Output 4. Global IPM networks (Integrated Whitefly Management Technology) and knowledge systems developed.

Activity 4.1. Dissemination of validated IPM Technology in developing countries affected by whitefly pests and whitefly - transmitted viruses that hinder food production and socio-economic development in the Tropics.

Goal: To promote sustainable agriculture and socio-economic growth in resource-poor farming communities possessing mixed cropping systems affected by whitefly pests and whitefly-transmitted viruses in Sub-Saharan Africa (SSA), India, South East Asia and Latin America.

Objectives

1. To provide technical assistance to small- (< 3 ha) and medium-scale (3-8 ha) farmers on the biology, dissemination, and integrated management of whiteflies and whitefly-transmitted viruses affecting major food and cash crops, based on previous diagnostic work and validation of suitable IPM practices.

2. To educate farmers about the multiple negative consequences of insecticide abuse for the control of whitefly pests and whitefly-transmitted viruses, emphasizing the need to reduce production costs, environmental and food contamination, human health risks, and the gradual development of resistance to insecticides in whitefly populations.

3. To establish sustainable mixed cropping systems in order to promote food security and economic growth in small and medium-scale farming communities seeking to diversify their traditional food staples with high-value horticultural crops.

Project Leader and Organization: Dr. Francisco J. Morales, CIAT.

Sub-project Leaders/Collaborators and Organizations:
Dr. James Legg, IITA-NRI
Dr. Richard Gibson, NRI
Dr. John Colvin, NRI
Dr. Ian Barker, CIP
Dr. Segundo Fuentes, CIP
Dr. Oscar Ortiz, CIP
Dr. Vyju Lopez, CABI
Dr. Francisco Morales, CIAT
Dr. Cesar Cardona, CIAT
Dr. Anthony Bellotti, CIAT
Dr. Peter Hanson, AVRDC

Subprojects

1. Whiteflies as vectors of viruses in cassava and sweet potato in sub-Saharan Africa.

2. Whiteflies as vectors of viruses in mixed cropping systems in the lowlands and mid-altitude valleys of Mexico, Central America, and the Caribbean.

3. Whiteflies as pests in the tropical highlands of South America.

4. Whiteflies as vectors of viruses in tomato-based mixed cropping systems in India and S.E. Asia.

5. Whiteflies as pests of cassava in South America and Africa.

Introduction

Phase III of the Tropical Whitefly IPM Project (TWFP) emphasizes the transfer of IPM information and improved germplasm to small-scale farmers affected by whitefly pests and viruses transmitted by whiteflies in the Tropics. The lack of improved germplasm possessing pest and disease resistance, and insufficient technical assistance to small-scale farmers, have been identified as the main constraints hindering the management of whitefly and whitefly-borne viruses that affect food production of major staples, such as cassava and common bean, and the adoption of high value crops, such as tomato, peppers and cucurbits, by small-scale farmers seeking to maximize the income derived from their limited landholdings. Therefore, it is necessary to disseminate information and train agronomists and agricultural technicians on the most effective IPM practices available to control these pests. In the absence of technical assistance and relevant information, pesticides become the pest control method of choice, leading to pesticide abuse, higher production costs, environmental contamination, contamination of agricultural food products, and health problems in rural communities.

Whiteflies as vectors of viruses in cassava and sweet potato in sub-Saharan Africa.

The sub-Saharan Africa project continues to train farmers and disseminate information and resistant cassava and sweet potato varieties in their target areas, primarily in Tanzania, Uganda and Nigeria. Emphasis on the education of farmers and adoption of phytosanitation practices is also important in this sub-project, as many farmers do not understand basic concepts of virus/vector epidemiology, such as the use of virus-infected vs. virus-free planting material; the role of infected plants as virus sources in the field; virus symptomatology; and the role of whiteflies as pests and virus vectors. This knowledge is critical to promote the adoption of virus-resistant cassava and sweet potato varieties in this region. The TWFP has linked the crop improvement activities of international centers, namely IITA (in the case of cassava) and CIP (for sweet potato) to its own IPM technology dissemination activities in order to assure the sustainability of the improved cassava and sweet potato germplasm released in sub-Saharan Africa by these two international centers.

Whiteflies as vectors of viruses in mixed cropping systems in the lowlands and mid-altitude valleys of Mexico, Central America, and the Caribbean.

In Central America, the distribution of common bean varieties possessing resistance to whitefly-borne viruses continues at a fast pace, together with the dissemination of information on the rational use of selective insecticides. Fortunately, the USAID-funded CRSP Project based in Honduras (Zamorano) has maintained a steady output of improved common bean materials possessing excellent levels of resistance to whitefly-borne viruses, and good commercial characteristics. The TWFP is helping the national agricultural research program of El Salvador to multiply seed of these improved varieties for distribution to small-scale farmers, together with an IPM package designed to reduce pesticide inputs.

In the case of tomato, seed of the virus-resistant genotypes identified by the TWFP is being distributed to national programs for use in their breeding programs. Linking of these national breeding activities to the tomato/pepper crop improvement activities of advanced international institutions, such as AVRDC and the University of Wisconsin, is also a major concern of the TWFP. Cuba has made considerable progress in the development of tomato genotypes possessing resistance to whitefly-transmitted viruses. Work is underway to develop the capacity to detect different genes responsible for the resistance to these viruses in Latin America. The molecular markers available could be used to select tomato hybrids and/or varieties bred in North America or the Old World, for resistance to neo-tropical whitefly-borne viruses. Some of these materials have been identified in South America.

In the absence of genetic resistance, the use of physical protection measures is the only alternative for horticultural zones affected by high whitefly populations. This strategy is being promoted and further evaluated as a biologically and economically viable practice to grow these crops under minimum insecticide protection despite high disease pressure. The entire region is now moving towards the concept of ‘Protected Agriculture’.

Whiteflies as pests in the tropical highlands of South America.

In the Andean region, the farmer field schools and complementary farmer participatory approaches have been very successful in increasing common bean yields and reducing pesticide applications in pilot sites of Colombia and Ecuador. This experience is being replicated in Bolivia, where farmers are currently struggling with whitefly pests in their meso-thermic valleys where traditional food crops have been diversified with high value horticultural crops to increase farm income. In these regions, we can find mixed cropping systems that include basic crops, such as maize, beans and potatoes, and high-value crops, such as tomato and peppers. In these environments, whiteflies act mainly as direct pests and, consequently, the project has been promoting the implementation of ‘economic or action thresholds' that tell farmers when to apply in order to minimize production costs and maximize yields.

Whiteflies as vectors of viruses in tomato-based mixed cropping systems in India and S.E. Asia.

In Asia and particularly India, the deployment of improved tomato lines possessing resistance to whitefly-borne viruses has been very successful. These lines are being constantly improved for other agronomic traits in order to increase their market value and levels of adoption of these varieties by small-scale farmers. In this sub-project, the private sector is being involved with a view to facilitating seed production and distribution of these valuable materials in India.

Whiteflies as pests of cassava in South America and Africa.

Resistance to whiteflies as pests has also been identified and transferred to commercial cassava cultivars in South America. Crosses with African cassava cultivars have already been made in hopes of transferring the resistance identified in South America, to African cultivars affected by different whitefly species in sub-Saharan Africa. However, the South American-based sub-project in charge of these activities, is also promoting other IPM measures to further increase the yields of whitefly-susceptible varieties.

Other support activities

Farmer participatory, Impact assessment and Policy guidelines have also been developed by the TWFP to scale out the IPM technology promoted by the project.

Coordination: State of the Project

The socio-economic importance of whiteflies as pests and vectors of plant viruses has not diminished in most developing countries of the world, even though these patho-systems are actively investigated by a relatively large number of researchers, both in developed and developing nations around the world. The fact is that whitefly and whitefly-borne virus outbreaks continue to cause significant crop losses, even in agricultural regions not previously affected by these pests. For instance, the sub-tropical regions of South America (e.g. Uruguay and Peru) have been experiencing alarming problems in legume and horticultural crops, induced by whitefly-transmitted viruses, in recent years (Figure 4.1.1).

Figure 4.1.1.

This region had been free from whitefly-borne viruses affecting legumes and tomatoes until recently. The emergence of yet another whitefly pest, *Bemisia afer*, in Peru, further complicates the agricultural situation of this country. Recent experiments financed by the TWFP in Peru, showed that this species has the ability to transmit Sweet potato chlorotic stunt virus, a major viral pathogen (Crinivirus) of sweet potato in different regions of the world, including sub-Saharan Africa, where *B. afer* is also present. A second crinivirus, Potato yellow vein virus, transmitted by the whitefly *Trialeurodes vaporariorum*, is also causing significant yield losses in potato producing regions (Figure 4.1.2), particularly in the Andean regions of Colombia, Ecuador and Peru. This virus was recently detected in the highlands of Colombia infecting tomato (Figure 4.1.3).

Figure 4.1.2.

Figure 4.1.3.

Whitefly-transmitted geminiviruses (begomoviruses) are also spreading in Mexico, Central America and the Caribbean, aided by the continuing dissemination of the B biotype of *B. tabaci*. This biotype has displaced the A biotype of *B. tabaci* from the lowlands and mid-altitude agricultural regions, as well as *T. vaporariorum* from higher agricultural areas, where the A biotype of *B. tabaci* could not thrive in the past. The B biotype of *B. tabaci* is now transmitting viruses not present before in inter-Andean valleys. In the Cauca Valley of Colombia, snap bean (Figure 4.1.4) and tomato (Figure 4.1.5) production have been practically abandoned due to these problems

Figure 4.1.4.

Figure 4.1.5.

Whitefly-transmitted viruses continue to disseminate and affect many different crops in Asia and the Americas. In Africa, new variants of African cassava mosaic virus are likely to emerge in the future and cause severe yield losses, as in the recent case of the Ugandan variant of East African cassava mosaic virus (Figure 4.1.6).

Figure 4.1.6.

Several begomoviruses affect food and industrial crops in Asia, particularly in India. Tomato leaf curl, for instance, is widely distributed in India (Figure 4.1.7), where a number of pathogenic variants of this virus, are known to exist.

Figure 4.1.7.

What are the factors driving whitefly and whitefly-transmitted virus epidemics?

There are different factors associated with the continuous spread of whiteflies and whitefly-borne viruses in developing countries around the world:

1) The lack of technical assistance to small-scale farmers. As funds for international and national agricultural research become increasingly scarce, or are devoted to socio-environmental issues devoid of any food production component, resource-poor farmers must resort to highly toxic and ineffective insecticides to protect their crops (Figure 4.1.8). Insecticide abuse eliminates natural whitefly-control agents, giving rise to higher than normal whitefly populations that cause significant direct and indirect damage. On the other hand, the increasing demand for pesticides has allowed agro-chemical companies to increase the number of employees promoting their pesticides in all agricultural regions of the world.

Figure 4.1.8.

2) Integrated Pest Management (IPM) requires adequate knowledge of the biological and physical factors that condition pest and disease outbreaks. This knowledge is only partially available at the professional and technical level, and practically non-existent at the farmer level. More important, there are some basic IPM practices that must be in place before other control methods can be successfully applied. For instance, genetic resistance or tolerance to plant viruses is required before other IPM strategies can be deployed. Trying to implement IPM practices, such as biological control agents, sticky yellow traps (Figure 4.1.9), live barriers, etc., before a significantly disturbed (high pesticide use) agricultural system has been stabilized, or in the absence of genetic resistance or more drastic IPM measures (e.g. physical barriers, legal measures), is a waste of time, resources and, more important, a total loss of credibility in farming communities that are instructed to implement ineffective IPM methods. Finally, the application of pesticides is a traditional practice that farmers are very familiar with, whereas IPM methods usually require previous training of farmers and their benefits are not always apparent in the short term.

Figure 4.1.9.

How is the Tropical Whitefly IPM Project addressing these constraints?

It is quite evident that one of the main obstacles in the implementation of IPM 'packages' in developing countries, is the incomplete understanding of the biological factors that play a critical role in the emergence of whitefly pests and whitefly-transmitted viruses. Unfortunately, this lack of understanding often affects the entire agricultural sector, from professionals to farmers. Thus, the objectives of Phase III of the TWFP become particularly relevant: "to disseminate information on the most sustainable and effective IPM measures available and validated to manage whitefly pests and whitefly-borne viruses". The main strategy of the TWFP has been the training of trainers (Figure 4.1.10); education of farmers (Figure 4.1.11); and distribution of technical literature (Figure 4.1.12) through different channels and collaborating national institutions. In this respect, the extension services and farmer participatory research activities play an important but limited role due to the economic situation of most national programs in developing countries, and the magnitude of the task, respectively.


Figure 4.1.10.


Figure 4.1.11.


Figure 4.1.12

The downsizing of national and international agricultural research institutions in developing countries, and particularly their commodity-oriented programs, has drastically diminished the probability of making a measurable contribution to the alleviation of hunger and poverty in developing countries. The replacement of crop production specialists and conventional plant breeders by molecular biologists and social scientists (instead of achieving the integration of crop production and social scientists), has resulted in a significant reduction in the availability of improved germplasm to resource-poor farmers. The importance of maintaining a constant supply of improved germplasm possessing resistance to the main biotic and abiotic constraints, has been clearly demonstrated by the TWFP in the case of the severe pandemic of African cassava mosaic disease in Uganda and neighboring countries, and in the case of tomato leaf curl in India. The deployment of begomovirus-resistant varieties by IITA and AVRDC with the help of NRI, not only averted a serious famine in the case of Africa, but also contributed to improving the livelihood of many tomato farmers in India (Figure 4.1.13).

Figure 4.1.13.

The past common bean improvement efforts of CIAT, to develop varieties resistant to whitefly-borne viruses, prevented the collapse of millions of common bean farmers throughout Latin America in the 1980s and 1990s. Unfortunately, CIAT's common bean improvement activities have been drastically reduced to less than 10% of the original output due to the disintegration of its original multidisciplinary, commodity-oriented research teams. In the absence of virus - resistant varieties, and considering the gradual deterioration of the genetic resistance incorporated in the old varieties, most IPM programs are bound to collapse in agricultural regions affected by whitefly pests and associated diseases.

The TWFP has identified pesticide abuse as one of the main causes driving whitefly pests and whitefly-borne virus epidemics in the tropics and sub-tropics of the world. Unfortunately, in the absence of technical assistance and availability of resistant germplasm, farmers do not have any other choice to protect their crops. Thus, the condemnation of the 'green revolution' by environmentalist groups, has actually contributed to an unprecedented increase in the use of highly noxious pesticides by farmers, in a desperate attempt to protect their crops against an ever evolving population of pests (e.g. biotype B of *B. tabaci*) and pathogens (e.g. new begomoviruses). Pesticide abuse also prevents the use of environmentally friendly IPM strategies, such as the use of biological control agents, and causes major damage to the flora, fauna and human communities exposed to these noxious and often lethal chemicals (Figure 4.1.14).

Figure 4.1.14.

The TWFP has thus emphasized the need to decrease the number of insecticide applications in order to reduce production costs and recover the biological equilibrium of the affected agro-ecosystems. The main strategy to reduce pesticide applications has been the use of varieties possessing resistance not only against whitefly-borne viruses (e.g. cassava, common bean, tomato), but against the whitefly pests as well (e.g. the development of whitefly-resistant cassava varieties in Latin America and sub-Saharan Africa). Another strategy has been the identification of 'action thresholds' for most cropping systems where whiteflies act only as a direct pest (not as vectors of plant viruses). This strategy has been successfully demonstrated in the Andean sub-project in Colombia, Ecuador and Bolivia. However, in the case of the whitefly pests of cassava in South America, it has been shown that chemical protection of the planting material for the initial stages of plant growth, has a significant positive impact in the final yield. Thus, the TWFP is actively disseminating information on the most effective and environmentally friendly insecticides available to farmers for all susceptible crops, at the lower possible cost or for use in the most cost-effective way. The TWFP has also been contacted by commercial companies to test new organic products against whitefly pests, as well as by representatives of the main agrochemical companies (e.g. CropLife) interested in the safe use of their products.

Last but not least, the constant feeding of information and active participation of national program scientists in developing countries (Figure 4.1.15), maintains a relatively small but important group of scientists and institutions active in the fight against these important pests. Many scientists have been trained or informed about the most effective and economically viable strategies available around the world to control whitefly pests and whitefly-transmitted viruses. This is a critical activity in developing countries already exposed to the pressures exerted by a globalized economy, particularly considering the dependence developing countries have on agricultural commodities in the international market.

Figure 4.1.15.

The way ahead

The success of the TWFP depends on the amount of technology dissemination achieved and potential beneficiaries reached at the end of the project. The weakest component of the IPM measures promoted by the TWFP, is the lack of virus-resistant varieties possessing desirable agronomic, cooking quality, and commercial traits sought by farmers (Figure 4.1.16). Unfortunately, crop improvement is the kind of research activity that has suffered the most drastic reductions at national and international agricultural research institutions, in response to the continuous economic crises that have already caused the financial collapse of some of these institutions. Diverting research funds into unproductive social studies; and false expectations created by novel research techniques, such as molecular marker assisted selection, are at the root of the problem. However, there is no sign in the CG System that crop improvement will become again the highly productive activity it used to be when IARCs had multidisciplinary research teams in charge of providing small-scale farmers with cultivars that did not require costly and noxious inputs. The TWFP can only expect that a significant reduction in pesticide use will help affected agro-ecosystems recover their biological control agents in detriment of whitefly pest populations. Once this is achieved, various other IPM measures could further contribute to the management of whitefly related problems in the tropics.

Figure 4.1.16.

Activity 4.2. Integrated management of whiteflies (*homoptera:aleyrodidae*) on cassava.

Contributors: C.J. Herrera, C. Holguin, A. Muñoz & A. C. Bellotti

Highlights:

∉ Whitefly control in cassava in the coffee growing region of Colombia based on the judicious use of pesticides increased yield from 16.2 to 38.8 tons per hectare, more than doubling yields.

∉ The successful management of whitefly populations in cassava depends on effective control practices that can be implemented early in the crop cycle and/or whitefly attack. These tactics include stake treatment or early application with an effective chemical and/or biopesticide product.

Rationale

In recent years whitefly populations have increased dramatically in certain regions of Colombia. Two whitefly species predominate, *Aleurotrachelus socialis* and *Trialeurodes variabilis*. These species are colonizing areas such as the coffee growing region of Colombia, where previously, they did not occur in high populations, nor cause economic damage to the cassava crop. Both aforementioned species are causing a considerable reduction in cassava root yield in this region and farmers are unaware of effective management practices.

This scenario has led to the implementation of an IPM project to generate alternatives for whitefly control in the coffee growing region. Chemical pesticide applications in the region are on the rise and this is increasing production costs as well as the potential to cause outbreaks of secondary pests. Whiteflies are difficult to control with agrochemicals and this often leads to more frequent applications (on a calendar basis), a build up to pest resistance to chemical pesticides, and eventually environmental contamination.

The general objective of this project is to establish a whitefly pest management program that will provide cassava producers with an adequate, opportune, economical and sustainable alternative that will reduce pesticide applications and provide high yields.

Specific objectives include:
1. Obtain information on the present whitefly situation on cassava and in the Colombian coffee growing region.
2. Determine current farmer practices being used to control whiteflies.
3. Determine doses and timing of application of appropriate pesticide use.
4. Provide cassava producers with information and training in integrated pest management and provide alternative techniques, such as biological control and host plant resistance, to reduce pesticide use.

Materials and Methods

Cassava Whitefly Diagnostic Survey:. A diagnostic survey was conducted in the target region in order to obtain information on pest distribution, crop damage levels and present farmer practices being employed to control whiteflies. Sixty two cassava farmers were interviewed in the regions, including the Department of Quindio, Risaralda, Caldas and Norte del Valle. Cassava fields were surveyed by selecting 10 plants at random and determining whitefly populations and damage with visual scales previously established in research trials. These 1 to 6 scales aid in determining the whitefly infestation levels in the region (Table 4.2.1 and 4.2.2).

A survey questionnaire was designed for use during farm visits. These visits and interviews were designed to obtain information on the actual situation confronting cassava producers in the field, the severity of phytosanitary problems and farmer needs and priorities. In addition, meetings were held with farmer groups, students, technicians and agronomists in the regions, providing them with information on pest biology and behavior and introducing some whitefly management practices.

Chemical Control. Farmer surveys show that cassava producers are trying to control whitefly outbreaks with numerous indiscriminate chemical pesticide applications. This misuse of agrochemicals indicated the need to develop an effective strategy for the rational use of pesticides, including the evaluation of new products and best dosage, and methods and timing of applications.

Pesticides evaluations were carried out in farmers' fields in the Department of Quindio during the 2005-06 growing season. Products with new active ingredients were evaluated, using the cassava variety ICA Armenia (HMC 1). The experimental design was completely randomized blocks with 7 treatments, four repetitions per treatment and an absolute control (Table 4.2.3). Evaluations of whitefly populations were initiated fifteen days after planting and continued until plants reached six months. Whitefly eggs nymphs and adults were recorded based on the populations scale (Table 4.2.1). Insecticide applications were made when whitefly populations reached level 3.0 on the 1.0 to 6.0 scale.

In treatments 1 and 2, the first foliar application was with Actara (Thiametoxam at a dose of 0.5 g/l of water). This rotated with a wettable powder (Diafentiuron, doses 2.5cc/l of water). In treatments 4, 5, and 6 a wettable powder combination (Imidacloprid-Beta-cyflutrina, doses: 4cc/l of water) and Opportune (buprofezin, doses of 3cc/l of water) for foliar applications. For the remaining treatments the same insecticide was used for all applications.

At harvest, cassava yields were recorded from the central plant rows for each treatment, and results analyzed (AOV). Cassava root commercial market prices were recorded at harvest. All costs incurred for each treatment, including manual labor and the product value, were registered. These data allowed for a cost-benefit analysis In each treatment the following parameters were calculated: variable costs, total costs, total benefit, net benefit and cost-benefit relationship.

Table 4.2.1. Population scale for the cassava whitefly Aleurotrachelus socialis Bondar.

GRADE	ADULTS – EGGS	NYMPHS-PUPAS
1	NO	NO
2	1 – 50	1 –200
3	51 – 200	201 –500
4	201 – 500	501 – 2000
5	501 – 1000	2001 – 4000
6	>1000	>4000

Table 4.2.2. Damage scale of Aleurotrachelus socialis Bondar in cassava.

Grade	Symptoms
1	Leaves with no damage
2	Young leaves green in color but slightly flaccid
3	Some distortion of young leaves, with slight curling
4	Upper leaves distorted, considerable leaf curling, yellow green mottled appearance
5	As in # 4, but lower leaves with sooty mold and leaf yellowing
6	Considerable leaf necrosis and defoliation, sooty mold on mid and lower leaves and young stems

Table 4.2.3. Doses and methods of application for pesticide treatments of cassava whiteflies.

Product	Doses/ ha	Method of Application
Thiamethoxam 25 WG	0.450 Kg	Drench at germination
Thiamethoxam 25 WG	0.2 Kg	Stake dip
Etofenprox 10 EC	1 lt	Drench at planting
Imidacloprid WG70	0.3 Kg	Drench at germination
Imidacloprid-Beta-cyflutrina SC Imidacloprid	0.8 litros	Stake dip
(stahe)	0.3 litros	Foliar
Comercial Control	0.06 Kg	
Absolute Control		

* Application at base of plant

Farmer Training: More than 300 persons, including students, farmers, technicians and other professionals have received training in the coffee growing region. Training methods concentrate on seminars and field days and include information on whitefly behavior, damage, natural enemies and pest management practices, especially biological control and judicious pesticides use.

The diagnostic survey described in this report was presented at the Colombian Entomological Congress (SOCOLEN) during 2006.

Results and Discussion

Cassava Whitefly Diagnostic Survey, Coffee Region:. The diagnostic survey was carried out with the assistance of the National Coffee Federation in each department, and CORPOICA and ICA (Regional Quindio). Surveys with cassava farmers were done between 1100 and 2900 m.a.s.l. The number of surveys in each department was determined according to the cassava hectares planted (Table4.2.4). The department of Quindio with the greatest area sown had the highest number of farmer surveys (41).

Numerous cassava pests were recorded during these surveys: Whiteflies were the most important and predominant, and recorded on 76% of the farms surveyed. This was followed by two additional pests, traditional in the region, fruitflies (*Anastrepha* sp) and the cassava hornworm (*Erinnyis ello*), both at 32% (Figure 4.2.1). These results show that whiteflies, previously a secondary pest in the regions, has displaced the more traditional pests, and have become a major pest causing yield losses.

Two whitefly species predominate: *Trialeurodes variabilis* was collected from 50% of the fields surveyed and *A. socialis* from 13%. *T. variabilis* predominated in all Departments while *A. socialis* was observed only in Risaralda (Figure 4.2.2). Sixty seven percent of the cassava fields surveyed presented whitefly populations. Fifty five percent of these with a rating of 2.0 (1-50 adults/eggs and 1-200 nymphs and pupae). Eleven percent had an intermediate to high level (grades 3, 4 and 5) and only 1% a grade level 6(>1000 adults and eggs; > 4000 nymphs and pupae per leaf) (Figure 4.2.3). Damage levels in general, remained low with the highest damage and population levels occurring in Quindio Department (Figures 4.2.3 and 4.2.4).

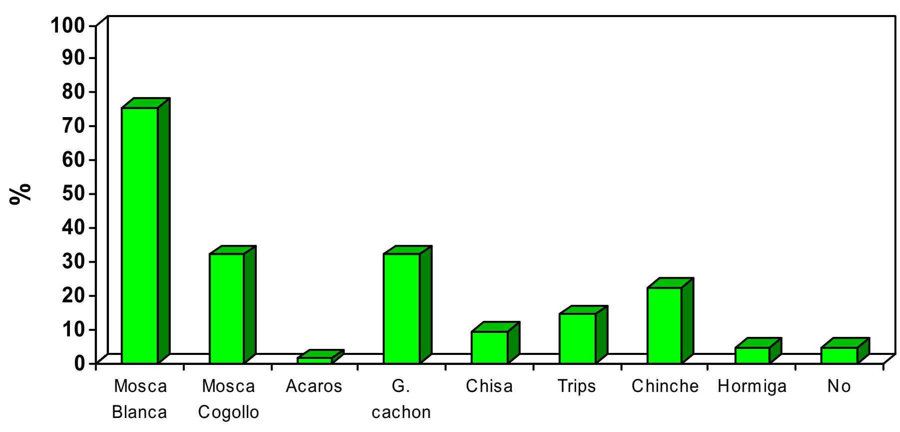

Figure 4.2.1. Arthropod pest presen in casavva field in four departments of the Colombian coffee region (2005-2006)

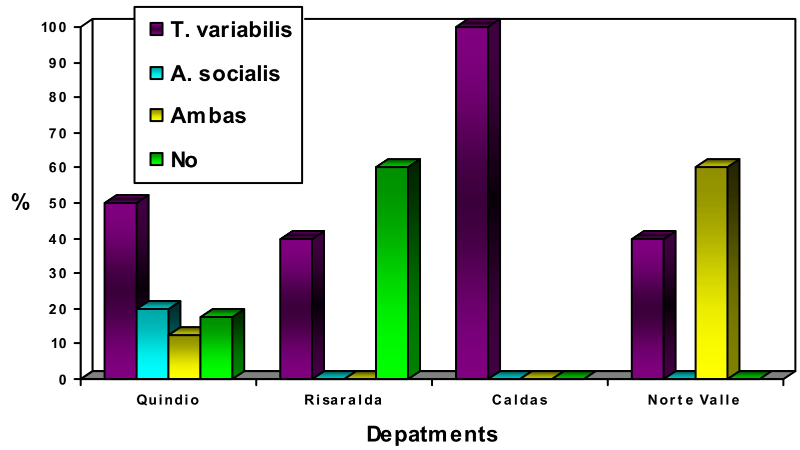

Figure 4.2.2. Whitefly species collected from casavva fields in the Colombian coffee region (2005-2006)

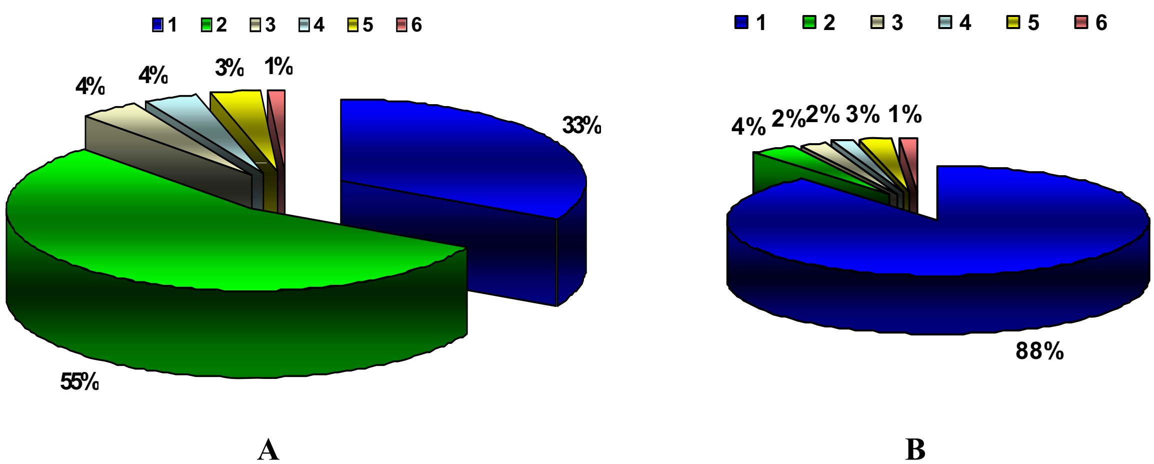

Figure 4.2.3. Population (a) and damage (b) grades caused by whiteflies on cassava in the Colombian coffee region (2005-2006)

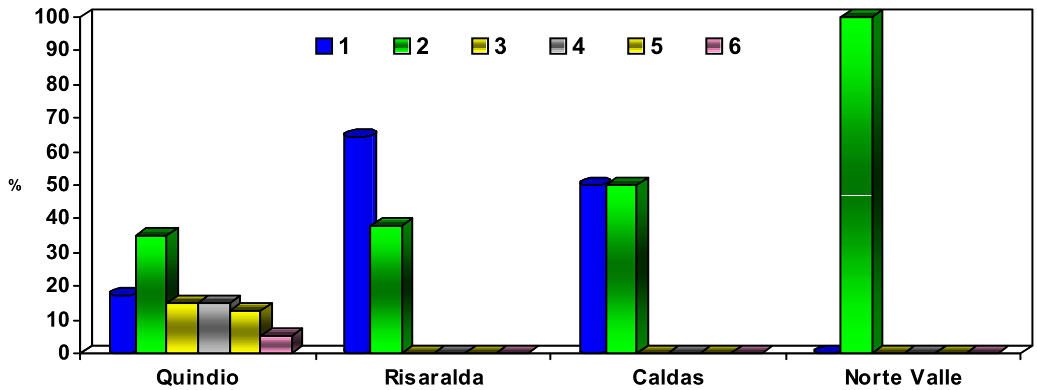

Figure 4.2.4. Whitefly population levels determined in cassava fields in four Colombian departments (2005-2006)

Survey results also revealed that cassava farmers in the regions had minimal knowledge about whiteflies, especially pertaining to their behavior, biology, ecology and management or control. This lack of knowledge resulted in the indiscriminate use of chemical pesticides (34.3% of the farmers surveyed), mostly without any technical advise (Figure 4.2.5). This system has not functioned, as none of the pesticides applied have given adequate control. More than 52% of the farmers have not employed any whitefly control, and only 4.6% have used biological products such as entomopathogenic fungi (*Beauveria bassiana* and *Lecanicillium lecanii*) and the generalist predator, *Chrysopa* sp.

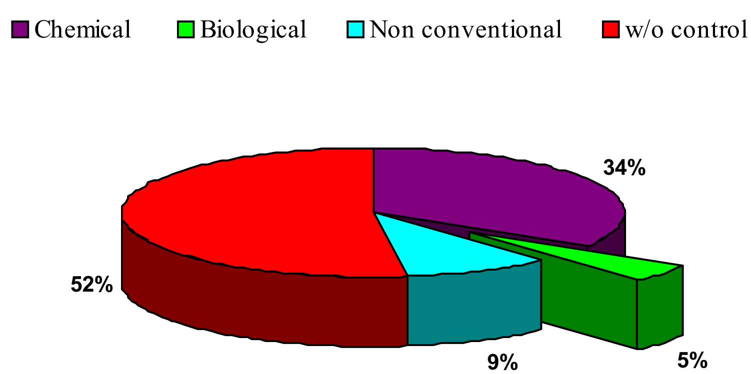

Figure 4.2.5. Whitefly control methods employed by cassava farmers in the Colombian coffee region.

Numerous chemical pesticides have been applied by cassava farmers for whitefly control. Dimethoate (Systemin) was the most frequently applied (34% of farmers) (Table 4.2.2). Active ingredients such as Thiametoxan (Actara), Etofenprox (Trebon) and Imidacloprid (Confidor) usually result in effective whitefly control; however applications of these pesticides by farmers have frequently not given good control due to inappropriate timing of applications and inefficient methods of control. This is often due to the lack of knowledge of the whitefly biology, especially of the immature stages (the presence of eggs and early instars nymphs). Farmers normally can only recognize the adult stages and pesticide applications are not timed properly to control immature stages, those most vulnerable to pesticide application.

Chemical Control:. All treatments resulted in significant differences of control on the three pest stages, when compared to the check treatment (Table 4.2.5). In general, all treatments retarded the appearance of the whitefly by 30 days (Figure4.2.6). The number of applications varied for each treatment (Table 4.2.5). When Imidacloprid WP was applied at planting (drench) and followed by foliar applications (Imidachoprid-Beta-Cyflutrina) only 3 applications were required for effective control. The Actara (Thiametoxam) treatment as a stake dip, followed by foliar applications of Actara and Diafentiuron required the most applications, five. The remaining treatments required four applications to adequately reduce whitefly populations (Table 4.2.5).

Nymphal stages provide the best indication of pesticide efficacy. All treatments reduced nymphal populations compared with the check (Figure 4.2.6). However, when Actara (Thiametoxam) and Confidor (Imidacloprid) were used as a stake (stem cutting) dip, low whitefly populations were observed up to 60 days after planting (Figure 4.2.6). This indicates that this type of stake treatment is efficient for maintaining low whitefly populations during the initial stage of crop development. These stake treatments were followed by three to five foliar applications. Over the duration of crop growth lowest whitefly populations were maintained with Imidacloprid as a drench at germination followed by foliar applications of a Imidacloprid-Beta-Cyflutrina combination (Figure 4.2.6).

Cassava root yields were higher in all pesticide treatments than in the check (no treatment), plot, where whitefly populations were highest. Yields were highest in the Imidacloprid WG 70–RE and Imidacloprid-Beta-Cyflutrina – F treatments with 38.8 and 37.0 T/ha respectively (Table 4.2.6), while yield in the control plot was 16.2 T/ha. These results show that yields were more than doubled when effective whitefly control was implemented. Treatments with Etotenprox-F and Imidacloprid (stake dip)-1E also resulted in doubling cassava yields.

These results demonstrate the damage that whitefly populations can cause to cassava and the need for efficient control methods.

Cost-benefit relationship was above 1.0 in all of the treatments including the check (Table 4.2.6). This indicates that farmers will turn a profit, although minimal, even when whiteflies are not adequately controlled. The greatest economic benefit occurred in the Etofenprox (Trebon) foliar treatment (3.38 to l), followed by the Imidacloprid-Beta-cyflutrina-F (3.14 to l) and Imidacloprid WG70–RE (3.10 to l) treatments.

Table 4.2.4. Chemical pesticide usage (in percent) for whitefly control by cassava farmers in the Colombian coffee region. (2005-2006).

Commercial Product	Active Ingredient	%
Sistemin	Dimetoato	34
Nudrin/Lannate	Methomyl	10
Evisect	Thiocyclam	3
Troxin	Troxin	3
Actara	Thiamethoxan	31
Thionil	Endosulfan	7
Trebon	Etoferprox	3
Confidor	Imidacropid	3
Karate	Landacyhalotrina	3
	Several I.A.. (mixtures)	3

Table 4.2.5. The effect of different insecticide applied for cassava whitefly (on eggs, nymphs and adults) control in the Colombian coffee region.

Treatment	Doses/ha	# Foliar applications	Adults	Eggs	Nymphs
Thiamethoxam – RE*	0.450 Kg	4	2.90 bc	2.82 c	2.81 bc
Thiamethoxam – IE	0.2 Kg	5	3.04 bc	3.03 bc	2.98 bc
Etofenprox - F	1 L	4	3.29 bc	3.29 bc	2.74 bc
Imidacloprid WG70 - RE	0.3 Kg	3	2.88 c	2.88 bc	2.73 bc
Imidacloprid-Beta-cyflutrina - F	0.8 L	4	3.33 bc	3.29 bc	2.98 bc
Imidacloprid (semilla) - IE	0.3 L	4	3.04 bc	2.84 bc	2.58 c
Thiamethoxam - F	0.06 Kg	5	3.43 b	3.34 b	3.17 b
Control			4.1 a	4.22 a	4.24 a

1. Duncan test: numbers followed by the same letter are not significantly different at the 5% level.

2. Based on population scale, 1= no presence; 2= 1-200 individuals per leaf; 3= 201-500 per leaf; 4= 501-2000 per leaf; 5= 2001-5000 per leaf; 6= > 4000 per leaf.

RS= Drench Application; IE= Stake Dip; F= Foliar Application; RE= Drench at germination

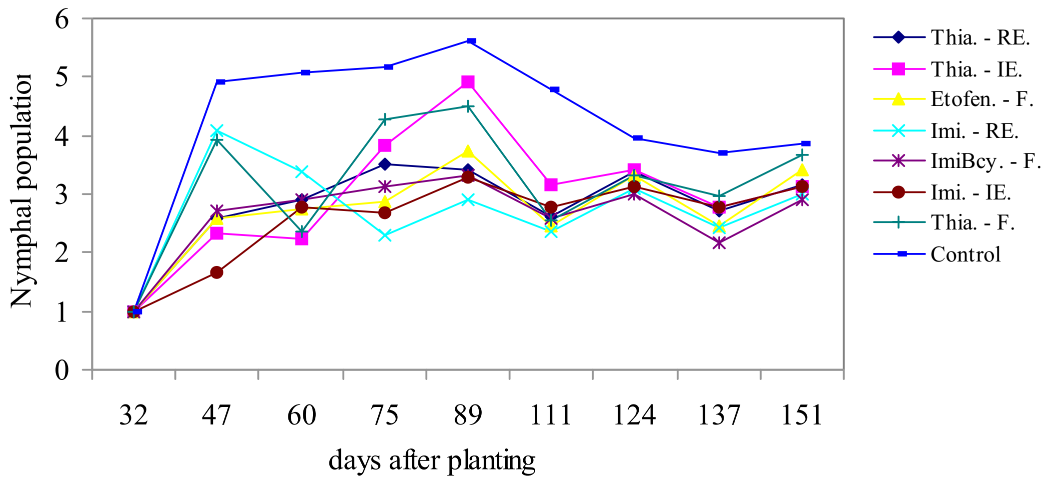

Figure 4.2.6. The effect of diverse insecticide applications on nymphal population of whiteflies on cassava

Table 4.2.6. Cassava fields and cost-benefit ratio (based on a price of 260 pesos Col. per root) resulting from different pesticide applications for whitefly control in the Quindio department in Colombia (2005-2006).

Treatment	**yield. Ton/ha**	**Total Cost**	**Total Benefit**	**Net. Benefit**	***Ratio c/b***
Thiamethoxam – RE*	26.16	2969	6801.4	3832.3	2.29
Thiamethoxam – IE	26.60	2941	6915.7	3974.6	2.35
Etofenprox - F	34.39	2647	8942.6	6295.6	3.38
Imidacloprid WG70 - RE	38.83	3257	10095.2	6838.4	3.10
Imidacloprid-Beta-cyflutrina - F	37.01	3068	9622.3	6553.9	3.14
Imidacloprid (semilla) - IE	31.68	3267	8236.8	4969.5	2.52
Thiamethoxam - F	25.35	2622	6590.7	3969.2	2.51
Control	16.20	2415	4212.4	1797.4	1.74

Results and Discussion

The continual and frequent use of pesticides in cassava for control of arthropod pest is not considered as a long term solution. The results from this research indicate that whiteflies will significantly reduce cassava yields when populations are not managed adequately. Previous results have demonstrated that the continual use of chemical pesticides by small farmers is uneconomical. These results indicate that pesticides, when properly and efficiently applied can greatly increase yields and farmer profits. Timing and mode of application are very important criteria to reduce pesticide applications to a minimum.

The initial application in the farm of a drench at stake germination appears to greatly retard the early build up of the whitefly population. It is currently considered that the follow-up chemical pesticide applications, that proved effective in the trial, can be replaced with biopesticide applications and achieve equal results. Two entomopathogenic isolates of *Lecanicillium lecanii* and *Beauveria bassiana*, have given very positive results for whitefly control in cassava in preliminary trials. Field trials are already underway to evaluate the effectiveness of these biopesticide as components of a cassava whitefly IPM program.

It is hypothesized that by limiting or controlling the initial build up of whitefly population that the natural biological control will be more effective in maintaining whitefly populations below economic injury levels. This hypothesis will also be tested in the field. A survey of whitefly parasitoids populations on cassava in the Colombian coffee region has been initiated. Five parasitoids have been identified parasitizing the two whitefly species. The highest percent parasitism on *T. variabilis* was by *Encarsia nigricephala*, while on *A. socialis, Amitus macgowni* was the predominant species. A more complete analysis will be presented in future reports.

Future evaluations in the region will also include the use of the whitefly resistant cassava variety, Nataima 31. This resistant variety developed by CIAT and CORPOICA scientists is being multiplied and released to cassava farmers. Its role is an integrated whitefly management strategy will be determined.

The results presented here and other research and observations strongly indicate that whitefly populations have to be controlled early in the crop cycle. Once whitefly populations begin to increase they are very difficult to suppress, even with chemical pesticide applications. It is for this reason that the initial, early pesticide application may be an important component in an IPM strategy.

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