the traps were more effective as detection and monitoring devices than as control devices and this lead to research, patent processing and development of the Boll Weevil Bait Stick (BWBS) by the USDA-ARS-Boll Weevil Research Laboratory.

Technology surrounding the bait stick, as patented by the USDA, was transferred as an exclusive license to Plato Industries, Inc. under the US Government's Technology Transfer Act. During 1990 to 1995, the BWBS was modified, improved, evaluated in more than 200 IPM field tests in the USA and Latin America and commercially introduced as the Boll Weevil Attract and Control Tube (BWACT). The use of the BWACT or Tubo Mata Picudo (TMP) or Tubo Mata Bicudo (TMB) in Central and South America was heavily influenced by the impressive results of a two-year (1993/1995) area wide program in Nicaragua. Through collaboration with the USDA-ARS, State Extension Agencies and Latin America co-operators, the BWACT technology was implemented as a "preventative" approach against the boll weevil, the number one cotton pest in the Americas.

The BWACT has been adopted by Paraguay (in 300,000 ha./750,000 ac.) and Colombia (in 60,000 ha./150,000 ac.) in their National Cotton Reactivation Programs and in the state program of Ceará in the Northeast of Brazil (currently 100,000 ha./250,000 ac. but projected to become about 500,000 ha./1,250,000 ac. by 2003) as a strategic component to reactivate cotton production. In the IPM programs of Brazil (in 150,000 ha./375,000 ac.), the BWACT has been adopted and is widely used in commercial IPM programs as an effective, environmentally friendly product. The country of Argentina (in 50,000 ha./125,000 ac.) implemented in 1994 the use of traps and BWACTs to detect, eradicate and prevent the establishment of the boll weevil in their major cotton zones; whereas, Bolivia (in 20,000 ha./50,000 ac.) and the Brazilian state of Mato Grosso (in 240,000 ha./600,000 ac.) are in early stages with similar programs. In the USA, the BWACT and traps are approved for use in Boll Weevil Eradication Programs (6,000,000 ha./15,000,000 ac.) and IPM programs of each cotton producing state. Traps are deployed in programs as key components for boll weevil detection and "insecticide application decisions"; but, for various reasons as explained in this paper, the BWACT has only been used to a minor extent in the Mid-South and Southeast programs.

BWACT results from the national (area-wide) programs in Argentina, Paraguay and Colombia are exemplary of the potential for using attract & control technology; where used correctly, boll weevil populations have been greatly reduced, seed-cotton yields have been increased an average of 400 kgs. per ha. (350 lbs. per ac.) and insecticide usage for boll weevil control has been reduced from 6 to 8 applications per crop to less than 1. As a consequence, the incidence of mammalian poisoning, outbreaks of secondary pests and damage to beneficial insects has been drastically reduced.

Results from the aforementioned programs are presented herein.

Index terms: *Anthonomus grandis*, boll weevil eradication, BWACT, Grandlure.

Introduction

In 1963, the USDA's Agricultural Research Service (ARS) established the Boll Weevil Research Laboratory (BWRL) at Mississippi State, MS to identify, research and develop technologies to control, prevent, suppress and eradicate the cotton boll weevil. The BWRL was instrumental in the discovery of Grandlure, the aggregation and sex pheromone of boll weevils, the practical development of boll weevil traps and pheromone dispensers and the application of sterile insect technology for boll weevil eradication. The BWRL worked closely with the USDA's Animal Plant Health and Inspection Service (APHIS) and cotton producer foundations in the development and implementation of boll weevil eradication programs. The 1990 introduction of the Boll Weevil Bait Stick (BWBS) by the USDA ARS's Boll Weevil Research Lab to the cotton industry (Smith et al., 1991) presented a potential, alternative, new approach to the control of cotton boll weevils, an approach that was "preventive" and could result in the reduction of damaging weevil populations and substantial reductions in the use of insecticides for boll weevil control. The inventors (Drs. Dickens, McGovern, McKibben and Smith), all located at the BWRL, were instrumental in conducting the early research (McGovern et al., 1993; McKibben et al., 1993; Smith et al., 1992) that provided direction on the correct use of the technology in cotton and other crops. Isolated ARS and APHIS field tests with the BWBS in Alabama and Mississippi and county-wide tests in Georgia and Tennessee provided positive and quantitative results on the potential for using the BWBS technology in the USDA/Cotton Producer Boll Weevil Eradication Programs (BWEPs).

While early BWBS results (Plato, 1994; Villavaso et al., 1993; Rummel and Carroll, 1992) were generally very encouraging, there were a series of negative tests reported during 1991-1993 in Texas and Oklahoma (Rummel et al., 1994). Performance failures in Texas, Oklahoma and certain other tests can be attributed to various factors, but, the primary technical reasons were related to the product characteristics of early BWBS prototypes (many with only 3 weeks of insecticidal activity but 6 weeks pheromone release), field test designs, test plot isolation and early BWACT prototypes (only 3 weeks of attraction and control). However, the real factors were lost in public and private statements between research workers of the involved states; their statements polarized the usefulness of the technology and created personal and professional differences that damaged the image of the BWBS and BWACT.

At the end of the 1991 cotton season, Plato Industries Inc. (PII) became interested in the BWBS technology and installed a field test in the Upper Gulf Coast of Texas; the attraction and kill results were impressive and convinced PII to pursue a license from the USDA to commercially develop the BWBS. During the U.S. Presidency of Ronald Reagan, a technology transfer act was established that provided for private industry to license US Government technology; it was under this act that PII licensed the BWBS Technology in January 1992. Even though this federal act was designed to stimulate more governmental research for practical technologies, a few

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 2:1185-1192 (2001)
National Cotton Council, Memphis TN

government scientists were opposed to it, because of their perception that private industry should not profit from governmental research and that the inventors should not gain monetarily from eventual royalty revenues to be paid to the U.S. Government. For that reason, there were some respected cotton entomologists against the licensing of the BWBS to and the commercial development of it by private industry.

During 1992 and 1993, significant progress was made in the commercial development of the BWBS under Cooperative Research and Development Agreements (CRADAs) with the USDA-ARS-BWRL and under Experimental Use Permits of the US EPA (McKibben et al., 1993; Plato, 1994). The product was modified from a coated, 4 feet long wooden broomstick to a coated, 3 feet long, biodegradable, paper fiber tube. The original coating components remained basically the same; they consisted of a color attractant, feeding enticer and insecticide, all formulated into a slow release system. However, the insecticidal toxicant was changed from cyfluthrin to malathion; this toxicant change provided a product with equivalent boll weevil mortality but a lower mammalian toxicity rating and a lower costing insecticidal component. The changes made to the "kill station" (from a stick to a tube) and to the pheromone dispenser (from a hand formed PVC cap to an extruded 3x3 inch PVC dispenser) provided a product that could be more readily, commercially produced. The coating was improved and calibrated for 55 to 60 days of color fastness, feeding enticer activity and insecticide liberation, and the pheromone dispenser was loaded to have a release of 50 to 55 days. In December 1993, the US EPA granted PII a full registration of the Boll Weevil Attract and Control Tube (BWACT), the first "low risk / low use" insecticide registration in the USA. Field tests during this time and subsequent years provided invaluable guidance on how to use and evaluate performance of the BWACT.

The BWACT development efforts in 1994 and 1995 were directed to the US BWEPs (Parvin and Smith, 1994; McGovern et al., 1995; McGovern et al., 1996; Allen et al., 1995) and U.S. / Latin American IPM cotton insect control programs. During this timeframe, a standard bioassay was developed by the BWRL to determine the efficacy and residual control of the BWACT; this was a valuable methodology for product registration testing in Latin America and for quality control of BWACT commercial production. In Argentina and Nicaragua, national programs were implemented against the boll weevil. The Argentine Department of Plant Protection (IASCAV) developed a program with the input of the BWRL and PII to prevent the boll weevil from entering (from Brazil and Paraguay) and establishing in its main production areas (about 750,000 ha./I,875,000 ac.). The program was established to operate year-round, mainly in the northeastern Provinces of Misiones, Corrientes and Formosa; it consisted of strategically placed boll weevil traps for monitoring migrating weevils, BWACTS for killing weevils before reaching cotton producing fields and applications of insecticides (Thiodan and cypermethrin) and BWACTS to eliminate outbreaks detected in producing cotton fields (only occurred in Formosa near the border with Paraguay in 2,000 ha./5,000 ac.). Since the beginning of the Argentine National Program to Prevent and Eradicate the Cotton Boll Weevil, the Department of Plant Protection has maintained its strategy and been successful against the weevil (Cosenzo, 1999), even though many visiting "experts" have suggested and continued to suggest strategic changes.

As with Argentina, the Nicaraguan Program was designed and implemented with input from the BWRL and PII. It was very successful in eliminating large populations of weevils (McKibben et al., 1994; Daxl et al., 1995). All of the cotton in the country (about 7,000 ha./17,500 ac. of isolated growing zones) was treated with the BWACTs at planting and at stalk destruction for two consecutive crops and this resulted in drastically reducing the production / insecticide costs (from 20 applications to 2) and increasing yields. The Nicaraguan Program ceased after 1995, due to infrastructure, political and commercial reasons, not for technical factors (Jansen, 1996). Even though the Nicaraguan results were very good and were reported by third party scientists, there were many respected cotton entomologists in the USA that discredited the results and this created doubts with the US BWEPs and state IPM Programs concerning the use of the BWACTs. The same excellent results and continued differences between experts have occurred with many other tests and area-wide programs in the USA and Latin America.

In the USA, field testing programs were designed and implemented as accurately as possible in the Mid-South (Plato et al., 1996) and Southwest states (Allen et al., 1995), but competitive pressures, historical business relationships, conflicts of commercial interests, PII's limited development funds for field testing with state agencies, personal and professional differences and availability of labor for timely BWACT installations restricted the success of the BWACT product in the US market place. The mentality of boll weevil control for 40 years was "curative" and this became a formidable obstacle in IPM programs; such programs proved to be more "Integrated Pesticide Management" than "Integrated Pest Management" programs. Good field results were obtained from 1992 to 1997 US IPM programs, but the mentality of "don't confuse me with the facts, I have already made up my mind" was and still is too prevalent with a lot of cotton entomologists in the USA and certain ones in Latin America. As a result and since 1997, PII has focused more of its activities with the BWACT in the US BWEPs and in the Latin American area wide programs of Argentina, Bolivia, Brazil, Colombia and Paraguay (Plato et al., 1997).

Discussion and Program Results

Even though the BWACT/TMP/TMB has numerous success stories, many cotton producers, research and extension workers question why the technology is more widely used in Latin American IPM and area wide Boll Weevil Programs than in the USA. These are valid questions and there are several reasons for the differences in use. It important to recognize that between Latin America and the USA, there are generally substantial differences in farming operations, climates, availability of farm labor, availability of aerial and ground application equipment, flexibility in program operations and availability financial resources. Some key factors are:

From an economic standpoint, the use of the BWACT has provided a 30% to 40% cost savings in insecticide and application costs; a savings of this magnitude is very important for the implementation of any Latin American Program.

From an operational aspect in Latin America, there is a farm labor force for BWACT installations, whereas such labor does not exist in the USA. The USA BWEPs and farming systems are not designed "operationally" for using BWACTs. Even thought the BWACT is approved for use in BWEPs by the USDA APHIS and recommended for use (Brashear, 1997) in certain states (Arkansas, Mississippi, etc.), it is easier for "program management" to use aerial application and "mist blowers" than the BWACTs. While this is more costly, the state BWEPs have largely continued with this method of operating, mainly because of the labor situation.

From a biological basis, boll weevils are strongly attracted to the grandlure pheromone; especially between crops, when there are no squares, flowers with pollen or small bolls for the feeding and reproduction. In non-temperate climates, weevils remain very active during the months between crops, when no cotton pollen is available for natural grandlure pheromone production (competitive with synthetic grandlure), fertile egg production and perpetuation of the species; herein lies one of the key reasons for the success of the BWACT in Latin America. Weevils are active year-round in Latin America, whereas they are not active during the winter months in most of the USA. The designs of the Latin American programs consider these biological aspects, as they determine the duration, economic viability and success of their program.

"Modeling" studies conducted in Brazil (Gutierrez, 2000), suggest that 30% of a weevil population (surrounding a field, within 200 meters) are attracted each day to a BWACT "kill station".

End of season population studies (Ridgeway et al. 1983) illustrate that it is common to find up to 30,000 weevils per acre at the end of a crop. With 30% of the population being attracted daily, the BWACT has the "per acre killing power" to reduce a 30,000 weevil population to less than 1 weevil by the end of 30 days. Studies in Arkansas (Tugwell, 1998) and Colombia (Castro, 1997) have illustrated more than 7,500 weevils per week are attracted to a BWACT and residual control studies (Villavaso, 1996; Gomez, 1998) report that the BWACT will kill at 90%+ levels for up to 42 days. These numbers become very impressive when they are applied to area-wide programs of 50,000 acres or 250,000 acres or 750,000 acres. When considering this and the foregoing, it is clear as to "why and how" the area wide Latin American Boll Weevil Programs using the BWACTs have been and continue to be successful.

The recommended use of the BWACT/TMP/TMB in IPM and in area wide control, suppression, eradication and prevention programs (based on several years of field experience) and key comments and results from Argentina, Bolivia, Brazil, Colombia, Paraguay and the USA are outlined in the following country sections. Each country program has certain variations, but PII's general use recommendations are:

During the end of a crop cycle, at the beginning of weevil dispersal (when weekly trap counts jump to 4+ per trap), BWACTs are installed at one per 200 feet (60 meters) on all sides of the field perimeters to attract and kill emerging/migrating weevils that occur between sprays; they should be replaced, if necessary, each 45 to 50 days. This program should continue through stalk destruction, with BWACTs remaining around the field until 3 weeks after stalk destruction to attract and kill any weevils emerging from the residual squares and bolls of the crop.

After stalk destruction on large farms, with "well defined" weevil refugios, a few traps should be installed adjacent to the refugios and if weevil captures occur, a barrier line of BWACTs (one per 60 meters) should be installed along side of, or around, any adjacent refugios capturing weevils. The barrier program should continue so long as there are captures in the traps.

After stalk destruction on the small, family farm fields (normally 2 to 6 acres), 1 to 2 traps should be installed on "down wind" field borders and if weevil captures occur, a barrier line of BWACTs (one per 60 meters) should be installed along side of, or around, any fields capturing weevils. The barrier program should continue with replacements each 45 days, so long as there are captures in the traps.

At planting of the next crop, BWACTs should be installed as soon as fields are planted (one per 60 meters and 30 days later, one in between the first installations, at the 30 meter positions), around all fields that were treated at the end of the last crop and/or around all fields that were in cotton, treated but are rotated out of cotton for this crop cycle.

In the planted fields, three weeks before the "pin-head square" stage, an adequate number of traps should be installed to determine if 1, 2, 3 or if any, "pin-head" sprays would be required. Subsequent to this, no further weevil treatments (unless punctured square data "trigger" an application) or BWACT installations should be made until weevil dispersal occurs at the end of the crop.

These general recommendations are applicable for a BWEP, an area-wide "Suppression Program" or for an IPM program. In the Colombian and Paraguayan Programs, the BWACTs have been instrumental in reducing boll weevil populations to very low levels and this has permitted the crop to be produced without economic damage from weevils. This was accomplished by installations of BWACTs in all fields of infested zones at planting, at stalk destruction and in some situations, installations alongside of "well defined" refugios.

Argentina

The Argentine program, as designed in 1993/1994, is implemented by the Department of Plant Protection of SENASA (formerly IASCAV) in concert with provincial departments of agriculture in a manner as described in the above Introduction. Its main objective is to prevent the boll weevil from entering and establishing in the cotton producing zones south of the three northeast provinces of Formosa, Corrientes and Misiones. The success of the National Plan for the Prevention and Eradication of the Boll Weevil is determined by weevil captures from about 20,000 boll weevil traps that are placed strategically in the 12 cotton producing provinces and by the elimination of infestations that periodically occur in a few hundred hectares of cotton in fields adjacent to Paraguay in the province of Formosa. The following map illustrates the involved provinces:

With the exception of one boll weevil captured in December 1998 in the northwest province of Salta, adjacent to Bolivia, all captures have been in the northeast provinces of Formosa, Corrientes and Misiones; migrations have been successfully halted in these three provinces and infestations eliminated in all but about 138 ha. (345 ac.) in Formosa (Ramirez et. al., 1999), as summarized in Table 1:

During the last two years in Argentina, there has been an increasing concern to move the "line of defense" (against boll weevil migrations) from the northeast border zones of Argentina into the Paraguay production zones (about 20,000 ha./50,000 ac.) in the Departments of Neembucu, Misiones and Itapua. This program is planned to commence in the 2000/2001 cotton crop as a Bi-National Program in which the Paraguayan Ministry of Agriculture (MAG), SENASA and private industry jointly will collaborate in the establishment of boll weevil traps (15,000) for monitoring, BWACTs (32,000) for population reductions and stalk destruction for the elimination of feeding and reproductive sites. The cotton production in these departments is typical in Paraguay, i.e. low technology, small family farms of 2 to 5 acres (1 to 2 ha.) of cotton, all production practices are by hand and domestic animals, a very favorable environment for boll weevil survival, weevils are active year round, etc. The results expected from this program are based upon a pilot project in Cerrito, Neembucu that was conducted in the 1999/2000 crop; in the project, as depicted in the map, there were 335 fields, each averaging 1.5 ha. (3.75 ac.) and about 500 ha. (1250 ac.) with weevil infestations.

The results of the pilot project are reported in Table 2 as the per trap number of monthly boll weevil captures from 1600 traps.

Bolivia

The country of Bolivia was free of boll weevils until the 1997/1998 crop, when at the end of the season, weevils were detected in a field on the eastern border, near a cotton production zone of Brazil. Through the efforts of ADEPA, the cotton growers association, a "boll weevil prevention and eradication program" patterned after the Argentine program was implemented with traps and BWACTs. The weevil outbreak was eliminated on the eastern border, but weevils continued to migrate into Bolivia from western Brazil. PII worked with ADEPA and the local "cotton industry committee" to train its field technicians on the correct use of traps for monitoring and BWACTs at cotton planting and at stalk destruction in 1998 and 1999.

Bolivia's main customer for its cotton is Peru. It is a cotton growing country that produces long staple, long growing season cotton but it is "free of the cotton boll weevil"; thus, Peru is very concerned about importing cotton from weevil infested counties. The government of Peru and Bolivia

executed a quarantine agreement that contemplated the elimination of the boll weevil problem in Bolivia by implementing a program similar to Argentina's. However in 1999, limited funds caused the "cotton industry committee" to seek outside funding; money was obtained for their boll weevil program through FAO IPM funding. At that point, the BWACT was dropped from the Bolivian boll weevil program because FAO insisted that the Program be based only on monitoring with traps and upon the detection of weevils, applications of insecticides. For the last 45 years, this approach has failed to stop weevils from establishing in South America; it has resulted in unprofitable cotton production, many growers (and countries) abandoning cotton production, excessive use of toxic insecticides, secondary pest outbreaks and programs of "Integrated Pesticide Management", not "Integrated Pest Management". This approach will probably put Bolivia "out of meaningful cotton production"; with these tactics, Bolivia can not economically or biologically eliminate the boll weevil and the Peruvians will continue to consider it dangerous to import cotton from weevil infested fields.

Brazil

In the Northeast of Brazil there are four programs to reactivate cotton in the states of Ceará, Paraíba, Pernambuco and Rio Grande Do Norte; the Ceará program seems to be the most advanced, clearly defined and appropriately financed. The Secretary of Rural Development is the executing agency and the Banco do Nordest is the financing body. Their plan is solve a serious social problem of unemployment by motivating the small growers, family farms of 1 to 2 ha. (2.5 to 5 acres), to return to their land and produce cotton. The goal is to increase cotton production from 100,000 ha. (250,000 acres) in 2000 to 500,000 ha. (1,250,000 acres) in 2003. The boll weevil has been widely established in Ceará for about 15 years; it was the main reason for cotton acreage in the Northeast to decrease from 2 million ha. (7.5 million acres) of mostly "perennial" cotton to less than 50,000 ha. in 1999.

The Ceará Program is to be largely designed after the Paraguayan Program; both have family farms of small acreage, low-tech production and the need for a good cash crop like cotton. One main difference is that in Ceará, they plan to produce fiber from a semi-perennial variety developed by Embrapa Cotton. The variety was bred for conditions in the Northeast; but for it to be productive, there must be an answer for the boll weevil. The only practical, economical and environmental acceptable solution for the boll weevil problem is the area wide destruction of cotton stalks and installation of BWACTs (1 per ha.) at the end of the crop cycle and BWACT installations (1 per ha.) at planting and/or re-sprouting of the subsequent crop. The Plan is to start in September/October 2000, with 70,000 ha. (175,000 acres) in 34 municipalities with about 25,000 family farms; this is to be increased to 120,000 ha. (300,000 acres) in 2001 and increased each year thereafter.

Embrapa Cotton is conducting replicated field tests in isolated municipalities with the BWACT in the nearby state of Paraíba; the test is designed to be for two crops and it will involve 2 at planting and 1 end of crop BWACT installations. The test is well designed and should provide good statistical information in support to the Ceará Program. Results of this test will be reported at the next Brazilian Cotton Congress in August 2001.

In the state of Mato Grosso, there is a growing concern about and a movement to launch some type of boll weevil prevention program. Cotton production in Mato Grosso involves about 20,000 ha. (50,000 acres) of isolated, small family farms (similar to those in the Sinú/Monteria/Cereté of Colombia, the Province of Formosa, Argentina and the country of Paraguay) and 220,000 ha. (550,000 acres) of large mechanized farms (similar to those of the RGV/Winter Garden/ Gulf Coast of Texas and the Mississippi Delta). Boll weevils have been established for 10+ years in the isolated, small family farms, where there are refugios/habitats all around the fields; but it was only recently that weevils invaded about 30,000 ha. (75,000 acres) of the large, mechanized farms where the over-wintering/out of season/between crop habitats are limited and definable. The crop is planted in Dec./Jan./Feb.; it is dry land produced cotton, under high tech practices (for the region), in an excellent climate, with adequate rainfall and yields of 3,000 to 4,500 kgs. of seed cotton, 5 to 7.5 bales per ha. (2 to 3 bales per acre). The mechanized farms have been producing cotton from varieties that are very susceptible to a virus (blue disease) and these varieties are typically treated 10 to 15 times for aphids, the vector of the virus. However, 10 to 15 sprays eliminate all pest issues, even any weevils. Virus resistant varieties are being introduced and this will eliminate most sprays; without sprays, there will be a need to prevent the weevil from establishing in the large farm growing zones.

The Cotton Growers Foundation of Mato Grosso has a "pilot project" with traps for monitoring and BWACTs for installation (1 per ha.) at planting and at the end of crop in the isolated, small grower's zone of Pedra Preta; there are 22 fields in the zone, 20 with the BWACT program and 2 without. This pilot project will be important to Mato Grosso and adjacent states in providing direction to any IPM program, BWEP, Boll Weevil Suppression Program (BWSP) and/or Boll Weevil Prevention Program (BWPP) that may be implemented. Also, there is a lot of good, published information on the BWACT programs in Latin America that can give supporting information to the Pedra Preta data. Data collected during 90 days after planting illustrated that the BWACT fields had an average of 4% weevil damage, while the "check" fields had 17%; the BWACT fields had required 2 to 3 sprays, while the check fields had required 5 applications. In all probability, the Pedra Preta results will be ready for presentation at the Brazilian Cotton Conference in 2001.

Colombia

In May 2000, The Colombian Agricultural Institute (ICA), the Corporation of Agricultural Research (Corpoica), the Cotton Growers Development Fund and the Cotton Growers Federation (Conalgodon) launched, as part of its National Cotton Reactivation Program, a National Program for the Control of the Cotton Boll Weevil. For the last three years, the leaders of the Colombian cotton growers have been developing this Program; it was apparent to leadership that without the new Program, cotton production was going to cease. The Program will be mandatory by law for anyone growing cotton and tied to crop financing, i.e. if a grower decides not to follow the Program, he will not get financing and if he plants on his own, the crop will be destroyed.

The objective is to increase cotton production from about 50,000 ha. (125,000 ac.) to 200,000 ha. (500,000 ac.) during the next 3 to 4 crop cycles; in recent history, Colombia has produced as much as 250,000 ha. (625,000 ac.), so the objective is not unreasonable. Colombia has the land, equipment, labor, infrastructure, financing, technology and textile demand; however, the boll weevil and the country's "internal conflicts" with rebels have caused the crop to fall to historical low levels and forced the county to be an importer of cotton fiber. The Reactivation Program contemplates that the Colombian Government will solve the problem with rebels and that the National Program will solve the boll weevil problem by implementing a program very similar to the successful one of Paraguay. The key components will be boll weevil traps for monitoring (traps lines in all producing zones), 2 BWACTs per ha. (at stalk destruction and at planting), 100% stalk destruction and concentrated crop plantings in each production zone.

During the last 2 crops, a pilot program similar to the Paraguayan Program has been implemented in a 4,000 ha. (10,000 ac.) isolated, northeastern production zone (Aguachica). By implementing programs of boll weevil traps for monitoring, 100% early stalk destruction, installations of BWACTs (2 per ha.) at stalk destruction and at planting and a concentrated planting, the growers of Aguachica have eliminated the damage from and populations of boll weevils during the growing season. As a result of not

having to spray for weevils, they have reduced costs, increased yields and built beneficial insect populations that have largely kept the lepidopteran pests in control. During the last 2 crop cycles, only an occasional application of Bt and the release of *Trichogramma* were required. In years prior to the pilot project, cotton in this zone would be sprayed from 8 to 15 times to keep weevils below the economic damaging thresholds; this resulted in unprofitable crops, yield losses from weevil damage, averaging 300 kgs. (about $140) of seed cotton per ha. (265 lbs. per ac., about $55) and insecticide costs of $200 to $375 per ha. ($80 to $150 per ac.). This same scenario and "war against the weevil" has been fought for the last 30+ years in the Colombian coastal and interior crops, with lost revenues and extra costs of $340 to $515 per ha. ($135 to $205 per ac.).

The Aguachica program has provided the confidence for a "green light" to the National Program and it has support from the country's president to cotton grower level. Even with the excellent results from Aguachica, there were many foreign experts that tried to convince the Colombians to change their program and drop the use of the BWACTs. These experts were informed by the Program leadership, that their Program is based on Colombian results and financing and that it is to be implemented as outlined in the foregoing.

Paraguay

Cotton is the number one "cash" crop for about 120,000 family farms, each averaging 1 to 2 ha. (2.5 to 5 ac.) of cotton; in the scheme of production, its employs and involves about 1.5 million people, a third of the country's population. When the boll weevil migrated into Paraguay in 1991, there were about 550,000 ha. (1,375,000 ac.) of cotton production. Prior to the weevil, cotton was produced with only 1 to 2 insecticide applications for the occasional outbreak of cotton leafworms (*Alabama argillacea*); within a few years, the beneficial insect populations were being decimated by 6 to 8 applications of toxic insecticides (for weevils), applied through knapsack sprayers by "campesino" producers who had only very little knowledge about the correct use of such products. By the 1996/1997 crop, yields were dropping, cotton had become unprofitable (for various reasons, including increased costs due to the weevil) and the planted area was reduced to 110,000 ha. (275,000 ac.). The lack of cotton production created the same social problems that had occurred in other countries of Central and South America.

In 1997, a 5 year National Plan to Reactivate Cotton was launched; it was based on a "pilot project" that had been conducted in a production zone of about 40,000 ha. (100,000 ac.) for 2 years. As part of this project, boll weevil traps and BWACTs at planting and stalk destruction had been used with good results. The National Plan was designed to eliminate the "boll weevil" problem, improve soils through crop rotation and fertilizers, improve seed quality, control insecticide quality, provide crop financing, provide technical services and expand R&D activities for crop production. Due to political problems and conflicts of commercial interests, the Program has had its "ups and downs", but it is continuing in a positive direction. In the 2000/2001 crop, 315,000 ha. (750,000 ac.) have been planted for cotton production.

The performance of the BWACTs has been measured primarily through a "trapping" program of 1200 traps in the major production zones; the zones and boll weevil captures are illustrated in the following Figure 1:

Trapping data as in the foregoing is very similar to the approach used by the BWEPs in the USA to measure program success.

In the following Figure 2, key data from 3 years of BWACT installations are presented as a comparison of trap captures to a 3 year average, prior to BWACT installations and a comparison of the average number of insecticide applications required to produce each crop during the last 5 years.

It would seem that with the success of the Paraguayan Program and other programs as described in the foregoing, there would be a greater consensus on the use of the "Attract and Control " technologies in IPM and area wide programs. But "real world" being "real world", the elimination of 6 applications of insecticides in 300,000 ha. (750,000 ac.), represents a loss of about $30,000,000 in insecticide sales and there are a lot of commercial interests to stop the use of the BWACT, regain the sales in Paraguay and in other programs deploying the BWACT.

USA

The BWEPs in the USA have been a success in the Southeastern and Western cotton growing zones and are a growing success in the Mid-South and Southwestern states. While they are costly, about $400.00 per ha. ($160.00 per ac.), and generally require from 5 to 7 years to achieve "zone" eradication, the "cost to benefit" ratio is 1 to 12 (National Cotton Council 1994). As explained in the Introduction, the BWACT is approved for US BWEP use and it is recommended in some states; but it is not widely deployed. With the boll weevil being "pushed back" to border with Mexico, research efforts against the weevil are "winding down" and it is questionable if another "definitive" test could be conducted that would convince BWEP leadership to broadly adjust and operationally reorganize for BWACT installations. However, in the state of Arkansas, a 3 year research project has been recently concluded that will provide more data on the use of the BWACT for BWEP and this study may encourage BWEP management to use the product in the Arkansas, Missouri and Tennessee Programs, about 800,000 ha. (2,000,000 ac.). The results of the study will probably be presented at the next NCC Beltwide Cotton Conference in January 2001.

Conclusion

The development and use history of the BWACT in IPM and area wide programs clearly illustrates that the product and its related technology of "attraction and control" provide an alternative to conventional spray programs (wash day, weekly or bi-weekly) and Integrated Pesticide Management programs in the USA and Latin America. The BWACT has been demonstrated during several years, in a multitude of tests, to be an ideal "tool" (product) for integration into true IPM (Integrated Pest Management) programs. Its use in USA programs has been limited for many different reasons, but labor for installation and the "operational design" of programs (with limited labor) affect the wide scale use of the technology.

In Latin America, the availability of labor for BWACT installations, the year round boll weevil activity and the 45+ days of weevil "attraction and control" by the BWACTs make the technology very suitable for use in IPM and area wide programs in the weevil infested countries [Mexico, Guatemala, Honduras, El Salvador, Nicaragua, Colombia, Venezuela, Bolivia, Brazil, Paraguay and Argentina (only in the Province of Formosa)].

The use history of the BWACT in the Nicaraguan, Argentine, Paraguayan and Colombian boll weevil programs provides sound agronomic reasons for continued use and for use in the expanding, area wide programs of Brazil and Colombia. History and current data illustrate that to have a successful cotton reactivation program in a weevil infested region, the weevil has to be "taken out" of the production scheme. In Latin America, concentrated plantings, BWACT installations at planting and BWACTs during complete stalk destruction have been the most economical, effective and environmentally friendly tactic to employ against the weevil. In boll weevil infested regions and countries where the technology is not used, it is primarily due to political, competitive and/or operational factors, not technical and economical.

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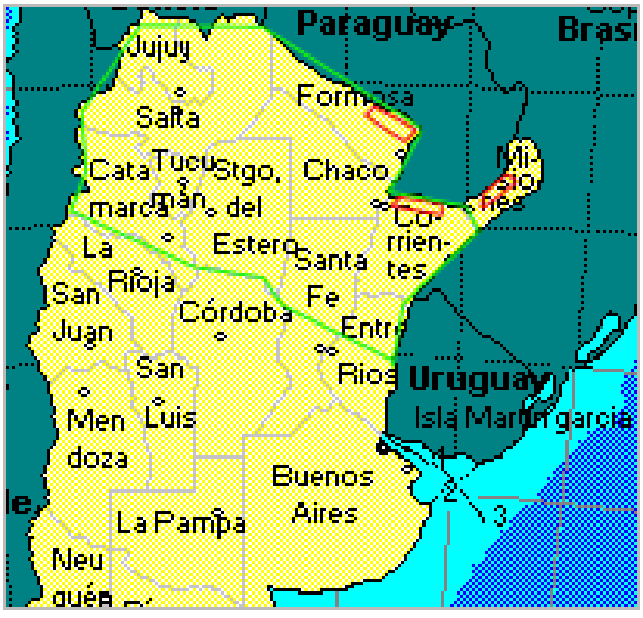


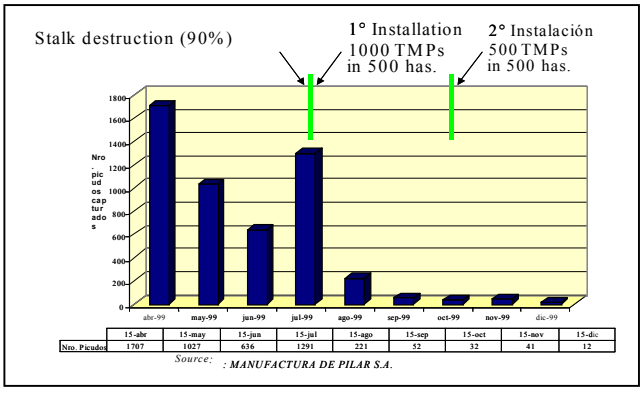
Argentine Cotton Provinces

Table 1. Weevil Captures from 2182 Traps in Formosa (the only infested Province in Argentina) – 1999.

Department	Zones	Area	No. Weevils May	No. Weevils Jun-Aug	No. Weevils Sept
	Mision Tacaagle	243.5	5	2	0
Pilagás	El Espinillo	524.0	36	0	0
	Tres Lagunas	746.5	773	599	0
	Sub-Total	1,514.0	814	601	0
	Riacho He He	282.5	549	520	33
Pilcomayo	Laguna Blanca	613.0	853	1,427	0
	Palma Sola	180.0	259	167	0
	Sub-total	1,075.5	1,661	2,114	33
	TOTAL	**2,589.5**	**2,475**	**2,715**	***33**

*Captures occurred in 1 field of 137.5 ha. (340 ac.)

Table 2.



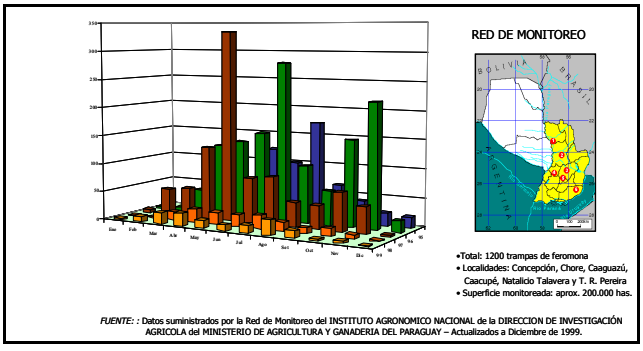


Figure 1.

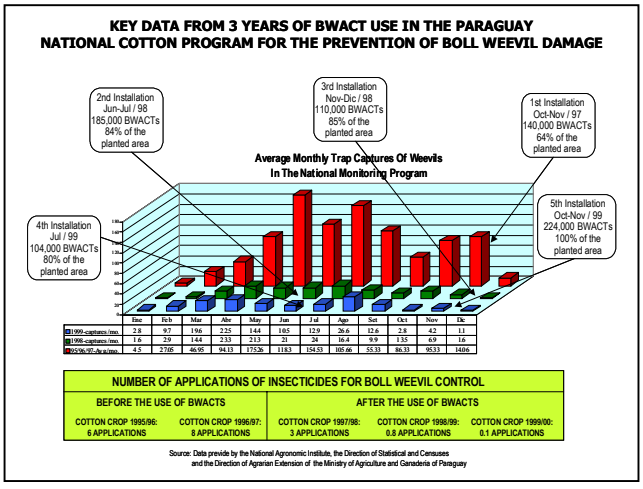

KEY DATA FROM 3 YEARS OF BWACT USE IN THE PARAGUAY
NATIONAL COTTON PROGRAM FOR THE PREVENTION OF BOLL WEEVIL DAMAGE
2nd Installation Jun-Jul / 98 185,000 BWACTs 84% of the planted area
3rd Installation Nov-Dic / 98 110,000 BWACTs 85% of the planted area
1st Installation Oct-Nov / 97 140,000 BWACTs 64% of the planted area
Average Monthly Trap Captures Of Weevils In The National Monitoring Program
4th Installation Jul / 99 104,000 BWACTs 80% of the planted area
5th Installation Oct-Nov / 99 224,000 BWACTs 100% of the planted area
Ene Feb Mar Abr May Jun Jul Ago Set Oct Nov Dic
1999-captures/mo. 2.8 9.7 1.96 2.25 1.44 1.05 12.9 26.6 12.6 2.8 4.2 1.1
1998-captures/mo. 1.6 2.9 1.44 2.33 2.13 21 24 16.4 9.9 1.55 6.9 1.6
95/96-97/98-captures/mo. 4.5 2.705 46.95 94.13 175.26 118.3 154.33 105.66 55.33 86.33 95.33 14.06
NUMBER OF APPLICATIONS OF INSECTICIDES FOR BOLL WEEVIL CONTROL
BEFORE THE USE OF BWACTS
AFTER THE USE OF BWACTS
COTTON CROP 1995/96: 6 APPLICATIONS
COTTON CROP 1996/97: 8 APPLICATIONS
COTTON CROP 1997/98: 3 APPLICATIONS
COTTON CROP 1998/99: 0.8 APPLICATIONS
COTTON CROP 1999/00: 0.1 APPLICATIONS
Source: Data previde by the National Agronomic Institute, the Direction of Statistical and Censuses and the Direction of Agrarian Extension of the Ministry of Agriculture and Ganaderia of Paraguay

Figure 2.