CROP PROTECTION PROGRAMME

Sustainable Integrated Management of Whiteflies as Pests and Vectors of Plant Viruses in the Tropics Sub-Project 4 (SP4): Andes subproject

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FINAL TECHNICAL REPORT

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Executive Summary. This project sought to establish technological means for (1) reducing levels of pesticide use by bean farmers, (2) reducing health risks to farmers and consumers, and (3) reestablishing the ecological equilibrium by developing integrated management systems in areas that have been disturbed by excessive pesticide use. Major activities included monitoring of whitefly populations, monitoring of whitefly natural enemies, testing of non-chemical alternatives for whitefly control, development and refinement of a simplified action threshold for whitefly control, development of a sampling method for whitefly populations, monitoring of insecticide resistance levels, and testing in farmers fields of different alternatives for management of whiteflies in snap bean and dry beans.

Changes in whitefly species and biotype composition were detected in the Cauca Valley where the B biotype of *Bemisia tabaci* is now more important than *Trialeurodes vaporariorum*. In Ecuador, *T. vaporariorum* is still the only whitefly species affecting beans, potatoes, and vegetable crops in highland areas. An action threshold for rational control of *T. vaporariorum* was refined. Highest increases in yield were obtained when chemicals were applied when first instar nymphs appear and occupy less than 30% of the leaf area. This means that the action threshold established in previous years can now be enunciated as follows: level 3, when first instar nymphs appear on lower plant of the plant and occupy less than 30% of the leaf area. Sampling methods for whitefly nymphs and adults were developed and tested. The parasitoids *Encarsia nigricephala* and *Amitus fuscipennis* were identified as the most important natural enemies of whiteflies in the Andean zone. Resistance to insecticides in *T. vaporariorum* adult and nymphal populations was measured in two critical locations in Colombia and in five locations in Ecuador. In general, the situation has not changed, with populations showing high levels of resistance to organophosphates, some susceptibility to certain pyrethroids, and susceptibility to carbamates like methomyl. With some differences among locations, there is a general trend for conventional insecticides (widely used by farmers) to be less efficient for whitefly control. *T. vaporariorum* nymphs in both Colombia and Ecuador are, in general, still susceptible to insect growth regulators and neonicotinoids.

We compared different approaches for whitefly control based on judicious and less detrimental use of chemicals. Seed treatments and drench applications of novel systemic insecticides were compared with the timing of foliar applications of conventional (less costly) products, in some cases with applications based upon pre-established action thresholds. These treatments were compared with farmers' practices and, in some cases, with untreated checks. In Ecuador, where the project has entered the diffusion stage, large-scale demonstrative plots were used to conduct the trials. In Colombia (snap beans) alternative management strategies resulted in yields that did not differ from those obtained by farmers with their traditional management approaches. Selective use of systemic insecticides as seed dressing or in drench application resulted in higher benefit cost ratios with a substantial reduction in the amount of applications per crop cycle and less detrimental effect on natural enemies. Our results indicate that it is feasible to reduce the number of insecticide application on beans and snap beans.

Background. Surveys conducted in the Andes revealed that the greenhouse whitefly, *Trialeurodes vaporariorum* (Westwood) is by far the most important whitely affecting annual crops as a direct pest in Andean highlands of Colombia and Ecuador. The survey also indicated that this whitefly has become the target of insecticide applications even in areas where there is no need to spray. This in turn has raised other insects (thrips, leafminers) to major pest status. An incredible 100% of farmers spray their crops on a regular basis. The number of insecticide applications per cropping season varies with regions, but 24 % of the farmers surveyed make 10 or more applications. For example, in western Colombia farmers spray their snap beans on a regular basis, up to 22 times in a in a 3-month cropping cycle. In other areas, spraying of tomatoes and beans can be as high as three times a week. About 70% of those farmers in mid-altitude and highland areas of Colombia and Ecuador use insecticides as the sole method of control. Highest insecticide abuse was detected in specific areas of Colombia (Nariño, Cauca Valley, Antioquia, and Cundinamarca) and in the Chota Valley in Ecuador. Applications are preventive and made with little or no regard for insect population levels or phenological stages of the crops. Few farmers receive technical assistance, and about one third are influenced by insecticide salesmen who recommend a wide array of chemicals (up to 34 different brands) for whitefly control. Most pesticides belong to the toxicological category I (extremely dangerous) and yet are handled and applied with minimal safety precautions. High levels of insecticide resistance to organophosphates and pyrethroids have been detected. The combination of these factors tends to undermine the sustainability of prevailing cropping systems in the region. The problem is more serious on beans and tomatoes than on any other crop, and is affecting the welfare and economy of small farmers throughout the Andean highlands and mid-altitude valleys.

Project Purpose. This project sought to establish technological means for (1) reducing levels of pesticide use by bean farmers, (2) Reducing health risks to farmers and consumers, and (3) Reestablishing the ecological equilibrium by developing integrated management systems in areas that have been disturbed by excessive pesticide use.

Research Activities. Since pest situations and natural enemy activity change throughout the years, species composition was monitored throughout the duration of the project. Measurement of incidence and effectiveness of natural enemies was also a continuous activity during the duration of the project. Frequent sampling of fields in Pradera (Colombia) and the Chota Valley (Ecuador) allowed us to monitor pest and natural enemy incidence, evaluate levels of mortality caused by parasites, predators, and pathogens and estimate their effectiveness by comparison of protected and unprotected plots in those sites in which activity was recorded. A series of replicated field trials in farmers' fields were set up to test the relative efficiency of non-chemical control methods. These included traps, oils, soaps, and destruction of crop residues. Data on infestation levels, crop phenology, and yields obtained with the different treatments were analyzed. Crop budgets were prepared and total and net benefits obtained with the different alternatives were calculated. To validate action thresholds, a series of replicated field trials were established in which control at different levels of insect damage was exercised. Data on infestation levels and yields were analyzed. Simultaneously, available information on action thresholds for whiteflies was used to test their validity and economic efficiency by means of a series of replicated trials in which control at two or three provisional action thresholds were compared with full protection, farmers' traditional practices, and unprotected plots.

Likewise, monitoring of insecticide resistance levels was a continuous activity in both target areas. The bulk of the work in years two and three was the testing of an IPM alternative for bean and snap bean farmers in target areas. A total of 12 trials were conducted to compare yields and economic returns of plots where the IPM strategy was applied with those obtained in plots using traditional methods of control. The recent introduction (and outbreak) of the B biotype of *Bemisia tabaci* into the Colombian hot spot prompted us to conduct diagnostic work on this problem in order to see how this new situation affected the management system proposed for *Trialeurodes vaporariorum.*

The project reached the stage at which results can be diffused through farmers' participatory research. In fact, farmers' schools are operating in the Ecuadorian target site. This approach will be used to extend research results. Training of national scientists was also a major activity of the project. Most results have been published (see Project Completion Summary Sheet).

Outputs.

Monitoring of whitefly populations in the Andean zone. Monitoring of possible changes in species composition in areas affected by whiteflies was a continuous activity. A reliable monitoring system for the proper identification of whitefly species and biotype composition using RAPD techniques (primer OPA-04) was developed. Whiteflies (adults or pupae) were collected on different host plants in the Cauca Valley in Colombia and the Chota Valley in Ecuador. All RAPD characterizations were made by comparison with patterns obtained from existing mass rearings of different whiteflies maintained at CIAT. In 2002, analysis of 32 samples from the Cauca Valley showed that *Trialeurodes vaporariorum* was at that time the most important species affecting snap beans, tomato, cucumber, dry beans, sweet potato, squash, and melon in the region (45% of samples taken). The B biotype, a relatively new pest in the area, was present in 30.3% of samples taken as a major pest of cucumber, snap beans, cotton, and sweet potatoes. The A biotype was not found. In the Chota Valley of Ecuador, *T. vaporariorum* was the sole species found on dry beans and potatoes.

The situation changed drastically in 2003. Analysis of 123 samples taken in 23 locations of the Cauca Valley showed that 63% of the whiteflies collected belonged to the B biotype of *Bemisia tabaci* and 21% to *T. vaporariorum.* Others were mixed infestations. The A biotype was not found. As shown in Figure 1, species composition in the Cauca Valley has changed since 1997 to the point where the B biotype is now the most important species. No changes in species composition were detected in Ecuador. The now predominant B biotype has caused very serious problems in agricultural areas of the Cauca Valley: uneven ripening of tomatoes, silver leaf disorder on squash, and sooty mold on cotton. In snap bean growing areas, it has become the causal agent of a physiological disorder known as pod chlorosis, which renders the produce useless. Most serious, it has become a very effective vector of a geminivirus that is devastating snap beans in the region (Figure 2). To what extent this new situation is going to affect future research directions is being carefully considered.

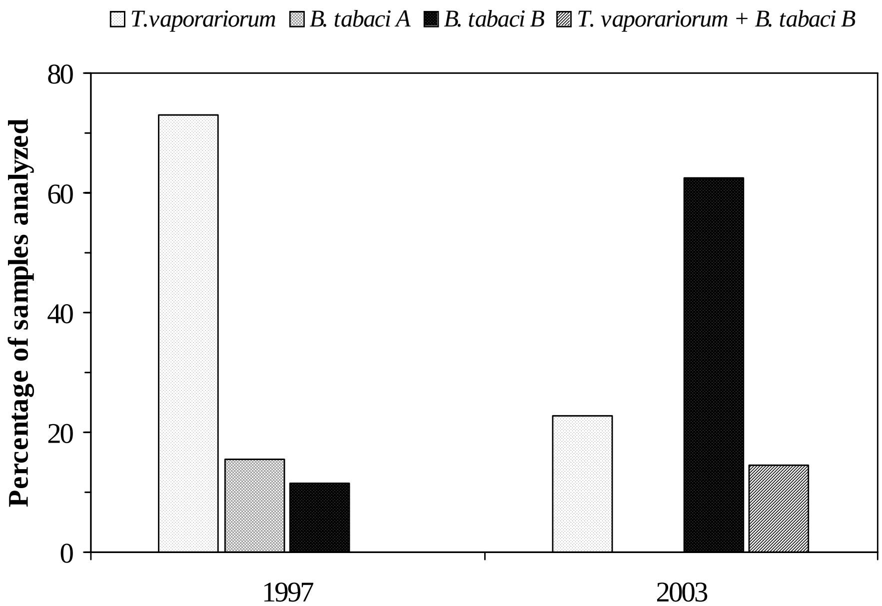

Figure 1. Changes in whitefly species and biotypes composition in the Cauca Valley of Colombia (1997-2003)

Figure 2. Pod decoloration and virus symptoms associated with the presence of the B biotype of *Bemisia tabaci* on snap beans.

Refining of an action threshold for *T. vaporariorum* control. We have successfully developed an action threshold for effective control of *Trialeurodes vaporariorum* on snap beans and dry beans. As shown in previous reports, economic control of the whitefly is achieved when an efficient insecticide is applied when first instar nymphs occur on lower leaves of the plant. To further refine this action threshold and make it user-friendlier, we have added a quantitative estimate of populations. We used the same methodology on snap beans and dry beans. Using a 4 x 4 Latin square design we compared the following treatments: 1, control of first instar nymphs when nymphs occupy less than 30% of the leaf area; 2, control of first instar nymphs when nymphs occupy 30-60% of the leaf area; 3, 1, control of first instar nymphs when nymphs occupy more than 60% of the leaf area; 4, untreated check. Insect populations, damage levels, yields, and costs were recorded and analyzed.

Highest increases in yield were obtained when chemicals were applied when first instar nymphs appear and occupy less than 30% of the leaf area (Table 1). This means that the action threshold established in previous years can now be enunciated as follows: level 3, when first instar nymphs appear on lower plant of the plant and occupy less than 30% of the leaf area.

Table 1. Yield responses of snap beans and dry beans to effective chemical control of *Trialeurodes vaporariorum* at varying levels of infestation with first instar nymphs

Control of first instar nymphs	Yields (t/ha)		Yield increase (%)[a]	
	Snap beans	Dry beans	Snap beans	Dry beans
When first instars occupy < 30% of leaf area	15.2 a[2]	1.06 a	52.0	14.0
When first instars occupy 30 - 60% of leaf area	11.4 b	1.01 a	14.0	8.6
When first instars occupy > 60% of leaf area	11.2 b	1.02 a	12.0	9.7
Untreated check	10.0 b	0.93 a	----	----
C. V. (%)	11.3	9.6		

[a] With respect to the untreated check

Means within a column followed by the same letter are not significantly different at the 5% level by LSD.

Development of sampling methods for whitefly populations. The development of appropriate sampling methods for whitefly nymphs and adults was another major objective within the DFID-funded project on Sustainable Management of Whiteflies in the Tropics. Sampling insect populations to estimate infestation levels is essential in any pest management system. Whiteflies pose special sampling problems compared with larger insects given their gregarious habits, small size, and large numbers. We conducted six field trials aimed at developing sampling methods for nymphs of *T. vaporariorum* on both snap beans and dry beans. Main objectives were: a) To quantify nymphal and adult populations at different crop growth stages; b) To determine the dispersion pattern of populations within the plant; c) To calculate sample sizes; d) To compare different methods of sampling; e) To develop an efficient sequential sampling plan to be used in an integrated management scheme.

As shown in Table 2, the spatial distribution of nymphal populations on snap beans follows a natural sequence of events: adult colonization, followed by oviposition, followed by establishment of nymphs on the leaves. This is why adults and eggs are more abundant on the upper part of the plant, while third instars and pupae (fourth instars) are more commonly found on the lower part of the plant (stratum 1). We found that all stages are aggregated. For example, nymph populations follow Taylor's Power Law and adjust very well to a negative binomial distribution meaning that populations are clumped. This has important implications for sampling purposes. Data obtained from aggregation studies was then used to calculate sample sizes (Figure 3) and to develop sequential sampling methods (data not shown) that will be useful in the implementation of integrated management systems for whiteflies on beans and snap beans.

Table 2. Number per leaflet of adults and immature stages of *Trialeurodes vaporariorum* on snap beans. Plants were divided into four strata for sampling purposes

Whitefly stage	Stratum	Days after planting									
		7	14	21	28	35	42	50	57	63	70
Adults	1	18.5	11.3	15.3	15.7b[a]	4.9c	2.7c	8.6c	4.1c	1.1d	0.7d
	2				47.7a	13.8b	3.9b	6.5c	3.5c	1.7c	2.5c
	3					35.1a	11.7a	14.9b	7.2b	4.0b	10.3a
	4						6.5b	67.8a	39.8a	6.2a	5.4b
Egss	1	62.2	46.7	76.9	42.3b	33.1b	0.9c	0.0d	0.04d	0.0c	0.09c
	2				154.3a	63.9a	17.7a	4.0c	1.9c	0.2c	4.3b
	3					36.2b	8.8b	31.7b	29.4b	3.6b	2.3b
	4						5.0c	54.0a	56.3a	19.6a	17.8a
Nymphs	1		5.5	9.4	45.0a	39.8a	51.8a	11.8a	3.4c	0.7c	1.8d
	2				0.01b	6.3b	12.8b	14.9a	10.4b	5.8b	10.6c
	3					0.0b	0.0c	0.3b	18.9a	19.7a	11.9b
	4						0.0c	0.04b	4.3c	16.6a	37.6a
Pupae	1					1.9a	16.1a	36.2a	21.5a	5.9a	5.0a
	2					0.0b	0.0b	0.3b	1.6b	3.9b	10.6a
	3					0.0b	0.0b	0.0b	0.0b	0.9c	10.9a
	4		Is low				0.0b	0.0b	0.01b	0.0c	7.0a

[a] Each stage analyzed separately. Means within a column followed by the same letter are not significantly different at the 5% level by LSD.

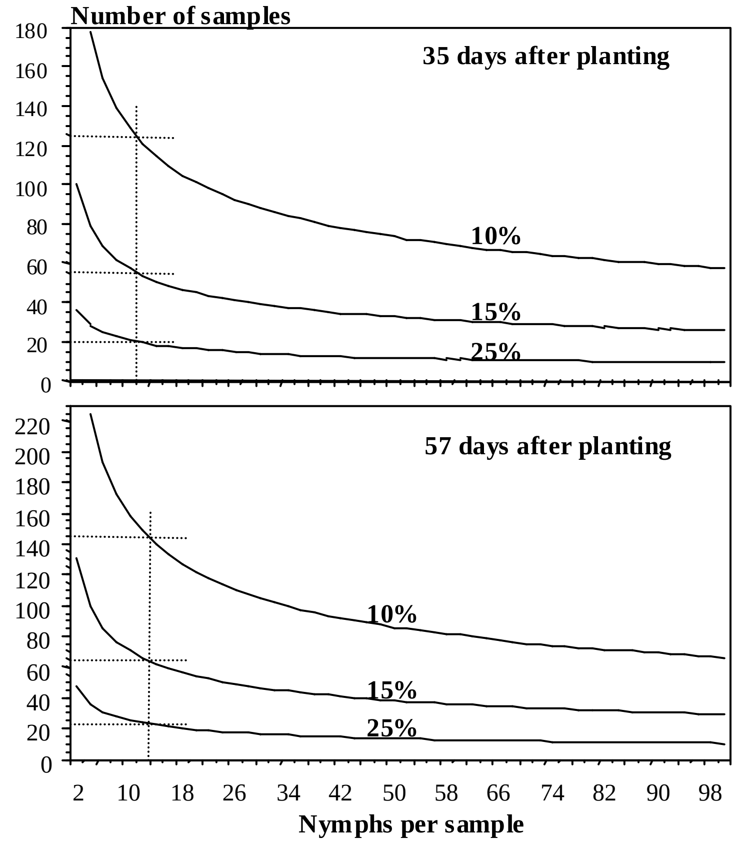

Figure 3. Sample sizes at different precision levels for nymphs of *Trialeurodes vaporariorum* on snap beans.

Monitoring of natural enemy activity. Our results indicate that, in general, natural enemy activity is low in both target areas, most likely due to the excessive use of insecticides by farmers. A list of natural enemies was published (see reference list in Project Completion Summary Sheet). Clearly, the most important parasitoids affecting whitefly populations in the target areas are *Encarsia nigricephala* and *Amitus fuscipennis*.

Monitoring of insecticide resistance in whitefly populations. Monitoring of insecticide resistance levels in whitefly populations was one of our major objectives. Given the fact that insecticides will continue to be an essential method of control of whiteflies, periodic monitoring of resistance becomes an important step in the design of appropriate insect pest management strategies. Baseline data on toxicological response of whitefly adults to 13 insecticides and of whitefly nymphs to three insecticides are now available.

In 2003 we used the baseline data and diagnostic dosages that were established in 2001. Using the diagnostic dosages for both adults and nymphs, we tested populations of whiteflies in the Cauca Valley in Colombia and in the Chota Valley in Ecuador. Adult resistance levels were monitored under field conditions by means of the insecticide-coated glass vial technique. Resistance of first instar nymphs was measured using the foliage dipping technique. Systemic novel insecticides (mostly neonicotinoids) were tested using the petri dish technique.

Resistance of *T. vaporariorum* adults and nymphs was measured in two critical locations in Colombia and in five locations in Ecuador. In general, the situation has not changed, with populations showing high levels of resistance to organophosphates, some susceptibility to certain pyrethroids, and susceptibility to carbamates like methomyl. With some differences among locations, there is a general trend for conventional insecticides (widely used by farmers) to be less efficient for whitefly control. *T. vaporariorum* nymphs in both Colombia and Ecuador are, in general, still susceptible to insect growth regulators like buprofezin and diaphenthiuron and to novel insecticides like the neonicotinoids imidacloprid and thiamethoxam.

Since the B biotype of *B. tabaci* has suddenly become the key pest in the Cauca Valley, we will highlight results of insecticide resistance monitoring with this species. Adults of this biotype showed high levels of resistance to methamidophos, monocrotophos, carbofuran, and bifenthrin. With some variations, adult populations showed intermediate resistance to carbosulfan and cypermethrin (Table 3). Fortunately, both nymphs and adults of this biotype are still susceptible to neonicotinoids and insect growth regulators (Table 4).

Table 3. Response (percentage corrected mortality) of adults of *Bemisia tabaci* biotype B to conventional insecticides in two consecutive growing seasons. Diagnostic dosages were tested using the insecticide-coated glass vial technique

Races	Percentage corrected mortality[a]			
	2002B	2003B	2002B	2003B
	methamidophos (32 μg/vial)		monocrotophos (300 μg/vial)	
'CIAT'[b]	93.9 a A	94.4 a A	94.8 a A	95.3 a A
Rozo	32.1 b A	18.2 b B	74.7 b A	68.4 b A
Santa Helena	16.8 bc A	17.8 b A	54.4 c A	46.1 c A
La Unión	11.2 c B	22.3 b A	26.1 d A	30.2 d A
	methomyl (2.5 μg/vial)		carbofuran (5 μg/vial)	
'CIAT'	100.0 a A	97.4 a A	96.0 a A	93.9 a A
Rozo	99.4 a A	85.0 ab B	64.8 b A	53.1 b A
Santa Helena	78.1 b A	87.1 b A	24.6 c B	42.1 b A
La Unión	65.1 c A	78.4 b A	21.6 c B	44.0 b A
	carbosulfan (100 μg/vial)		cypermethrin (500μg/vial)	
'CIAT'	94.8 a A	93.4 a A	93.9 a A	93.4 a A
Rozo	88.7 a A	77.5 b B	48.3 c A	39.6 c A
Santa Helena	89.7 a A	70.7 b B	88.7 a A	71.2 b B
La Unión	47.4 b A	53.4 c A	68.5 b A	74.8 b A
	cyalothrin (500 μg/vial)		bifenthrin (5 μg/vial)	
'CIAT'	94.3 a A	91.2 a A	94.3 a A	96.4 a A
Rozo	81.0 b A	60.2 c B	28.8 b A	12.6 d B
Santa Helena	90.6 ab A	78.5 b A	25.2 b A	21.6 c A
La Unión	84.3 b A	84.5 ab A	36.7 b B	49.8 b A

[a] Means within a column followed by the same lowercase letter and means within a row followed by the same uppercase letter are not significantly different at the 5% level by LSD. Each product was analyzed separately

[b] A susceptible strain of *B. tabaci* biotype B maintained at CIAT.

Table 4. Response (percentage corrected mortality) of adults and nymphs of the B biotype of *Bemisia tabaci* to novel insecticides in the Cauca Valley region of Colombia. Adults tested in two consecutive seasons (2002-203). Nymphs tested during the 2003-growing season.

Race	Adults				Nymphs		
	imidacloprid (40 ppm)		thiamethoxam (200 ppm)		buprofezin (16 ppm)	diaphenthiuron (300 ppm)	imidacloprid (300 ppm)
	2002	2003	2002	2003			
Rozo	81.9bB	97.3aA	97.3aA	99.5aA	80.6 b	100.0 a	89.3 b
S. Helena	91.9abA	93.4abA	100.0aA	96.4aB	100.0 a	100.0 a	100.0 a
La Unión	87.4 bA	90.7 bA	97.9aA	91.4bB	100.0 a	98.2 a	100.0 a
'CIAT'	96.3aA	97.9aA	99.5aA	98.9aA	98.4 a	100.0 a	91.1 b

Each product within each semester was analyzed separately. For adults, means within a column followed by a lowercase letter and within a row followed by an uppercase letter are not significantly different at the 5% level by LSD. For nymphs, means within a column followed by the same lowercase letter are not significantly different at the 5% level by LSD.

Management strategies for whiteflies. Whiteflies have become the object of excessive pesticide use by snap bean and dry bean farmers in the Andean zone. With the body of knowledge acquired in previous years, it is possible to develop whitefly management systems that will at least contribute to reduce pesticide use. We now report on trials conducted to develop ways to reduce pesticide use on snap beans in Colombia and on dry beans in Ecuador

Several trials were conducted in the reference sites (Pradera in Colombia, Chota in Ecuador). We compared different approaches for whitefly control based on judicious and less detrimental use of chemicals. Seed treatments and drench applications of novel systemic insecticides were compared with the timing of foliar applications of conventional (less costly) products, in some cases with applications based upon pre-established action thresholds. These treatments were compared with farmers' practices and, in some cases, with untreated checks. In Ecuador, where the project has entered the diffusion stage, large-scale demonstrative plots were used to conduct the trials. Damage levels, insect populations, and quality of produce, yields, and benefit/cost ratios were recorded and analyzed.

In Colombia (snap beans) alternative management strategies resulted in yields that did not differ from those obtained by farmers with their traditional management approaches (Table 5). Crop appearance, damage (sooty mold) levels, and final produce quality did not differ either. Use of novel systemic insecticides as seed dressing or in drench application resulted in higher benefit cost ratios with a substantial reduction in the amount of applications per crop cycle (Table 5).

Table 5. Snap bean yields and benefit/cost ratios obtained with different alternatives for management of the whitefly *Trialeurodes vaporariorum* in the Pradera region of Colombia

Treatment[a]	No. of applications	Yield (t/ha)[b]	Benefit /cost ratio
Trial 1			
Seed dressing + conventional insecticides 28 and 43 DAP	3	18.4a	3.0
Drench + AT with conventional insecticides	2	17.4a	2.8
AT with conventional insecticides	2	17.5a	3.0
Conventional insecticides at 28 and 43 DAP	2	17.0a	2.9
Farmer's practices	6	13.1b	1.9
Check	0	9.0c	1.7
Trials 2 and 3			
Seed treatment + AT with conventional insecticides	3	13.6a	2.0
Drench + Conventional insecticides at 18 and 42 DAP	2	12.1a	1.7
Farmer's practices	6	12.6a	1.6
Check	0	8.7b	1.4
Trial 4			
Seed treatment + conventional insecticides 34 DAP	3	10.7a	1.7
Seed treatment + AT with conventional insecticides	3	12.7a	2.0
Farmer's practices	7	11.8a	1.6

[a] Seed dressings and drench treatments with neonicotinoids; AT, action threshold; DAP, days after planting

[b] Means within a column followed by the same letter are not significantly different at the 5% level by LSD.

The use of systemic insecticides in application as drench or seed dressing also had a less detrimental effect on populations of the nymphal parasitoid *Encarsia nigricephalla*, the most important natural enemy of whiteflies in the region (Figure 4).

Trying to find alternatives to insecticides, we tested several entomopathogens. Two commercial formulations of *Verticillium lecanii* and two of *Beauveria bassiana* were completely ineffective against whitefly adults or nymphs. Soaps, oils also failed to provide adequate control when high whitefly populations occur.

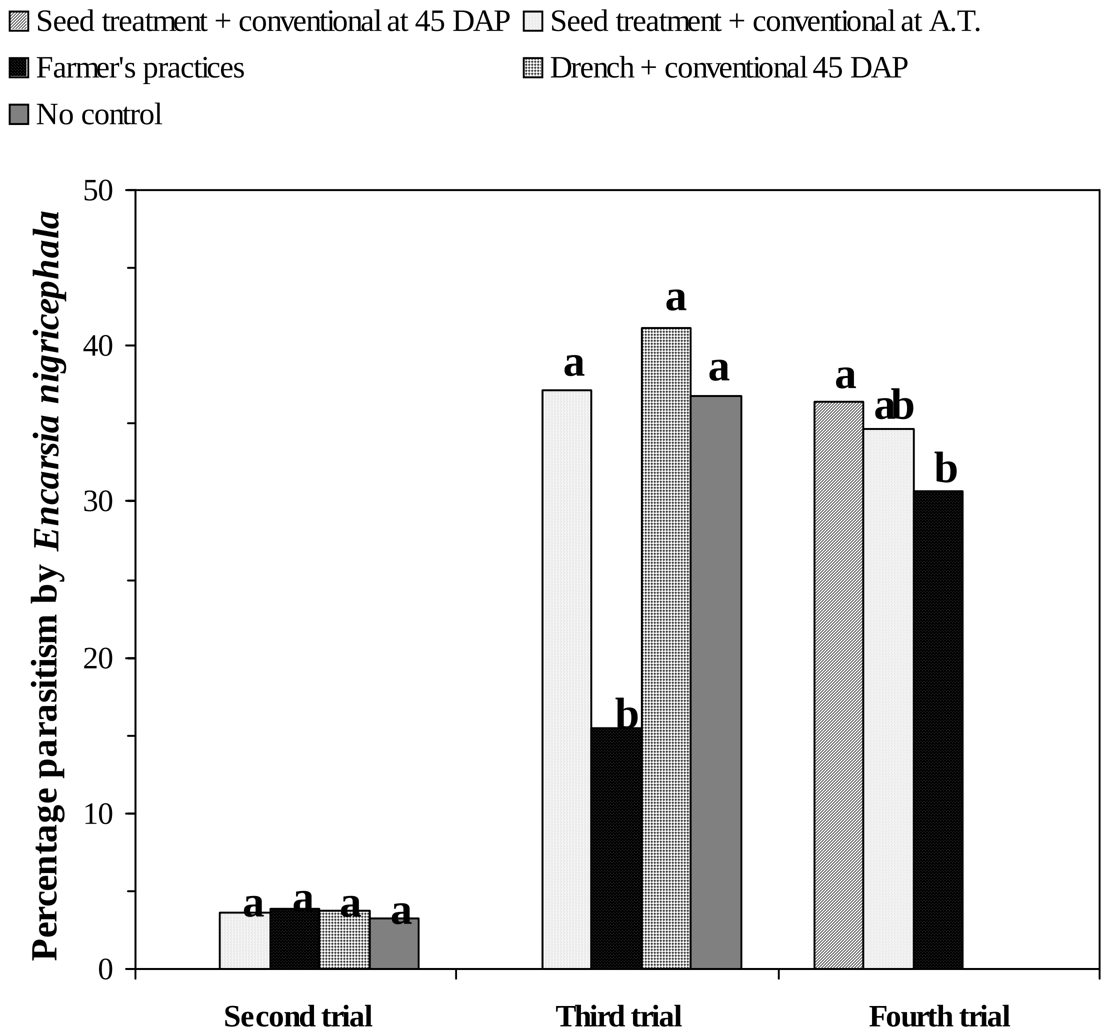

Figure 4. Impact of different whitefly management strategies on parasitism of *Trialeurodes vaporariorum* nymphs by *Encarsia nigricephala*. Bars with the same letter do not differ at the 5% level (LSD).

In the Chota region of Ecuador, two consecutive demonstrative trials showed that integrated management approaches result in high yields of beans of excellent pod quality comparable to those obtained by farmers with traditional (conventional) approaches to whitefly control (Table 6).

Table 6. Whitefly damage levels, quality of produce and dry bean yields obtained in large scale demonstrative trials conducted in the Chota region of Ecuador. Comparison of two management strategies of the greenhouse whitefly, *Trialeurodes vaporariorum*

Treatment	Damage (sooty mold)[a]		Quality of pods[b]		Yield (kg/ha)
	30 DAP	60 DAP	30 DAP	60 DAP	
Conventional	2.3 a	2.6 a	3.6 a	3.3 a	1327.7 a
MIP	2.0 a	3.3 a	3.6 a	3.3 a	1328.3 a
Coefficient of variation (%).	18.8	36.0	19.2	21.2	17.6

[a] On a 1-5 visual scale (1, no damage; 5, very serious damage

[b] On a 1-5 visual scale (1, very poor; 5, excellent)

DAP, days after planting

Means within a column followed by the same letter do not differ at the 5% level of significance by LSD.

Contribution of outputs to developmental impact. We have demonstrated that a significant reduction in pesticide applications (from an average of 6-7 down to 2 per cropping season) can be achieved by timely use of selective insecticides coupled with destruction of crop residues and monitoring of whitefly populations until they reach pre-established action thresholds. If properly diffused, results of this project should contribute in several manners to the welfare of small peasant farmers and consumers in the Andean zone. Expected impact will include the widespread adoption of IPM practices. Fewer insecticide applications will be made, and farmers and their families will suffer less exposure to dangerous chemicals. The load of pesticides received by the environment will be reduced, thus restoring the ecological equilibrium in target areas. Farmers working with IPM will find their production costs reduced by at least 25% and their incomes thus maintained or improved. Consumers will also suffer less exposure to residues of dangerous chemicals in final products. Reduced presence of chemical residues will also improve access to markets in the developed world.

Solid information is now available to initiate diffusion of results in farmers' communities in Colombia and Ecuador. In fact, in spite of the lack of funds some diffusion activities are now in progress in Ecuador through Farmers Schools and in Colombia through a grower's association. Teaching material is being prepared. Part of the diffusion process has been initiated with the publication of the following papers:

Rodríguez, I., and C. Cardona. 2001. Problemática de *Trialeurodes vaporariorum* (Westwood) y *Bemisia tabaci* (Gennadius) (Homoptera: Aleyrodidae) como plagas de cultivos semestrales en el Valle del Cauca. Rev. Colombiana de Entomol. 27(1-2): 21-26.

Quintero, C., F. Rendón, J. García, C. Cardona, A. López-Avila, and P. Hernández. 2001. Especies y biotipos de moscas blancas (Homoptera: Aleyrodidae) en cultivos semestrales de Colombia y Ecuador. Rev. Colombiana de Entomol. 27(1-2): 27-32.

Cardona, C., F. Rendón, J. García, A. López-Avila, J. Bueno, and J. D. Ramírez. 2001. Resistencia a insecticidas en *Bemisia tabaci* (Gennadius) y *Trialeurodes vaporariorum* (Westwood) (Homoptera: Aleyrodidae) en Colombia y Ecuador. Rev. Colombiana de Entomol. 27(1-2): 33-38.

Rendón, F., C. Cardona, and J. Bueno. 2001. Pérdidas causadas por *Trialeurodes vaporariorum* (Westwood) (Homoptera: Aleyrodidae) y *Thrips palmi* Karny (Thysanoptera: Thripidae) en habichuela en el Valle del Cauca. Rev. Colombiana de Entomol. 27(1-2): 39-44.

López-Avila, A., C. Cardona, J. García, F. Rendón, and P. Hernández. 2001. Reconocimiento e identificación de enemigos naturales de moscas blancas (Homoptera: Aleyrodidae) en Colombia y Ecuador. Rev. Colombiana de Entomol. 27(3-4): 137-141.

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Other dissemination activities include:

- 15 Technicians were trained in whitefly biology and management: three from Bolivia, six from Ecuador, six from Colombia
- 90 visitors were attended: three technicians, 75 students, and 12 farmers. These were interested in whitefly research
- The following meetings were hosted and organized by the sub-project:
    - Three meetings with farmers in the Pradera site were organized in 2003. These were attended by 25, 30, and 80 farmers, respectively
    - Two technical meeting with technicians were attended. One in 2003 (attendance: 51), one in 2004 (attendance: 105)
- A field day was organized in the Chota Valley site of Ecuador. This event was attended by 132 people (33% women)
- Results of the project were presented to participants in the following events: XXVIII and XXX Congresses of the Colombian Entomological Society
- Two B. Sc. and one M. Sc. Theses were supervised.