CROP PROTECTION PROGRAMME

Sustainable Integrated Management of Whiteflies as Pests and Vectors of Plant Viruses in the Tropics

R8041 (ZA0484)

Coordination

FINAL TECHNICAL REPORT

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Executive Summary

Background

The Co-ordinator's position was created by the original Task Force that conceived the Tropical Whitefly IPM Project (TWFP), to co-ordinate the various research activities conducted by the different subprojects that operate in Africa, Asia and Latin America. The TWFP was born under the umbrella of the CG System-wide IPM Programme, but Phase I was initiated thanks to the financial support of the Danish Development Agency (DANIDA) following negotiations with the Co-ordinator of the TWFP.

During Phase I, the appointed Co-ordinator followed an active global agenda to incorporate more research groups and additional donors to pursue complementary research activities, such as the search of sources of resistance against whiteflies in cassava (New Zealand AID) and against whitefly-borne viruses of horticultural crops in Asia (ACIAR).

The TWF Coordination (CIAT-based) has maintained the communication and coherence of the research conducted by the different subprojects of the TWFP in: Africa (two cassava subprojects, one of which is also financed by USAID); Asia (begomoviruses of horticultural crops, financed by ACIAR); Central America, Mexico and the Caribbean (common bean and horticultural crops in Mesoamerica); the Andean Region (common snap beans); and East Africa (horticultural crops and begomoviruses). The coordination of the TWFP has also maintained close linkages with other DFID-funded whitefly projects managed through the Crop Protection Programme (CPP), particularly in Africa and Asia, and has facilitated the interaction and exchange of sources of resistance between IITA and CIAT (cassava) and between national programs (CENTA-El Salvador and INIFAP-Mexico and AVRDC).

The Coordinator of the TWFP created and supervises the Communications Office located at CIAT, which manages the databases that contain global information on pertinent literature, whitefly research networks, collaborating scientists and technical guidelines, mainly through a Web Page created for this purpose. This office also compiles and submits technical reports produced by the various subprojects of the TWFP.

Project purpose

The DFID-funded Tropical Whitefly IPM Project (TWFP-Phase II) sought to implement sustainable pest management strategies to control the devastating yield losses caused by whiteflies and whitefly-transmitted viruses in cassava, sweet potato, common bean, tomato, sweet pepper, chilli, and other horticultural crops, and, thus, prevent hunger and famine, and ultimately improve the

livelihood of resource-poor farmers in developing countries of Africa, S.E. Asia, and Latin America.

The specific objectives of Phase II of the TWFP were to : 1) Strengthen the pan-tropical whitefly research network created during Phase I by developing information management and exchange channels to disseminate research findings among project collaborators (NARIs, Universities, NGOs, Advanced Research Laboratories, Farmer Associations, Policy Institutions, and the general public interested in these topics). 2) Undertake basic studies on whitefly population dynamics and disease epidemiology in order to understand whitefly/virus pathosystems and thus implement effective IPM strategies. 3) Select and evaluate the most promising IPM measures available to date in selected 'hot spots' identified in Phase I, in order to develop area-wide IPM packages for crops and/or cropping systems currently affected by whiteflies and whitefly/transmitted viruses. 4) Develop training materials for the last phase (III) of scaling up the dissemination of results on the most suitable IPM packages validated in the different whitefly-affected regions of Africa, Asia and Latin America.

The economic importance of whiteflies as pests and vectors of plant viruses was recognised in the late 1980s, not only by developing countries but by industrialised nations as well, including the United States, where a “National Research, Action, and Technology Transfer Plan” was conceived in 1991 to combat the ‘silverleaf whitefly’ (*Bemisia tabaci* biotype B), and European and Middle East countries in the Mediterranean region. Popular news media called it the ‘Pest of the Century’ and yield losses have been calculated in the billion of dollars, leading in some countries to famine, as in the case of Uganda, following the emergence of a recombinant variant of different viruses associated with African cassava mosaic disease. Whitefly-transmitted viruses also caused the collapse of food and industrial crops in Latin America, particularly in Central America, Mexico and the Caribbean region. Nascent industries (tomato paste) in the Dominican Republic and Haiti had to close down following the epidemics of *Tomato yellow leaf curl virus* in the 1990s. The entire industry of vegetable production for export to North America also collapsed in the 1990s due to the emergence of numerous viruses transmitted by *B. tabaci* throughout Mesoamerica.

Small-scale farmers throughout the tropics have been struggling for the last two decades to increase the income derived from their limited land resources, by diversifying their subsistence crops with more valuable crops, mainly vegetables. Unfortunately, neither national nor international agricultural research institutes have provided technical assistance to resource-poor farmers for non-traditional crops, leaving poor farmers in the hands of pesticide salesmen. As a result, production costs have increased (up to 60% of current vegetable production costs are related to crop protection), environmental and human contamination due to pesticide residues has become a serious problem, agricultural produce is

rejected by international markets that test for pesticide residues, and pest problems have worsened due to the development of insecticide resistance and elimination of the beneficial bio-control fauna. The TWFP focuses on all of these production and environmental problems with the ultimate purpose of improving the livelihood of the poor rural and urban population of developing countries in the Tropics.

Coordination activities

The Coordination of the TWFP has contributed to the strengthening of whitefly management networks in developing countries, and to the exchange of information compiled from all of the accessible and grey literature sources on whiteflies. A database has been created at CIAT, which has also establish links with a complementary database created by USDA on whitefly research conducted primarily in the U.S.A. and other developed countries. A directory of professionals conducting research on whitefly-related production problems around the world has also been created.

A Web Page (www.tropicalwhiteflyipmproject.cgiar.org) has been gradually developed to make all of the available information on whitefly and geminivirus management, accessible to users around the world (see **Appendix 1**).

The project has a Communication Office and a communications specialist in charge of information dissemination and data management, including Geographic Information Systems (GIS) to implement more interactive channels for data reporting and sharing among users. The Co-ordinator has been involved in the improvement of the information dissemination capabilities of the TWFP, including various articles, presentations and publications that describe the work and results obtained by the TWFP and related CPP projects financed by DFID.

The main publication in the pipeline is a book containing the results of all of the diagnostic work conducted in Phase I: surveys, biological characterisation of whitefly species/biotypes, molecular characterisation of begomoviruses, description of crops affected, identification of 'hot spots' in east and west Africa, the Andean region, Central America, Mexico and the Caribbean, and socio-economic studies (Contents shown in **Appendix 2**) .

The building of the Tropical Whitefly Research Network started in Phase I, and it is now linked to all the national and international projects that conduct research on whitefly pests and related problems around the world. This network includes the International Whitefly Studies Network, managed from the U.K., which includes all of the European countries that suffer crop losses caused by whiteflies and the different viruses these insects transmit, mainly in the Mediterranean region.

The TWFP Coordinator is also involved in the strengthening of National Agricultural Research Institutions (NARIs) that have not been previously covered by the TWFP, but which have asked the TWFP for assistance to manage severe whitefly problems. This has been the case of the Andean Region, where whiteflies have recently emerged as direct pests and virus vectors, particularly in Bolivia, Perú and Colombia. The Coordinator has been invited by these Governments to observe the whitefly problems that affect crops, such as potato, common bean, tomato, and cucurbits. A special report was prepared on the whitefly problem of mixed cropping systems in the mesothermic valleys of Bolivia, where DFID has special projects (**Appendix 3**). With respect to collaborating NARIs, the TWFP Co-ordination has provided training for some national program scientists, particularly in the area of molecular characterisation of plant viruses and whitefly species/biotypes, but also in the area of rural development and participatory research.

The emergence of *Bemisia tabaci* biotype B, as a vector of viruses affecting common bean and tomato in the main agricultural region of Colombia, the Cauca Valley, is primarily a consequence of unusual climatic phenomena (climate change), represented by persistent, dry conditions for two consecutive years beginning in 2001. The attacks have been so severe that snap bean production has been eradicated from the valley in the last year. The TWFP Co-ordinator organised a series of talks for tomato farmers in order to explain the nature of the problem and recommend and IPM package, which has been successful in maintaining tomato production in this region.

1n 2003, the Co-ordinator received an urgent request from El Salvador to diagnose an unusual whitefly outbreak in cereals and grasses, mainly rice, sorghum, maize, and forage pastures. This is the first time that grasses have been attacked in Mesoamerica by whiteflies. Samples were sent to CIAT where the TWFP's taxonomist, Ms. Pilar Hernández, identified the exotic whitefly pest as *Aleurocybotus occiduus*. This is apparently a neotropical whitefly species that has been previously reported in S.W. USA, and the Amazon region of Perú, where it was also reported on rice. The Coordinator visited the affected rice-growing area in N.W. El Salvador and confirmed the complete destruction of over 35 has of rice (**Figures 1 and 2**) and several sorghum fields.

Figure 1. Total yield loss in rice fields of El Salvador caused by the emergence of a new whitefly pest capable of attacking cereals

Figure 2. Damage and pupae of the new whitefly pest of rice in El Salvador

The TWFP has also provided information and advice to CPP ("Adaptive evolution within *Bemisia tabaci* and associated *Begomoviruses*: A strategic modelling approach to minimising threats to sustainable production systems in developing countries" by Frank van den Bosch and M.J. Jeger), and other international projects currently engaged in the validation of sustainable IPM practices and modelling of whitefly/geminivirus epidemics.

The Coordination of the TWFP has also facilitated six meetings of sub-project coordinators to discuss project activities and future research strategies. The last two meetings to plan Phase III, took place at CABI, U.K., and CIMMYT, Mexico, with the participation of NRInternational (CABI meeting), all sub-project coordinators, and other potential participants in Phase III. Several concept notes have been prepared in anticipation of Phase III.

Outputs

In terms of Information Management and Technology, the TWFP has made a significant effort to collect all the pertinent available and 'grey' literature on whiteflies and whitefly-borne viruses published around the world. To complement this effort, the TWFP has also linked with the extensive bibliography of *Bemisia tabaci* compiled from various sources since 1995 by USDA scientists in Arizona. These extensive databases and hard copies of the original documents are still in the process of transformation into electronic documents, but can be consulted for the most part by contacting the TWFP's Information Officer at CIAT, Palmira, Colombia.

Two publications (**Appendix 4)** were produced to: 1) promote the integration of the TWFP and the CPP projects conducting research on whitefly pests and whitefly-transmitted viruses. This publication, "A United Effort Against a Global Pest", has been distributed in Latin America, Africa, Asia and Europe. A second publication describing the various sub-projects that integrate the Tropical Whitefly Project, its participating institutions and donor agencies, was recently published for global distribution. The Coordination of the TWFP has also facilitated six meetings of sub-project coordinators to discuss project activities and future research strategies. The last two meetings to plan Phase III, took place at CABI, U.K., and CIMMYT, Mexico, with the participation of NRInternational (CABI meeting), all sub-project coordinators, and other potential participants in Phase II.

The TWFP Coordination also promoted the dissemination of information regarding information on IPM strategies and packages that have been shown to be effective for the management of whitefly pests and whitefly-transmitted

viruses in Latin America. Three electronic documents on: 1) management of whiteflies as direct pests in highland crops; 2) management of whiteflies as virus vectors in mixed cropping systems in the tropics; and 3) use of physical barriers for the control of whitefly-borne viruses in horticultural crops in the tropics, have been made available through the TWFP Web Page (**Appendix 5)**. The TWFP has also provided information and advice to CPP ("Adaptive evolution within *Bemisia tabaci* and associated *Begomoviruses*: A strategic modelling approach to minimising threats to sustainable production systems in developing countries" by Frank van den Bosch and M.J. Jeger), and other international projects currently engaged in the validation of sustainable IPM practices and modelling of whitefly/geminivirus epidemics.

The Coordination has maintained permanent contact with all the national and international institutions involved in Phase I and new partners in preparation for Phase III: technology dissemination through farmer participatory research. The Coordination has also maintained the communication with all project partners and the donor community, since the termination of Phase II on March 31st, 2004, to assure the continuity of the project. A series of Concept Notes have been prepared to this end (**Appendix 6**).

Contributions of outputs to developmental impact

Poverty alleviation: This project primarily responds to the needs of resource-poor farmers in need of technical assistance to manage whitefly pests and whitefly-transmitted viruses in staple and cash crops. In the case of basic food crops, such as cassava in Africa and common bean in Latin America, whitefly management is necessary to prevent significant and even total yield losses induced by African cassava mosaic and bean golden/yellow mosaic viruses. The deployment of virus-resistant cassava and common bean cultivars in Africa and Latin America, respectively, assures the food and the regular income derived from these crops by poor farmers. The TWFP has also provided technical assistance for small-scale farmers on IPM measures designed to protect high-value vegetable crops in mixed cropping systems. Vegetable crops, such as tomato, pepper and chillies, provide resource-poor farmers with additional income in very small areas (e.g. a tenth of a hectare planted to tomato, may produce more income than 4 has of common bean or maize). Vegetable production is not possible in whitefly-stricken agricultural areas without the adoption of effective IPM practices.

Food security: The TWFP has intervened in the mitigation of a famine caused by the emergence of a new recombinant whitefly-transmitted virus of cassava in East Africa (USAID funds). This event demonstrates that whiteflies can cause food security problems. In Latin America, the damage caused by whitefly-borne viruses in common bean plantings, caused the abandonment of over a million hectares to bean production. The resulting shortage forced many Latin American countries (including Brazil, the main producer of common bean in the world) to

import beans from countries as far as China. Central America, Mexico and countries in the Caribbean region have to import beans on a regular basis, because of the whitefly problem. Vegetables have become an important component of the diet in developing countries, where the cost of sources of animal protein is beyond the purchasing power of poor people.

Generation of income: Horticultural crops have become an important source of income for small-scale farmers in developing countries of Asia, Africa and the Americas. A hectare of tomato, produced under high whitefly/virus pressure thanks to the IPM measures implemented by the TWFP in Mesoamerica, may produce over £ 5,000 in income (as compared to a £ 100 profit obtained from a hectare of maize or common bean). Hence the emphasis of the TWFP on mixed cropping systems for food security and income generation, particularly in East Africa and Latin America. The co-ordinator of the TWFP has secured the help of AVRDC's breeders in Taiwan, to initiate genetic improvement activities for tomato and peppers in Latin America, the centre of origin of these crops.

Sustainable use of Natural Resources: The implementation of IPM measures, such as use of virus- or vector-resistant varieties, use of physical barriers, and bio-control agents, results in a major reduction of pesticide applications, This fact has been demonstrated in the experimental trials conducted in Mesoamerica and the Andean region. The DFID-funded CPP and TWF projects are unique in combining food production with natural resource management (NRM) practices. Emphasis on NRM per se, without a food production component, has led to unimaginable levels of pesticide abuse in developing countries, in detriment of the environment (contamination of soils, water sources and the environment), public health (applicators, rural communities, and consumers of highly contaminated produce), and the beneficial fauna (bio-control organisms).

As mentioned before, the co-ordinator of the TWFP has promoted three different meetings to discuss with subproject co-ordinators, the best approach to promote the findings of the work conducted so far by the project. In general terms, the TWFP recognises the need to scale up the implementation of IPM measures found to be effective and sustainable to control whitefly pests and the viruses that these vectors transmit. To this end, the Co-ordinator has contacted the Farmer Participatory Research (FPR) and Impact Assessment Groups of the System-wide IPM Programme, to develop a joint work plan for Phase III. This objective does not preclude the need to continue some basic research activities in the area of pathogen and pest monitoring, ecology and epidemiology of whiteflies and whitefly-borne viruses, and refinement of IPM strategies. The organisation of Farmer Field Schools (FFS) and analysis of policy issues related to this project, are also contemplated.

Further studies are necessary to link small-scale farmers to markets, and to develop agro-enterprises. Area wide impact assessment studies are also needed to determine the real contribution of the TWFP to poverty alleviation in target

countries. To fulfil these objectives, the TWFP has been contacting Information and Communication specialists on electronic, radio and written media to chose the most effective channels to deliver the technology generated.

One of the major obstacles to the dissemination of technology in its initial stages ('pilot sites') has been the lack of trained personnel in FPR and FFS. There is a need for qualified personnel knowledgeable in transferring IPM technology to small-scale farmers, emphasising the economic benefits of adopting IPM measures. The co-ordination and subproject leaders of the TWFP have taken initial steps to establish collaborative links with FPR specialists working in the target regions, particularly in Africa and the Andean region. In Central America, the co-ordinator and leader of the Mesoamerican subproject has made possible the training of a national program scientist in Rural Development and Farmer Participatory Research at a regional international centre (CATIE).

DFID has expressed its interest in continuing its support to the TWFP in order to disseminate the technology generated by the different subprojects in sub-Saharan Africa, South East Asia, Mesoamerica and the Andean region.