CROP PROTECTION PROGRAMME

Implementing pheromone traps and other new technologies for control of cowpea insect pests in West Africa through Farmer Field Schools

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FINAL TECHNICAL REPORT

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cowpea technologies (new varieties, pheromone traps and plant extracts) used by farmers across agro-ecological zones in Benin.

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EXECUTIVE SUMMARY

Replicated, on-station trials for control of cowpea insect pests in Benin and Ghana built upon earlier results to show that a variety of botanical pesticides, with or without pheromone traps for the legume podborer, *Maruca vitrata*, yields and infestations were generally intermediate in effectiveness between conventional pesticides and untreated controls. Neem seed oil was the best botanical for controlling flower thrips and *M. vitrata*. Farmer field school trials (FFS) in the first year (18 villages) largely confirmed these findings and recommendations were developed for the optimal use of traps.

On-farm trials of these recommendations were carried out in the second year with PRONAF, OBEPAB, CRI and GOAN in 15 villages across Benin and in central Ghana. Feedback from farmers and researchers indicated that the use of traps with a flexible approach to choice of control agent enabled better integration with existing farmer practice and better understanding and interest among farmers than previously. A survey of several villages carried out to assess the potential for farmer-to-farmer transmission of information about the technologies showed that such informal transmission occurs among the majority of farmers. Farmers also wanted more practical information regarding the use of pheromone traps and this influenced the production of two posters on the traps intended for distribution to FFS, as well as a leaflet for FFS facilitators and extension staff.

Progress to develop pilot-scale systems of manufacture and distribution of pheromone traps and lures, and of botanical insecticides was mixed. It has not yet been possible to identify local commercial companies to either manufacture or supply pheromone traps or lures for *M. vitrata* (partly due to unavailability of the project leader to undertake travel on medical grounds). As a result planned activities intended to sensitise regulatory authorities to the novel characteristics of pheromone and botanical products could not be covered. Studies of the social and economic feasibility of technologies showed that a substantial proportion of farmers would be willing to pay the estimated economic cost of traps and lures. In the longer-term farmers wish to make purchases of traps, lures and botanical pesticides through existing providers, but farmer production of traps was successfully carried out and a short-term supply route for lures (through PRONAF from the UK supplier) has been identified.

Replicated trials with a putative *M. vitrata* new pheromone blend component were carried out at five sites across W. Africa. These provided no evidence that the new component produced any improvement in catches. In Burkina Faso the greatest catches were with the single (already known), major component alone, not with the standard 3-component blend. At Savè (central Benin) all the blends did equally well. On the basis of these results, expansion of on-farm work to Burkina Faso (in the final project phase), but not to northern Nigeria, is appropriate.

BACKGROUND

Cowpea, *Vigna unguiculata* (L.) Walp., is a highly important grain legume crop grown in semi-arid and dry savannah agro-ecological zones of the tropics. Cowpea grains contain around 22% protein (Batino et al., 2002) and provide a cheap source of dietary protein for low-income urban and rural populations (Rachie, 1985). Within West Africa, cowpea is grown mostly in subsistence farming systems and on small scale in the lowland dry Savanna and Sahelian regions. Traditionally, it is inter-cropped with sorghum, millet or maize but there is a move towards mono-cropping as its economic importance increases (Coulibaly & Lowenberg-Deboer, 2002). It forms a vital cattle forage crop in subsistence cereal-based farming systems (Mortimore *et al*., 1997). Africa produces 75% of world cowpea production of which the majority comes from West Africa.

Maruca vitrata Fabricius (syn. *M. testulalis*) (Lepidoptera: Pyralidae), the legume podborer, is a key pest of cowpea (Jackai, 1995) as well as other legume crops. The larvae attack flower buds, flowers and young pods (Singh & Jackai, 1988) and on cowpea yield losses due to *M. vitrata* have been reported in the range 20-80% (Singh *et al*., 1990). In West Africa *M. vitrata* forms one of a complex of damaging insect pests of cowpea, which can also include aphids *Aphis craccivora* Koch (Homoptera: Aphididae), foliage beetles *Ootheca mutabilis* Sahlberg (Coleoptera: Chrysomelidae), several species of pod bugs and legume bud thrips, *Megalurothrips sjostedti* Trybom (Thysanoptera: Thripidae (Singh *et al*., 1990).

Conventional insecticides can control cowpea insect pests effectively and raise yields several-fold (Afun *et al*., 1991; Amatobi, 1995; Asante *et al*., 2001); where no control is attempted yields are correspondingly low. However, expense limits insecticide use by many poor farmers (Alghali, 1991; Bottenberg, 1995). Use may be higher in areas in which cotton is grown; for example in Benin farmers may often use cotton insecticides (which are sold at subsidised prices), which are not recommended for cowpea (Coulibaly pers. comm.) – generally on a calendar basis (PRONAF-Benin, 2000). Resulting from this, health and environmental hazards are increasing. Resistance in *M. vitrata* to three classes of insecticides has also been reported from Nigeria (Ekesi, 1999a).

Recent research efforts, often led by IITA, have been made to develop resistant varieties (none yet available for *M. vitrata*) and biological control against key cowpea pests (Bottenberg *et al*., 1998; Wooley, 1997; Fatokun *et al*., 1997; Tamò *et al.*, 1997; Asante *et al*., 2000). Although a viral pathogen of *M. vitrata* has been discovered in southern Benin (and investigated under CPP project R7247) (Cherry, 2003) and the fungal entomopathogen *Metarhizium anisopliae* has shown considerable promise (Ekesi, 1999b, 2001; Ekesi et al., 2000a,b), neither of these latter possibilities is likely to be implemented at farm level for some time. Much current research therefore focuses on botanical pesticides such as neem *Azadirachta indica*, A. Juss. (Meliaceae), papaya *Carica papaya* L. (Caricaceae) and *Hyptis suaveolens* (Lamiaceae) extracts (Bottenberg and Singh, 1996; IITA, 2000, 2001), which already form indigenous methods of control for some farmers (Kossou et al., 2001).

PRONAF (formerly PEDUNE) was established in the late 1990s, by IITA and its partner organisations in nine W. African countries, as a result of concern about the negative development impact of cowpea crop losses and indiscriminate pesticide use in cowpea and associated crops. PRONAF aims to enable the transfer and implementation of research on cowpea to subsistence farmers in West Africa. Although several technologies were developed within PRONAF during its early stages, a need was identified for application of research results in rural societies in such a way as to reach a significant number of users in the most appropriate form. To address this, PRONAF introduced Farmer Field Schools (FFS) in 1999 (Agli et al. 2002).

Some of the technologies most commonly adopted through the FFS have been: cowpea varieties resistant to some important pests, use of botanical insecticides, and innovative storage practices (Agli et al. 2002). Training of farmers in pest identification has also been beneficial according to the same source. With regard to botanical insecticides, on-farm trials have confirmed that spraying cowpea with ULV formulations of neem and papaya leaf extract can double cowpea yields compared to untreated controls, or give similar yields to common farmer practice involving synthetic pesticides (PRONAF-Benin, 1999, 2001, unpub. data for 2002). Neem seed extracts could be more effective still, due to their higher azadirachtin content and *H. suaveolens* leaf extracts have shown some promise against *M. vitrata* in on-station trials (Hammond, *pers. comm*.). However, neither of these have been tested on-farm.

Afun *et al*. (1991) demonstrated the effective use of action thresholds, based on cowpea flower infestation rates, to achieve control of *M. vitrata* with reduced conventional insecticide sprays. Potentially, catches in pheromone-baited traps for *M. vitrata* could be used by cowpea farmers in the same way, thus minimising insecticide inputs whilst maximising control. This was the rationale for the previous project R7441.

Adati & Tatsuki (1999) had previously indicated that (*E,E*)-10,12-hexadecadienal (EE10,12-16:Ald) and (*E,E*)-10,12-hexadecadienol (EE10,12-16:OH), were major and minor components, respectively, of the *M. vitrata* sex pheromone but they carried out no field testing. Downham *et al*. (2003) had extended this work during an earlier phase of CPP-funded work (R6659) by demonstrating that in field experiments in Benin, traps baited with a blend of EE10,12-16:Ald, EE10,12-16:OH and E10-16:Ald in a 100:5:5 ratio caught significantly more males than traps baited with the major component alone, either two-component blend or virgin female moths.

Under R7441 an effective and practical trapping system for *M. vitrata* was developed for the first time (Downham et al., 2002, 2004). Trap lures showed no loss of attractiveness for up to 4 weeks under field conditions. The precise dose, blend ratio or isomeric purity of the EE10,12-16:Ald and EE10,12-16:OH components were found not to be critical in achieving catches – with positive implications for cost and general practicality. The best trap height was 120 cm and the most effective traps were those produced from locally available 5-litre plastic jerry-cans. Not only were these relatively much cheaper than imported, commercial designs – less than £1 compared to £2 or more – they are also easy to construct and robust in use. The 5-l jerry-can trap was adopted as the standard for subsequent work.

In Benin it was shown that trap-catches occur up to 12 days before larval infestations in flowers and a week or more in advance of flowering within cowpea fields (Rurema, 2003; unpub. project data). Thus it was clear that trap-catches can signal impending infestations and provide an earlier warning than the appearance of flowers. During R7441 several factors were found to produce variability in the relative timing of trap-catches and infestations so as to reduce the predictive value of traps (Downham, 2003). Consideration of these suggested that the detection of the arrival of *M. vitrata* into fields should be most reliable if based upon several traps distributed over several fields within a village, for which planting dates and crop-cycle length were similar.

Project (R7441) surveys confirmed that farmers in Benin consider *M. vitrata* to be one of the most damaging pests of cowpea, along with aphids, *A. craccivora* (Adetonah et al., 2003). Thrips, *M. sjostedti,* although highly damaging, were less frequently mentioned, probably due to their cryptic infestation habits. Similar results have been found in the Northern Region of Ghana (PRONAF-Ghana, 2001). The project surveys also showed that large majorities in both Ghana and Benin believe pheromone traps could assist in control of the pest (Downham, 2003). However, as shown by the surveys, and borne out by project monitoring in Benin and Ghana, there is clearly a need to consider other pests, particularly aphids and thrips which occur earlier in the cropping season than *M. vitrata*.

Two constraints to trap use were identified from one survey. Firstly, most rural farmers in Benin and Ghana consider that trap materials may be relatively difficult to obtain (although they are available in large towns in those countries). Furthermore, although about half of farmers surveyed already use botanical insecticides, the labour of production and the lack of a market premium for 'botanical cowpea' act as disincentives for their full uptake.

On-station trials of the trap-threshold concept provided evidence of its effectiveness, compared to spraying based on crop stage. The effect was most clearly seen when traps were used in conjunction with a conventional insecticide, but neem and papaya leaf extracts produced lower *M. vitrata* infestations and higher yields than the unsprayed control.

A provisional cost-benefit analysis of the use of traps to determine spray dates was carried out in early 2002 (Adetonah et al. unpub.). This used on-farm yield data from 56 farms during the second season of 2001 in Benin. It was concluded that, assuming six traps ha^{-1} and three lures per trap at full cost, the use of traps should improve profitability if, compared to previous practice, they enable a reduction of two conventional insecticide sprays, while maintaining yield.

Thus, prior to this project, great progress had been made in developing pheromone traps to enable the timing of control measures for *M. vitrata* infestations to be optimised. In parallel with this, plant-based insecticides had been researched and actively promoted to farmers, with promising results. However, to realise the full potential of previous work undertaken the follow-on project aimed to address the following points:

- extend the uptake of the pheromone traps, and determine their best mode of use by farmers;
- test and refine the use of botanical pesticides, against *M. vitrata* and early season pests such as aphids and thrips;
- find ways to facilitate the manufacture and supply of trap materials, lures and botanical insecticides to farmers.

PROJECT PURPOSE

The project purpose was to improve food security and reduce poverty among small-scale rural farmers in Benin and Ghana by enabling the reduction of costs of pest control in cowpea. This was to be brought about by completing development of a pest control package combining pheromone traps for *M. vitrata* and (ideally) botanical pesticides for control of this pest and two others, aphids (*Aphis craccivora*) and thrips, (*Megalurothrips sjostedti*). The project would also decrease usage of conventional pesticides, thereby bringing health benefits to producer farmers and the eventual consumers of their cowpea. This would be underpinned by developing the commercial availability of the novel technologies to farmers.

RESEARCH ACTIVITIES

Research activities are described under the respective planned project outputs. Note that Output 4 was an add-on granted to the project in June 2004.

Statistical analysis of experimental results, where appropriate, was carried out using Genstat 6 for Windows using the "*One-way ANOVA (in randomised blocks)"* procedure unless otherwise indicated. Data were appropriately transformed to meet normality and constant variance assumptions (the procedure allowed inspection of various residuals plots). Where analysis of variance indicated statistically significant effects, treatment means were separated using the least significant difference (LSD) at the 5% level.

Output 1: Recommendations developed for the combined use of botanical or conventional insecticides, and pheromone traps, to control *M. vitrata* and early season pests

Activities under this output fell into three areas: firstly, a set of three on-station trials, secondly, some on-farm testing – both to refine and develop recommendations for the pheromone and insecticide package – and thirdly an assessment of farmers' views concerning practical aspects of traps and botanicals, through surveys in Benin and Ghana.

<u>On-station trials</u>

Building on results obtained under the previous project phase (R7441) the three on-station trials were carried out with the following aims:

- To compare four threshold approaches (2- and 5-moth per combined with 3- or 6-day delays in spraying) with a regimen based on spraying by crop stage, each using a conventional insecticide ('Decis' = deltamethrin), for control of *M. vitrata*;
- Also for *M. vitrata* control, to compare a variety of botanical insecticides and 'Decis' each sprayed according to a 2-moth, 3-day trap threshold, plus a regimen of spraying 'Decis' by crop stage;
- To compare a variety of botanical insecticides and 'Decis' for thrips control (effects on *M. vitrata* were also evaluated).

The first and second of these were carried out at the IITA station near Cotonou, Benin from June – September and October – December 2003, respectively. The third trial took place at the Savanna Agriculture Research Institute station near Tamale, Ghana from August to October 2003. Each trial employed six-fold replication of treatments applied to plots in the size range 8 × 10 m to 10 × 15 m (but uniform within each trial), set out to a randomized complete-block design. Each trial took place in a field of cowpea 1.0 – 1.5 ha in area, each block was separated by a minimum of 10 m and within each block individual plots were at least 1 m apart.

Fifteen 5-l jerry-can pheromone traps[1] for *M. vitrata* were distributed evenly throughout the field in each experiment and these were monitored daily to enable determination of the respective trap threshold dates. Where the traps were used to indicate application dates for botanical pesticides the first spray was made on the indicated date and subsequently three more sprays were at intervals of a few days, in accordance with previous practice developed by PRONAF. Where an initial spray of 'Decis' was applied according to a trap threshold, a second spray was made when 25% of plants held a green pod ('25% podding'). Sprays made only by crop stage were at 25% flowering and 25% podding. For the two trials at IITA, Cotonou, against *M. vitrata*, a single early season spray of papaya leaf extracts was made in all treatments to control thrips.

[1] Details of trap design and lures according to Downham *et al.* (2004).

Results were assessed both in terms of yield and of infestation rates of flowers and green pods, both of which were sampled on a weekly or twice-weekly basis from their first appearance in the crop.

Further details of the respective methodologies are given as Annexes 1a – c.

On-farm testing in year 1

Testing in Benin

The objective of the on-farm testing in 2003 in Benin was to test a range of trap-based thresholds for determining when to spray botanical and a recommended insecticide (Decis = deltamethrin) against *M. vitrata* and other cowpea pests and to compare this to conventional farmer practice (typically involving use of non-recommended pesticides).

Details of the intended methodology for trials in Benin are given in Annex 2. Actual practice followed this closely except that five (not four) villages in each of the Mono (also called Couffo), Zou (Collines) and Borgou (Alibori) departments (= agro-ecological zones) were chosen as sites with the threshold used in each village being 1, 2, 3, 4 or 5 moths per trap. Sites in the Mono and Zou were the responsibility of PRONAF-Bénin and those in Borgou were managed by OBEPAB. Testing was done as far as possible using a farmer field school (FFS) approach whereby all interactions with farmers within a village were done on an inclusive, collective basis, with a weekly meeting to review developments and plan activities. However, given the relatively prescriptive, research-oriented of the testing it is recognised that it did not constitute a true FFS approach as normally considered.

Within in each village 15 cowpea plots were selected. All were situated within an area approximately 500 m × 500 m and were planted within 7 days of each other, so they were at a similar developmental stage. Five were designated as trap/botanical (T+B) plots, 5 as trap/Decis (T+D) plots and the remainder as Farmer-practice (FP) plots. One 5-l jerry-can pheromone trap was positioned in each T+B and T+D plot; these were monitored three times each week.

Control decisions in the trap/botanical plots were made as follows. One application of papaya leaf extracts (against thrips) was made around first flower bud appearance. To control *M. vitrata*, spraying of botanical extracts (neem leaf in Mono and Borgou, neem or *Hyptis* leaf in Zou) commenced three days after attainment of the designated trap threshold (calculated from on all traps within the village). Botanical applications then continued at 5-day intervals to a maximum of four sprays. Control decisions in the trap/insecticide plots were made as follows. One application of Decis, against thrips, was made around first flower bud appearance. To control *M. vitrata*, one application of Decis was made three days after attainment of the designated trap threshold. A second spray was made at 25% podding. Application rates of botanicals were in accordance with those previously developed by PRONAF and were according to manufacturers' recommendations for Decis. Control decisions in the farmer practice plots were the free choice of the farmers, but normally used non-recommended pesticides; in Mono the most commonly used insecticide was 'Sherphos 280 EC' with some use of 'Dursban', 'Delphos' and 'Conquet 88EC', while in Zou 'Dursban' was used exclusively. In Borgou because many farmers cannot afford to control cowpea pests and because OBEPAB philosophy favours a pesticide-free approach the FP treatment here involved no sprays at all. Generally, all same-treatment plots within a village were treated on the same days.

Crop inspections for *M. vitrata* larvae and other pests were carried out in all plots two times each week.

Testing in Ghana

A similar approach to that taken to that in Benin (see above) was originally planned, but due to a range of budgetary and practical constraints some significant changes were necessary. Generally only a traps/botanical treatment was compared to farmer practice – the traps/Decis treatment was omitted. Testing was carried out in only three villages, namely Cheyohi near Tamale (Northern Region), Ejura (Ashanti) and Derma (Brong Ahafo) and activities in these villages were overseen by SARI, the Crops Research Institute (Kumasi) and the Ghana Organic Agriculture Network (Kumasi), respectively.

At Cheyohi, activities could not be commenced in time for the normal cropping season and were centred on fields that had been sown late, between15 – 25 August, whereas late-June or July is more common in the area. Four large fields around the village were each divided into 'farmer practice' (FP) and pheromone trap/botanicals (IPM) plots and six traps were positioned around each field.

At the CRI site near Ejura activities followed the protocol (Annex 2) quite closely. Testing took place in 12 separate farmers' fields (six T+B, six FP), each 40 × 50 m in area. A further eight farmers followed weekly FFS activities as observers. Day-to-day activities were overseen by a staff member of the Ministry of Agriculture extension service, while farmers met together on a fortnightly basis, with CRI staff. All fields were sown during the first half of September, with a mixture of varieties. Traps were installed on 3 October. In the T+B fields papaya leaf extracts were applied against thrips and neem seed extracts against *M. vitrata*. In the FP plots a variety of pyrethroid compounds were applied by farmers. Flowers were sampled on two occasions, 17 and 22 October, and pods on three occasions, 3, 8 and 15 November. See also Annex 3.

At Derma a single large block of land was used for testing. It was divided into 12 individual sub-plots each 20 × 30 m with approx 1 m borders separating them. There were12 active participants in the FFS with around 8 – 10 additional farmers regularly looking on as participants. Sowing was on 25 and 30 September (six plots on each date) with variety 'Asontem' in all plots. Six pheromone traps, one per T+B sub-plot, were installed on 17 October. Compost, of an unspecified type was applied to all T+B, but not FP, plots. Botanical applications against *M. vitrata* in the T+B plots varied – neem leaf (2 plots), papaya leaf (2 plots), neem leaf + pepper (1 plot), neem seed (1 plot). Farmer practice plots all used 'Thionex' against *M. vitrata*. Two MofA extension agents oversaw day-to-day activities with GOAN staff visiting weekly for an FFS-style meeting. The FFS was divided into four groups each of whom carried out agronomic practices in their assigned plots in addition to trap and pest monitoring. Simple pest monitoring (3 plants/plot) was employed in FP plots to determine spray timings. See also Annex 4.

<u>Assessment of farmers' views concerning practical aspects of traps and botanicals – year 1</u>

The objective of this activity was to evaluate the practical experience of the new technologies gained by farmers from the previous activity – the on-farm testing – and to assess their perceptions as to their utility.

This was achieved through a survey carried out in late 2003 and early 2004 – immediately following the on-farm testing described in the previous section. This used a structured questionnaire (English version at Annex 5) to assess the views of farmers in 17 villages in Benin and three in Ghana. Twelve of the villages in Benin (five in Borgou, four in Zou and three in Mono) and all three of those in Ghana had participated in the on-farm trials described above. An additional five villages in Mono that had participated in previous project phase activities were also included. In Benin approximately 20 farmers per village were selected for inclusion in the survey in Mono and Zou, and 10 per village in Borgou (n = 268 for Benin). In Ghana approximately 40 farmers per village were chosen (n = 120). In each village approximately half of the selected farmers had previous direct experience of the traps and/or had participated in FFS or on-farm trials. The remainder had no such experience and were chosen randomly from among the rest of the village farmers. See also Annex 6a for further details of methodology. Annexes 6a – 6d report the survey findings (all in French).

Output 2: Uptake increased for pheromone traps and best package of botanical/conventional insecticides for controlling the pest complex

Planning and co-ordination meetings

Workshops involving all appropriate project partners from Benin and Ghana were held at Cotonou (IITA) and Kumasi (CRI), respectively, in April and July 2003. The Cotonou workshop formed part of the annual PRONAF planning meeting, while that in Kumasi was specifically organised for the project. In each case the nature and aims of on-farm activities for the 2003 season were agreed. Plans were developed for on-station and FFS/on-farm trials, for supply of traps, lures and botanicals. Objectives of follow-up surveys of farmers in the off-season were also explained. Subsequently partner organisations submitted proposed budgets to IITA for on-farm trial/FFS activities.

In 2004 the annual PRONAF workshop was held in Burkina Faso in April that year. The project leader, Dr Downham, was unable to attend for medical reasons, but results for 2003 in Benin were summarised by Dr Coulibaly of IITA. Suggested details of activities in Benin for the 2004 season (see below) were also presented and discussed at that time. These were followed up during the visit of Dr Cherry (NRI) in July (deputising for the PL) and plans for on-farm trials in particular were finalised for both Benin and Ghana at that time.

On-farm scaling-up trials – year 2

For the second year's activities (2004) PRONAF co-ordinated on-farm trials in six villages, three each in Mono and Zou departments in Benin; with one exception (in Zou) these villages had not been involved in previous activities involving pheromone traps. OBEPAB oversaw five villages in Borgou, although only one of these was not included in 2003. In Ghana, CRI and GOAN managed two villages each in Ashanti and Brong Ahafo regions, respectively; one of each pair of villages participated in on-farm trials in 2003 and one was new.

Following informal feedback and criticism that the trials in 2003 had been too inflexible and did not fit well with standard farmer practice, the general approach to using traps was modified to better integrate the traps with existing farmer practice. As before, 5 – 6 traps were deployed in cowpea fields distributed within a 500 × 500 m areas around a village and the threshold date determined as that date when the cumulative average of two moths per trap is reached, but farmers were free to decide collectively the best control agent to apply for each field – botanical or conventional pesticide – and when to apply it, taking account of the overall pest situation. However, the recommendation is to spray within three days of the trap threshold. This is subsequently referred to as the 'Traps' treatment (since it did not necessarily include a botanical pesticide component), to distinguish it from farmer practice (FP). A more detailed methodology is given in the protocol for Ghana as Annex 7. Reports by CRI and GOAN are given at Annexes 8 and 9, respectively.

The total number of villages involved (15) was reduced compared to those originally planned (31) and those carried out in 2003 (18). This was as a result of the unforeseen higher cost of the activities in 2003, which resulted in an IITA budget overspend and from delays in payments from IFAD to IITA in respect of PRONAF funding.

Assessment of potential for transmission of technologies from participating to non-participating farmers – year 2

There is evidence from former PRONAF FFS for farmer-to-farmer transmission of cowpea technologies in the absence of formal FFS structures (Downham unpub. visit report, 2001), apparently through informal training of non-participants by former FFS participants.

Fostering such transmission was made an explicit objective by PRONAF from 2002. The function of this activity is thus to gauge the likely scale and routes of transmission of pheromone trap and botanical insecticide technologies from participating to non-participating farmers.

A formal survey with a questionnaire (Annex 10) was conducted in six villages in Benin (two each in Mono, Zou and Borgou departments) and four in Ghana (two each in Ashanti and Brong Ahafo regions) each of which had hosted an FFS during the previous cowpea season. Respondents comprised 160 farmers in Benin (51% male, 49% female) and 124 in Ghana (63% male, 37% female). These included all previous FFS participants in the respective areas, plus randomly selected non-participants farmers. The survey was carried out from November 2004 to January 2005. A report of this is at Annex 11.

Development and analysis of the survey and its results was led by IITA in partnership with senior INRAB/SARI staff who provided most of the survey enumerators (1 per village). Data was tabulated with calculated frequencies of key factors. Logit model analysis was used to assess the impact of key factors in the adoption and diffusion of pheromone traps and botanicals.

Dissemination of recommendations and trap/botanicals package

No dissemination workshop took place in December 2004, as originally planned, due to the unavailability of the PL, Dr Downham for overseas travel for long-standing medical reasons. It is planned to carry over this activity into the agreed project extension in 2005.

Two posters (aimed at farmers) and a training leaflet (for extension workers) were developed. Drafts of each, previously prepared by the PL, were amended and translated into French by IITA. Local language translations of the posters were obtained by IITA in Benin and for Ghana by CRI. English language versions are given at Annexes 12 – 14.

Output 3: Local/regional systems of manufacture and distribution of pheromone traps and lures, and of botanical insecticides, developed on a pilot-scale

Identification of potential suppliers and producers of pheromone traps and botanicals, production and distribution of pilot-scale products

The NGO TechnoServe[2], which operates in Ghana, was contacted and two meetings took place between the PL and their representatives. Subsequently the PL was not able to travel due to medical problems, but email contacts were continued.

TechnoServe were approached because of promising interactions with other RNRRS-funded projects. It was hoped that they would assist in the identification of prospective suppliers and producers of pheromone traps and botanicals. Unfortunately, during the first meeting in Accra, during July 2003, their representative Mr Ofori Addo, could not assist much and knew only of a small company called Jeloise which distributed neem oil, possibly imported from India. More significantly, he indicated that he felt the NGO needed evidence of a problem, a commercial need that could be answered by the pheromone lures and would be of interest to the private sector, before becoming involved.

[2] TechnoServe is a US-based NGO whose mission is to help "entrepreneurial men and women in poor rural areas of the developing world to build businesses that create income, opportunity and economic growth for their families, their communities and their countries." Within Ghana it was established in 1971, it has a staff of 85, with offices located in Accra (headquarters) and seven regional centres. It targets crops such as pineapple, cashew, palm oil, grains, legumes and shea nuts and has aided partners producing botanical insecticide equipment. NRI and TechnoServe have previously collaborated on the commercialisation of polyethylene storage tanks for cowpea in northern Ghana.

To this end a brief tour of an on-farm site at Ejura was arranged for October 2003, during the middle of the cowpea season. The visit enabled a second representative, Mr Adjei, based in the TechnoServe office, to familiarise himself with the work of the project, and the pheromone traps in particular, and he appeared interested in how TechnoServe might assist in furthering the work. The PL mentioned his initial ideas that TechnoServe might help identify private sector partners for the large-scale production of traps and botanical pesticides, and of distributors of lures. However, Mr Adjei suggested that at least an equally productive intervention might be for them to assist in finding a market niche for the sale of 'botanical' or organic cowpea at a premium. The lack of any such premium is currently cited by farmers in Benin as a reason for limiting their production of organic cowpea, thus remedying this would be extremely helpful.

Unfortunately subsequent correspondence with TechnoServe was intermittent and rather unsatisfactory. The only significant progress was establishment of email contact with a Mr Yelyen at their Wa office (in Upper West region) who has personal contact with a small group of organic farmers, growing cowpea for special export. It was thought that these farmers in particular might be interested in using pheromone traps in tandem with their current use of botanical pesticides. However, it was not possible to arrange any demonstration of the traps in time for the 2004 season.

After the 2003 season attempts were made to locate neem oil supplies on the Ghanaian market. It was not possible to locate an outlet of Jeloise (see above) but one product, NeemAzal of Indian origin, was available to a limited extent. It was initially planned to test this during the 2004 season, but Dr Braimah of CRI advised that CRI had tested the product for cowpea pest control and found it almost useless; subsequent testing in Germany under an earlier GTZ Integrated Crop Protection project reportedly found that it was devoid of active ingredient (although NeemAzal bought in Germany was apparently of good quality). Hence the matter was not pursued and neem oil tested during the project (see Output 1) was made by project partners.

Production of botanical pesticides is generally noted by farmers as being laborious and time-consuming. Prior to the 2004 season the possible use of borrowed or hired grinding mills or other, potentially time-saving equipment from an organic-oriented 'le Centre Songhai' NGO based at Porto-Novo, Benin was investigated by IITA but no progress made.

During the 2003 season respective partner organisations made the pheromone traps and demonstrated their fabrication to farmers FFS. Lures were distributed to project partners, having been purchased by IITA from a UK commercial supplier, International Pheromone Systems. Individual farmers produced botanical pesticides within their FFS.

During the 2004 season traps were made by farmers as part of FFS activities (i.e. following demonstration by the respective project partner staff). Lures were supplied commercially, through IITA thence project partners and botanical pesticides were again produced by farmers.

<u>Assessment of social and economic feasibility of supply</u>

As originally conceived the function of this activity was three-fold:

1. To assess farmers' willingness to pay for pheromone traps, lures and botanical pesticides, if bought commercially;

2. To determine the preferred mechanism(s) of supply of these technologies;

3. To carry out a profitability analysis on the use of the various trap-threshold/botanical technologies by farmers across the agro-ecological zones, based on known input costs and real yield data obtained from the on-farm trials.

In practice it was found more convenient for the first of these aspects to be covered during year 1 of the project by the “Assessment of farmers’ views concerning practical aspects of traps and botanicals”, carried out under Output 1. The second aspect was carried out during year 2 under the “Assessment of potential for transmission of technologies from participating to non-participating farmers” as part of Output 2.

The third part consisted of carrying out a financial and economic profitability analysis of the use of various cowpea technologies – including pheromone traps, conventional or botanical pesticides and local or improved varieties – based on known input costs and real yield data. The aim was to assess the financial and economic profitability of different cowpea production systems (combinations of technologies and varieties) and combine this with determining the effects of changes in key factors such as prices of the various inputs or the market selling price of cowpea.

The study was carried-out in Department of Mono-Couffo (southern Benin). Data collection was done through pre-tested structured questionnaires in three villages where project Farmers Field Schools (FFS) and on-farm trials were done during the period of 2004-2005. The villages are the following: Domi, Glolihoue and Koyihoue. Two types of data were collected from farmers (primary data) and from public and private services (secondary data). Part of the primary data was collected by technicians from the on-farm trials. A formal survey was conducted to collect complementary data from farmers - mainly participants of FFS and/or PRONAF-BENIN on-farm-trials in the same areas. For the complementary survey, the sampling was non-random. Thirty (30) farmers were selected from an original list of participants provided by PRONAF-BENIN. Different combinations of improved and local technologies including improved and local varieties, neem or papaya extract used as insecticide, chemical pesticide, use of pheromone traps and IPM practices were evaluated. The profitability analysis was based on farming systems of the on-farm trials and existing in the study zone. Farming systems were defined as combinations of improved technologies and local technologies of cowpea production.

The various data collected were used in an economic analysis which is described in full in the report of the study at Annex 15.

<u>Investigation and initial development of registration requirements for botanical and pheromone products</u>

Under previous project phases discussions with Environmental Protection Agency (EPA), Ghana, OBEPAB (Benin) and IITA had indicated that there is no specific registration or regulatory framework applicable to botanical pesticides or pheromone products in Benin or Ghana.

In July 2003 the PL met with Mr S. Adu-Kumi (Senior Programme Officer) and Mr J.A. Pwamang (Agricultural director) of the EPA. The PL had met Mr Adu-Kumi on an earlier visit in May concerning a permit to allow on-farm use of the pheromone lures in 2002. This time the outcome of the meeting was that, in the absence of specific regulations governing pheromone products EPA could issue a letter, on request and at no charge, to enable imports of lures direct from outside Africa to be cleared at customs on entry to Ghana.

Due to the continued unavailability of the PL for medical reasons, the planned meeting intended to sensitise regulatory authorities to the novel characteristics of pheromone and botanical products did not take place. It is planned to make this good during the project extension. A linked short review and report of stakeholders’ (i.e. NGO, commercial and parastatal institutions) perceptions concerning pheromone and botanical products could not be completed by IITA. This was intended to generate recommendations for supplementary requirements for changes to registration procedures to accommodate such products.

Output 4: Re-examination of the pheromone blend of *Maruca* to improve its effectiveness in Nigeria and Burkina Faso

Following the discovery of a possible additional or new *M. vitrata* pheromone component by a post-graduate student at NRI, Mr M.N. Hassan, this activity was added to the project to allow a renewed assessment of *M. vitrata* pheromone blend. The purpose of this was to try to overcome poor catches in some parts of W. Africa and thus facilitate potential uptake among cowpea farmers in the region.

On-station trials using a randomised complete block design (with 5 replications) took place at IITA-Cotonou (southern Benin), IITA-Kano (northern Nigeria), SARI-Tamale (northern Ghana) and at Bobo-Dioulasso (managed by INERA staff based in Ouagadougou, Burkina Faso). A similar trial also took place in farmers' fields at one village near Savè in central Benin, under the direction of IITA-Cotonou staff. Each trial ran for 2 – 3 months during the latter half of 2004.

The trials compared four different pheromone blends, each dispensed in polythene vials lures in 5-l white, plastic jerry-can traps. Two incorporated the putative new component E10-16:OH, while one formed the hitherto standard, 3-component blend and fourth treatment consisted of the principal blend component alone. An un-baited control was also included (Table 1).

Table 1. Different treatments to be used in comparison of *M. vitrata* pheromone blends, West Africa, 2004.

Treatment	Amounts of each component per lure			
	EE-10,12-16:Ald	EE-10,12-16:OH	E10-16:Ald	E10-16:OH
1	100 μg	5 μg	5 μg	-
2	100 μg	-	-	-
3	100 μg	-	-	100 μg
4	100 μg	5 μg	5 μg	100 μg
5	un-baited control			

N.B. Treatment 1 = standard blend.

Operation and placement of the traps was according to Downham *et al.* (2004). Each was checked at least three (3) times each week, when the numbers of males and females caught were recorded separately. Dead insects and other debris were removed and water replenished as necessary. Lures were replaced every two weeks.

OUTPUTS

Output 1: Recommendations developed for the combined use of botanical or conventional insecticides, and pheromone traps, to control *M. vitrata* and early season pests

On-station trials

Trap threshold comparison at IITA, Cotonou

In the comparison of different thresholds with crop-stage based spraying, for *M. vitrata* control, relatively low pest populations were observed. A prophylactic spray of papaya leaf extracts was made against thrips in all treatments on 28 July. Total trap catches of *M. vitrata* in the 15 traps for the entire trial were 59 moths. The 2-moth threshold was reached on 8 August, thus Decis was applied on 11 and 14 August in treatments 1 and 2, respectively. The 5-moth per trap threshold required for treatments 3 and 4 was not reached, thus no related sprays were made in these cases. The 25% flowering date was 6 August and the initial spray in treatment 5 was made on 8 August; 25% podding was observed on 14 August, as a result further sprays were made in treatments 1 – 5 on 15 August.

Thrip numbers per 20 flowers sampled rarely exceeded 100 in all treatments – a low figure compared to observations in previous trials of several hundred per 20 flowers. Similarly, sampled *M. vitrata* larvae averaged less than 1 individual per 20 pods. Probably as a result of these low pest levels no between-treatment differences emerged in respect of infestations or yield, although yield levels were surprisingly low in all treatments (Table 2).

Table 2. Summary results from the comparison of different thresholds with Decis, IITA-Cotonou, June – Sept 2003.

	Trap Threshold	Treatment Details	*M. vitrata* larvae per 20 organs** ± SE		Yield (Kg/ha) ± SE
			flowers	pods	
1	2 moths/trap	'Decis' 3 days after threshold, then @ 25% pods	1.57 ± 0.20	0.50 ± 0.29	334.8 ± 50.9
2	2 moths/trap	'Decis' 6 days after threshold, then @ 25% pods	1.81 ± 0.08	0.63 ± 0.23	392.9 ± 62.0
3*	5 moths/trap	'Decis' 3 days after threshold, then @ 25% pods	2.12 ± 0.33	0.73 ± 0.22	359.1 ± 64.3
4*	5 moths/trap	'Decis' 6 days after threshold, then @ 25% pods	1.31 ± 0.21	0.87 ± 0.25	346.1 ± 61.7
5	crop stage	'Decis' at 25% flowers, then @ 25% pods	1.31 ± 0.34	0.53 ± 0.22	316.9 ± 71.5
6	-	Untreated control – no sprays	1.88 ± 0.42	0.53 ± 0.22	293.0 ± 48.9
		LSD (5%)	0.84	0.63	136.7

* In practice, no threshold-related spray made for these treatments, only one at 25% podding. ** Based on average infestation rates across all sample dates. N.B. LSDs calculated following ANOVA of respective data-sets.

Botanical pesticides for M. vitrata *control at IITA, Cotonou*

In the comparison of different botanical pesticides combined with the 2-moth/3-day threshold for *M. vitrata* control, pest populations were rather higher, although not great by normal levels. A prophylactic spray of papaya leaf extracts was made against thrips in all treatments on 30 October. Total trap catches of *M. vitrata* in the 15 traps for the entire trial were 95 moths. The 2-moth threshold was reached on 10 November, thus initial threshold-based sprays against *M. vitrata* were applied on 13 November in treatments 1 - 6. The 25% flowering date was 3 November and thus the first spray in the crop stage treatment with Decis (treatment 7) was made earlier, on 5 November. Podding reached 25% on 15

November and as a result the second Decis sprays were made in treatments 6 and 7 on 17 November, whereas the fourth and final botanical spray was not until 27 November in treatments 1 – 5.

Mean thrip numbers per 20 flowers ranged between 140 and 400 and differences among the treatments were statistically significant ($P < 0.05$, ANOVA), being lowest in the two Decis treatments (trap threshold and crop stage) and highest in the untreated control. The four botanical/trap threshold treatments were all intermediate, apparently achieving significant control of thrips compared to the untreated control, although less than the two Decis treatments ($P < 0.05$, LSD following ANOVA). There was little difference among the botanical treatments, in terms of thrip control, although Neem seed was significantly better than Neem leaf ($P < 0.05$, LSD following ANOVA). In addition, even the water-spray treatment produced a small, but significant, reduction in thrip numbers.

Sampled *M. vitrata* larvae mostly averaged 1 - 2 per 20 flowers. Numbers were highest in the untreated control and significantly less in the two Decis and two neem treatments ($P < 0.05$, LSD following ANOVA). In respect of pods, only the Decis treatments produced any significant reduction in sampled larvae. All treatments produced higher yields than the no-spray control. However, with the Decis treatments producing the most striking reductions in pest numbers it was unsurprising to observe that the only significant effects on yield were for these two treatments ($P < 0.05$, LSD following ANOVA) (Table 3).

Botanical pesticides for thrips control at Tamale

The trial of different botanical pesticides for control of flower thrips produced some interesting results, most particularly in respect of *M. vitrata* although this was not the primary target. Rates of flowering reached 25% on 21 September, when the first spray was made in all treatments. Sampled thrips populations rose steadily through the three flower sampling dates to a maximum of over 400 per 20 flowers in the untreated control by 7 Oct. Taking the second sampling for illustrative purposes, a highly significant reduction in thrips was seen in the Decis treatment ($P < 0.05$, LSD following ANOVA), but none of the botanical treatments produced any reduction at all, compared to the control (Table 4), in contrast to the previous trial at IITA where some thrips reduction was observed with botanicals. Similar between-treatment trends were seen on the other sampling dates.

Much higher *M. vitrata* infestations were seen in both flowers and pods, than in the two trials at Cotonou. This was despite trap catches throughout the trial being far lower, totalling only 15 moths[3]. In flowers, Decis dramatically reduced larval populations although none of the botanical treatments had any impact, relative to the control ($P < 0.05$, LSD following ANOVA). However, in pods, while Decis also produced a marked suppression of infestations, both neem treatments, particularly the need seed oil also controlled *M. vitrata* to a moderate but significant extent ($P < 0.05$, LSD following ANOVA) (Table 4). This was also in contrast to the previous trial at IITA where no such reduction with neem seed extracts was seen.

Effects on yield appeared to reflect those on pests: yields in the Decis treatment were far greater than the control. All the botanical treatments showed intermediate mean yields, but only the neem seed treatment was significantly higher than the control ($P < 0.05$, LSD following ANOVA).

[3] Similar observations of poor trap catches and high larval infestations had been noted previously at Tamale, which is why the trial was primarily aimed at comparing thrips control. See also Output 4, this report.

Table 3. Summary results from the comparison of botanical insecticides for control of *M. vitrata*, IITA-Cotonou, Oct – Dec 2003.

	Trap Threshold	Treatment Details	Thrips per20 flowers* ± SE	*M. vitrata* larvae per 20 organs* ± SE flowers	pods	Yield (Kg/ha) ± SE
1		*Hyptis*, 3 day delay, 4 sprays @ 5 days	213 ± 19	1.67 ± 0.35	1.69 ± 0.46	295.9 ± 48.4
2		Neem leaf, 3 day delay, 4 sprays @ 5 days	225 ± 13	1.22 ± 0.33	2.11 ± 0.54	190.9 ± 57.5
3		Neem seed, 3 day delay, 4 sprays@ 5 days	182 ± 14	1.11 ± 0.32	2.44 ± 0.98	285.7 ± 46.6
4	2 moths/trap	Papaya, 3 day delay, 4 sprays @ 5 days	201 ± 18	1.47 ± 0.21	1.67 ± 0.64	351.6 ± 142.4
5		Water, 3 day delay, 4 sprays @ 5 days	356 ± 23	1.47 ± 0.24	1.75 ± 0.58	324.7 ± 46.1
6		Decis, 3 day delay & 25% pods	171 ± 11	1.17 ± 0.25	0.44 ± 0.25	632.2 ± 100.0
7	crop stage	Decis @ 25% flowers & 25% pods	140 ± 15	1.31 ± 0.49	0.50 ± 0.42	583.7 ± 78.2
8	-	Untreated control – no sprays	407 ± 8	2.14 ± 0.25	2.14 ± 0.75	166.8 ± 17.7
		LSD (5%)	39	0.74	0.72	199.6

* Based on average infestation rates across all sample dates. N.B. LSDs calculated following ANOVA of respective data-sets.

Table 4. Summary results from the comparison of botanical insecticides for control of flower thrips, SARI, Tamale, Ghana, Aug – Oct 2003.

Treatment*		Pests per 20 Flowers** ± SE Thrips adults	*M. vitrata larvae*	Damage, pests per 20 Pods** ±SE *M. vitrata damage*	*M. vitrata larvae*	Yield (Kg/ha) ± SE
Decis	21-Sept & 4-Oct	70 ± 11	0.83 ± 0.40	2.83 ± 0.65	1.33 ± 0.67	717.0 ± 45.4
Neem seed	21-Sept, 29-Sept	215 ± 29	6.00 ± 1.03	9.50 ± 1.12	6.00 ± 1.39	378.5 ± 60.8
Neem leaf	& 4-Oct	222 ± 24	3.67 ± 1.15	12.00 ± 0.93	9.67 ± 1.02	288.8 ± 62.6
Papaya leaf		217 ± 32	5.17 ± 1.11	11.50 ± 1.12	10.33 ± 1.71	270.3 ± 43.5
Hyptis		229 ± 38	3.33 ± 0.67	14.50 ± 0.92	14.33 ± 0.42	255.8 ± 25.7
Control	No sprays	233 ± 22	5.50 ± 1.45	13.67 ± 1.12	13.33 ± 1.65	199.1 ± 29.3
	LSD	74	2.98	3.05	3.69	92.0

* First spray in all cases (21-Sept) was made at 25% flowers. **Based on infestation rates observed on 2-Oct for flowers and 12-Oct for pods. N.B. LSDs calculated following ANOVA of respective data-sets.

Conclusions to the on-station trials

Although pest populations were low, and no significant differences observed, in the trap threshold comparison, the fact that the 5-moth threshold was not reached did suggest that such a threshold level may be too risky – in that in the on-farm situation necessary sprays against *M. vitrata* might be made late or omitted completely.

From the two trials of botanical extracts there evidence of some weak controlling influence of these agents on thrips. The trial at IITA showed intermediate effectiveness between Decis and control treatments, while the SARI trial indicated no effect relative to the control. With broadly similar thrips numbers in both trials the difference in results might be accounted for by the greater number of applications in the IITA trial (five *versus* three), although most of these were actually targeted at *M. vitrata*.

Similarly, in the latter two trials there was a moderate influence of neem extracts on *M. vitrata* infestations: in the IITA trial neem leaf and seed extracts reduced flower infestations (but not pods), while the SARI trial showed significant control in pods with neem seed extracts, at much higher infestation levels.

Reflecting pest infestation trends, all the botanical extracts produced higher yields than their respective controls in the two trials, although only those of the neem seed extracts were significantly higher.

The active ingredient content of neem extracts, in particular, is known to vary with geographical location. While no information on this is available for the extracts used in these trials, such variation could account for slightly differing results between the trials.

Overall, these findings confirm previous indications from earlier trials conducted under the previous project phase.

<u>On-farm testing – Year 1</u>

Testing in Benin

The use of the appearance of flower buds to determine timing of applications against thrips in the T+B and T+D treatments produced differences of as much as 10 days earlier or later with respect to the application dates in FP fields, although in several instances very similar timing occurred (Table 5). In general thrips populations were moderate in all cases and similar across all three treatments with the exception of the FP treatment (i.e. no applications) in Borgou where thrips infestations were normally at least 50% higher than in the T+B or T+D treatments.

Table 5. Comparison of dates of botanical or conventional insecticide applications against cowpea flower thrips for the different treatments evaluated in on-farm threshold pheromone trap testing trials, Benin 2003.

	Date of applications to control thrips in respective treatments/villages – labelled according to the *M. vitrata* trap threshold used (all 5 fields treated in each case)				
Treat.	1 moth/trap	2 moths/trap	3 moths/trap	4 moths/trap	5 moths/trap
Mono dept.					
T+B	2 Oct	4 Oct	4 Oct	18 Oct	20 Oct
FP	12-15 Oct	No spray	5-13 Oct	10-17 Oct	21-31 Oct
T+D	2 Oct	4 Oct	4 Oct	18 Oct	20 Oct
Zou dept.					
T+B	4 Oct	11 Oct	18 Oct	3 Oct	30 Oct
FP	25 Sept	10 Oct	4-8 Oct	2-4 Oct	28-30 Oct
T+D	4 Oct	11 Oct	18 Oct	3 Oct	30 Oct
Borgou dept.					
T+B	10 Oct	6 Oct	10 Oct	8 Oct	8 Oct
FP	No sprays	No sprays	No sprays	No sprays	No sprays
T+D	10 Oct	6 Oct	10 Oct	8 Oct	8 Oct

Comparison of the dates of first sprays against *M. vitrata* in Mono and Zou departments shows that using trap thresholds of one or two moths per trap resulted in earlier or similar application dates than were chosen by farmers for the FP treatment (Table 6). Thresholds of 3 – 5 moths either produced later sprays than the FP treatment, relative to farmer practice, or meant that the threshold was not reached at all or the threshold was reached so late that the crop was already mature and applications were not useful. For these reasons no sprays were made in the T&B treatment for the 4- and 5-moth threshold villages in Mono, and for the 3-, 4- and 5-moth threshold villages in Borgou. For the same reason in the same villages no initial spray was made in the T&D treated fields – only the spray timed for 25% podding was made.

Considering infestations of *M. vitrata*, there were few strong differences between the three treatments and in Mono infestations were relatively low. There was some evidence of a trend of effectiveness in the order T+D > FP > T+B with respect to infestations in flowers and for those in pods the FP treatment was clearly better in the 1-moth threshold village in Zou and the 3-moth threshold village in Mono (Figs. 1 and 2). However, the 4- and 5-moth villages for both departments showed lower infestations in all treatments, so this made comparisons difficult. In Borgou, where the FP treatment was unsprayed, it was clear that infestations in pods (Fig. 3) and flowers were highest in this treatment, while the T+D treatment was perhaps most effective.

Table 6. Comparison of dates of botanical or conventional insecticide applications against *M. vitrata* for the different treatments evaluated in on-farm threshold pheromone trap testing trials, Benin 2003.

	Trap threshold used in respective village with dates of first and subsequent sprays (all 5 fields treated on a given date unless otherwise indicated)									
Treat.	1 moth/trap		2 moths/trap		3 moths/trap		4 moths/trap		5 moths/trap	
	1st spray	2nd and later	1st spray	2nd and later	1st spray	2nd and later	1st spray	2nd and later	1st spray	2nd and later
Mono dept.										
T+B[A]	4 Oct	3 sprays	6 Oct	3 sprays	2 Nov	1 spray	No spray – threshold 7 Nov		Threshold not reached, no sprays	
FP	19-22 Oct	24-30 Oct & 30 Oct – 5 Nov	5 Oct	21-22 Oct (2 fields)	15-21 Oct	28-30 Oct & 1 Nov (1 field)	25 Oct (4 fields)	-	21-31 Oct	28 Oct – 2 Nov (2 fields)
T+D[B]	4 Oct	24 Oct	6 Oct	22 Oct	2 Nov	27 Oct	No spray - threshold 7 Nov	24 Oct	No threshold	1 Nov
Zou dept.										
T+B[A]	3 Oct	3 sprays	12 Oct	3 sprays	28 Oct	3 sprays	17 Oct	3 sprays	16 Nov	1 spray
FP	2 Oct	15 Oct	19-22 Oct	1-3 Nov	9-16 Oct	16-28 Oct	15-17 Oct	-	11-12 Nov	-
T+D[B]	3 Oct	10 Oct	12 Oct	20 Oct	28 Oct	4 Nov	17 Oct	20 Oct	16 Nov	10 Nov
Borgou dept.										
T+B[A]	13 Oct	3 sprays	10 Oct	3 sprays	No spray – threshold 31 Oct		No spray – threshold 24 Oct		No spray – threshold 27 Oct	
FP[C]	No sprays		No sprays		No sprays		No sprays		No sprays	
T+D[B]	13 Oct	22 Oct	10 Oct	22 Oct	No spray, threshold 31 Oct	24 Oct	No spray, threshold 24 Oct	19 Oct	No spray, threshold 27 Oct	17 Oct

[A]For the T+B treatment, timing of the first sprays was determined by the trap threshold; the second and any subsequent sprays were made at successive 5 day intervals after that.. [B]For the T+D treatment, timing of the first spray was determined by trap threshold; that listed second was always that made at 25% podding (in some cases this occurred *before* the trap threshold spray). [C]In Borgou, few farmers normally attempt control of cowpea pests, hence the FP treatment here involved no sprays.

Two further striking observations were that aphid infestations (early season) and pod-sucking bugs (late season) were almost entirely suppressed in the T&D treatment in all villages of each of the three project locations, whereas moderate and roughly equal infestation levels of both pests were noted in the FP and T&B treatments. This strongly suggests that both the latter two treatments are had little impact on these pests.

Figure 1. Cumulative *M. vitrata* pod infestations in on-farm testing of pheromone trap threshold, Zou, Benin 2003 (error bars indicate standard errors).

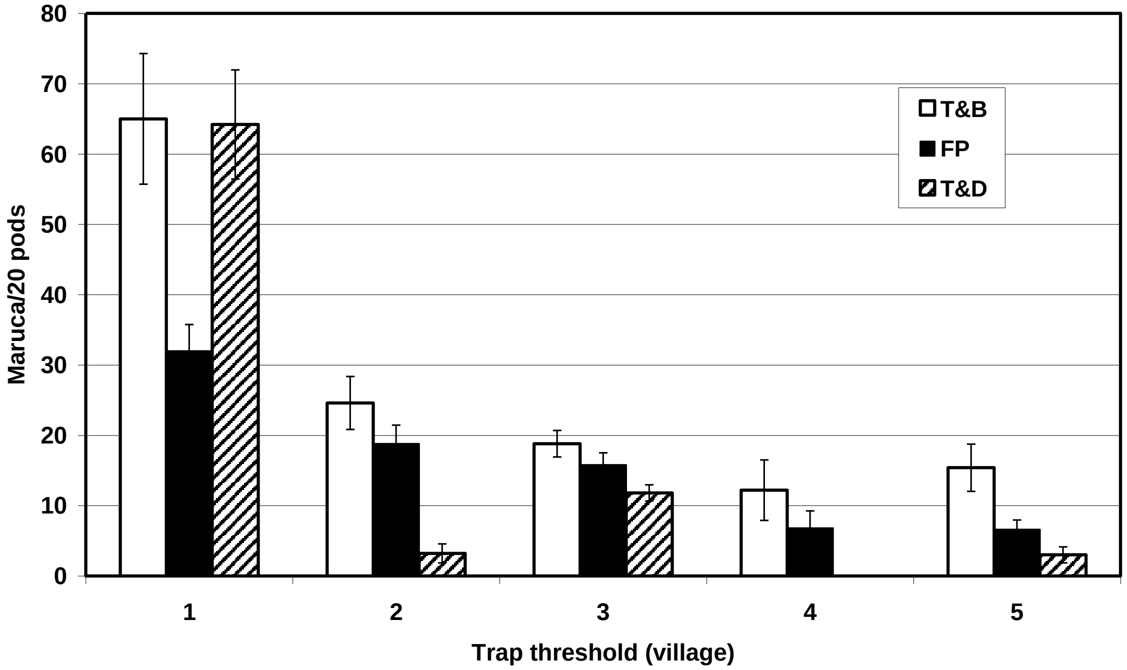


Figure 2. Cumulative *M. vitrata* pod infestations in on-farm testing of pheromone trap threshold, Mono, Benin 2003 (error bars indicate standard errors).

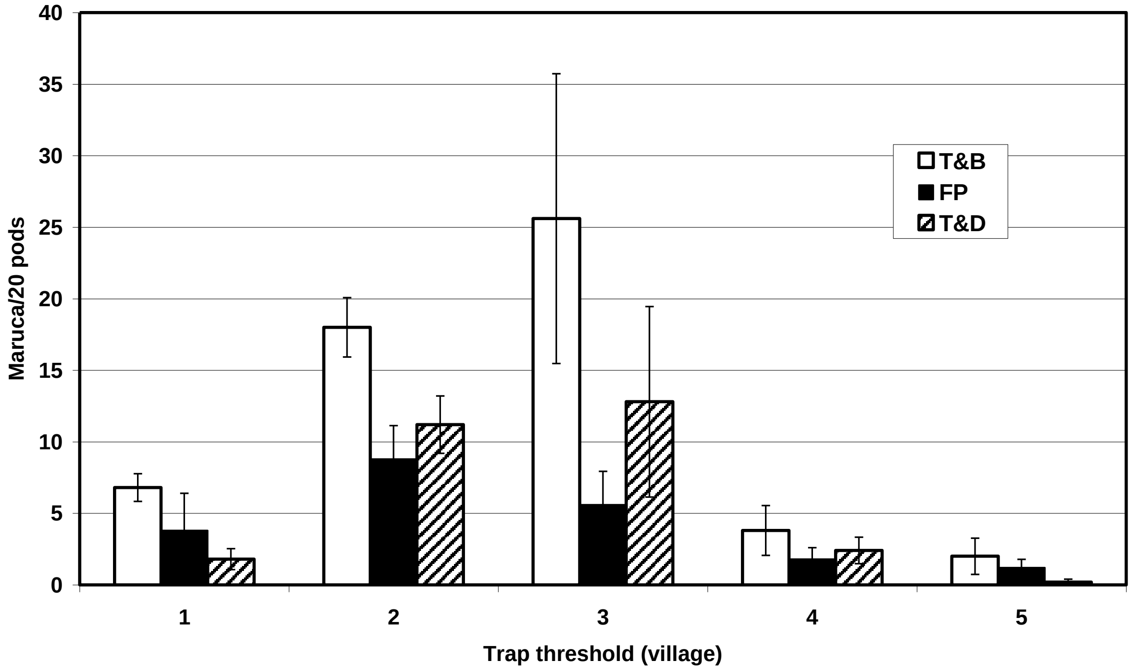
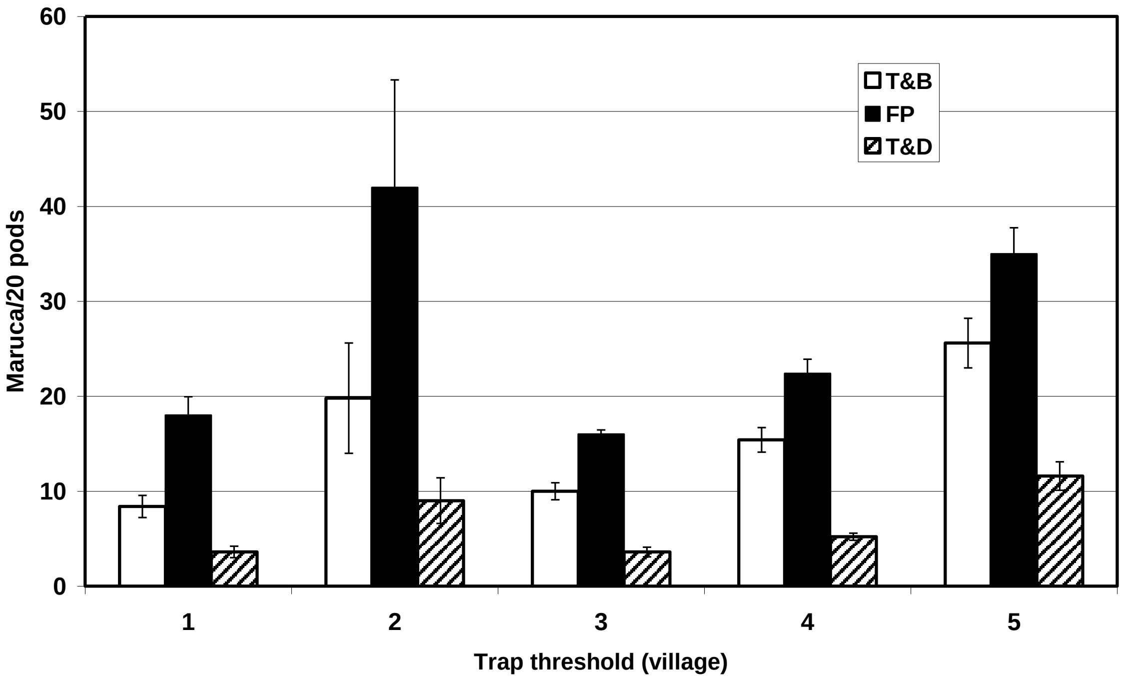


Figure 3. Cumulative *M. vitrata* pod infestations in on-farm testing of pheromone trap threshold, Borgou, Benin 2003 (error bars indicate standard errors).



Yields in Mono department were quite similar across the three treatments in all villages and no statistically significant differences were found (Table 7). In Zou there was evidence that the T&B treated fields produced lower yields than in the T&D and FP fields and this trend was significant in the villages using trap thresholds of 1-, 2- and 4-moths per trap. However, in three villages, including those with the 1- and 2- moth thresholds, unusually high yield were observed in all treatments. This was believed to be due to systematic errors by the supervising technician in extrapolating from harvested sub-samples. Although the relative differences should be valid, unfortunately the original data and calculations were lost and cannot be corrected. In Borgou, it was clear that the FP (no spray) treatment produced inferior yields to those of thee T&B and T&D treatments (which were similar). This trend was significant in the 1- and 3- moth thresholds.

Following earlier FFS carried out by PRONAF under the auspices of the project (or its earlier phase) feedback was obtained from farmers to the effect that they would like to receive certificates of participation in the FFS. Such certificates are highly valued by the farmers and appear to raise their esteem with their local community, as they are reckoned to demonstrate the acquisition of improved knowledge. The PL and IITA and PRONAF staff decided to issue these certificates to participating farmers for the 2003 and later seasons as they judged that they would enhance attendance and attention to the subject matter of the FFS. A sample certificate is given at Annex 16. The citation indicates that the participant:

> "… has followed with assiduousness the training session organised a Oké-okounou, in the Département des Collines (Zou), by the cowpea project for Africa (PRONAF) and the National Institute for Agricultural Research (INRAB) from 21 August to 28 November 2003 on the production and integrated protection of cowpea in the context of a 'Farmers Field School'. In witness whereof this certificate is presented to him to rightly serve and value."

Table 7. Comparison of yields for the different treatments evaluated in on-farm threshold pheromone trap testing trials, Benin 2003.

		Mono			Zou			Borgou		
Threshold	Treatment	Village	Yield - Kg/ha	SE	Village	Yield - Kg/ha	SE	Village	Yield - Kg/ha	SE
1	T&B		490	71		1298 a	177		460 b	60
1	T&D	Toïmey	450	72	Dani*	2164 b	175	Borodarou	471 b	25
1	FP		469	48		2148 b	174		186 a	7
2	T&B		468	28		1348 a	95		346	54
2	T&D	Fantodjihoué	450	41	Ayekofowin*	2070 b	100	Sinanwongourou	495	44
2	FP		421	38		2852 c	103		299	80
3	T&B		462	78		1373	210		400 b	28
3	T&D	Avegamè	510	80	Bethel*	1860	193	Padé	393 b	15
3	FP		532	73		1720	285		219 a	17
4	T&B		508	42		688 a	67		350	116
4	T&D	Tchopkohoué	781	154	Okeokounou	530 a	72	Kassakou 1	397	64
4	FP		473	72		945 b	35		252	82
5	T&B		822	253		946	17		376	12
5	T&D	Ahohoué	817	252	Logbodjin	910	44	Kassakou 2	371	48
5	FP		678	216		940	27		379	19

Within the data group for a single village means followed by a common letter are not significantly different ($P > 0.05$, T-test); where no letters are given no significant differences exist. *Yields in these three villages are unusually high in all treatments. This is due to systematic errors by the supervising technician in extrapolating whole-field yields from the sub-samples taken. Unfortunately, original data were subsequently lost, but the relative differences should be valid.

Testing in Ghana

At Chehoyi, all four fields had been sprayed twice with conventional insecticides against aphids prior to the approach of SARI to the farmers in early September. Due to this no application of botanicals against thrips was made at the flower-bud stage in the IPM plots (as envisaged in the original protocol), although some thrips damage was suffered. Trap catches of *M. vitrata* were almost zero, the trap threshold for botanicals was not reached and no sprays were undertaken against this pest in the T+B plots. Larval *M. vitrata* infestations were minimal (possibly due to the late sowing), so no applications were made against this pest in FP plots. Nor was the planned spray against *M. vitrata* at 25% podding made. Although some pest infestation and yield data were obtained, given the findings noted above these were not considered to be useful and results from Chehoyi are not discussed further in this report.

In general discussions with Dr Asante of SARI it was determined that farmers in the district around Tamale were somewhat reluctant to devote fields to an FFS-style trial unless the costs of a number of inputs were met by the project. Furthermore, cotton insecticides were quite freely available in the region, on beneficial terms to farmers. Their availability for use on cowpea acted as a disincentive for farmer involvement in developing IPM strategies. These points clearly have adverse effects on the sustainability of both the project approach and the technologies being developed, thus it was not judged appropriate to continue working in the region the following year.

At Ejura, overseen by CRI, the thrips treatment with papaya leaf extracts was made on 9 October in T+B plots, whereas a variety of pyrethroids were applied in the FP plots on dates varying from 2 -19 October. In the T+B plots the first *M. vitrata* catches were seen on 15 October and the trap threshold was reached on 27 October; thus the first spray with neem seed extracts was thus made on 1 November, with a second on 12 November. Total catches in the six T+B plots reached 50 throughout the season[4]. Farmers in the FP plots all chose to apply three times with pyrethroids, with the first sprays taking place rather earlier, on dates between 14 and 26 October. Thrips and aphid infestations were insignificant but *M. vitrata* infestations in the T+B plots were substantially higher in flowers (means 5 – 7 against 1 – 2 larvae/20 flowers) and pods (means 2 – 7 against 0.7 – 4 larvae/20 pods) than in FP plots. Some pod bugs were noted (0 – 2 bugs/5 plants) but numbers did not differ between treatments. Despite the difference in *M. vitrata* infestations there was no significant difference the respective yields of the two plots ($P > 0.05$, T-test) (Table 8).

Table 8. Mean yields for treatments in the on-farm testing at Ejura, 2003.

Treatment	Mean yield (g per sample quadrat)	SE
T+B	200.2	33.4
FP	180.9	27.4

A report provided by CRI staff is given as Annex 3. The report indicates that the farmers reacted very positively towards both the use of pheromone traps and botanical pesticides:

“The farmers were quite excited about the results they obtained at the end of the project. In general they appreciated the idea of the use of thresholds for monitoring insect infestation and application of pesticides. Although it appeared this was not the first time they were

[4] At least seven captures were also made in un-baited traps placed in the FP plots. The reason for this high rate in unclear, but might relate to their proximity to normal, baited traps or it could indicate a high adult population.

being exposed to the idea of thresholds, this was the one practical demonstration of its use that they understood very well. The use of the pheromone traps appeared to have really given them the best time frame within which to apply their pest management interventions. Indeed this was the first time the idea of integration of pest management had been given a meaning in their case. The high point was the fact that the use of the botanical extracts (papaya and neem) gave as good harvest as the farmers practice where noxious insecticides were used, although the numbers of insects were higher on the fields where only pheromone traps and botanical extracts were applied…

"…They were pleasantly surprised that they could achieve so much by way of pest management through the use of common botanicals they hitherto fore had taken for granted. Now their frustration is where to obtain the pheromone."

In the GOAN managed site at Derma very low populations of all pest species were recorded throughout the trial, with the possible exception of aphids in some plots. *M. vitrata* catches totalled only three (the first two being on 10 November) during the whole cropping season and larvae seen in flowers and pods were negligible. In the T+B plots, in the absence of attainment of the trap threshold botanicals were applied three times against *M. vitrata* on the 4, 18 and 25 November; in the FP plots Thionex was sprayed on the same dates. Although mean yields in the T+B plots were substantially higher than in the FP plots, this difference was not statistically significant ($P > 0.05$, T-test) due to large variability in individual values (Table 9).

Table 9. Mean yields for treatments in the FFS testing at Derma, 2003.

Treatment	Mean yield (Kg/plot)	SE
T+B	17.2	3.8
FP	8.7	2.8

A short report of activities provided by GOAN is given at Annex 4. The report does not record the attitude of the participating farmers to the trials, but this feedback was provided by surveys conducted under the next section.

<u>Assessment of farmers' views concerning practical aspects of traps and botanicals – year 1</u>

Provisional survey results were initially summarised in two reports by IITA staff, one for all sites except Borgou department in Benin (Annex 6c) and the other for Borgou alone (Annex 6d). Subsequently, a fuller report was produced for all sites (Annex 6a). However, following criticism from the Project Leader that the important distinction between previous FFS participants and non-participants had not been made in the analysis of results, a supplementary report was then written to correct this omission (Annex 6b), although this does not include results from Borgou. Key findings from this were as follows.

Among previous FFS or on-farm trial participants in Benin and Ghana, more than 90% considered that the pheromone traps could trap and control *M. vitrata*, with around additionally noting advantages of economy. Among non-participants 11% and 19% of respondents reported having used the traps – suggesting some informal transmission of the technology, although it is not clear in this case where fresh lures were obtained (if any).

In Ghana, despite the detailed explanations given of the mode of trap use by project and/or partner organisation staff, only 22% of previous participant farmers fully understood that role – as a warning tool – and 12% believed the traps principal mode of action was through the direct killing effect of moth captures.

A range of constraints to trap use were mentioned by participant farmers, but the principal ones were the lack of availability of the trap materials and lures, noted by 67% and 78% in Ghana and Benin, respectively. In Ghana 18% also mentioned the high cost of trap materials or components as a difficulty. Beyond the obvious suggestion of remedying this situation 65% of participant farmers in Benin made the suggestion of providing further training on trap use and production. This request was taken into account later, in particular in developing and providing poster and leaflet instructions on trap use to supplement verbal and hands-on training.

Knowledge and recognition of the different life stages of *M. vitrata* was greater among previous FFS or trial participants than among non-participants, suggesting that such involvement had a useful training role. Furthermore use of botanical and recommended conventional pesticides was greater, whilst use of non-recommended (e.g. cotton) insecticides was lower, among participants.

Output 2: Uptake increased for pheromone traps and best package of botanical/conventional insecticides for controlling the pest complex

<u>On-farm scaling-up trials in Year 2</u>

Trials in Benin

The treatments chosen by farmers for both the Traps and FP treatments in each village are summarised in Table 10 and further details on the conventional insecticides mentioned are tabulated in Table 11.

Table 10 shows that in Zou and Mono departments, given a free choice, farmers generally chose conventional pesticides (recommended or otherwise), although botanical pesticides formed part of the Traps treatment in three of the six villages, as well as being included in the FP treatment in three cases. In each case 2 – 4 sprays were applied, although IITA recommendations indicate that two sprays of a recommended insecticide should be adequate for full pest control. There was relatively little indication of a reduced number of sprays in the Traps treatment, but use of the trap threshold did result in substantial differences in the dates of first applications between the Traps and FP treatment in five of the villages (see last column of Table 10).

In Borgou, the Traps treatment involved only botanical pesticides (4 – 6 sprays) in each of the five villages, whereas conventional insecticides (up to four sprays), recommended or not, were used in most of the FP treatments. In this case noticeable differences in the dates of first spray only arose in two of the villages.

Table 10. Summary of insecticide treatments used in on-farm scaling-up trials in Benin, 2004

Dept & village	Treat.	Treatments against Thrips		Treatments against *M. vitrata*		
		Insecticide(s)	No. sprays	Insecticide(s)	No. sprays	Date 1st spray*
Zou (PRONAF)						
Oké-owo	Traps	Orthène	0 – 1	Orthène	3	24 Oct
	FP	cotton insecticide*	1	cotton insecticide*	3 – 4	23 – 24 Oct
Oké-okounou	Traps	Neem or *Hyptis* leaf	1	Orthène + neem leaf	2 – 3	28 Oct
	FP	Orthène	1	Orthène	2 – 3	18 Oct – 7 Nov
Rongbondjin	Traps	Orthène	1	Orthène	3	17 Oct
	FP	*Hyptis* leaf	1	Curacon or Conquest	4	16 – 22 Oct
Mono (PRONAF)						
Glolihoué	Traps	Orthène, neem or papaya leaf	1	Orthène, neem or papaya leaf	2 – 3	26 Oct
	FP	cotton insecticide*	1	Calfos or Profenofos	1 – 3	11 – 21 Oct
Koyihoué	Traps	papaya leaf	1	Orthène + Neem leaf	3	18 Oct
	FP	neem leaf	1	Cypercal, sherpas or deltaphos	2 – 3	25 – 28 Oct
Domi	Traps	Orthène	1	Orthène	2 – 3	2 Nov
	FP	cotton insecticide* or *Hyptis* leaf	1	cotton insecticide* or *Hyptis* leaf	2 – 4	26 Sep – 18 Oct
Borgou (OBEPAB)						
Tissarou	Traps	papaya leaf	1	neem leaf	5	27 Sep
	FP	-	0	Decis or cotton insecticide*	1 – 2	19 Sep – 1 Oct
Padè	Traps	papaya leaf	1	neem leaf	4	26 Sep
	FP	-	0	cotton insecticide*	1 – 2	15 – 27 Sep
Kassakou 1	Traps	papaya leaf	1	neem leaf	5	24 Sep
	FP	-	0	cotton insecticide* (1 field only)	0 - 3	27 Sep
Borodarou	Traps	papaya leaf	1	neem leaf	6	27 Sep
	FP	-	0	Endosulfan or Cotalm D	0 - 1	27 Sep – 4 Oct
Sinanwongourou	Traps	papaya leaf	1	neem leaf	5	27 Sep
	FP	Kinikini	0	Kinikini	3 – 4	27 Sep

* For the 'Traps' treatment the date of the first spray against *M. vitrata* was 2 – 3 days after the trap threshold was reached in all cases. ** Unspecified.

Table 11. Summary of insecticides used in on-farm scaling-up trials in Benin and Ghana, 2004**.**

Name	Insecticide	Class
Orthène*	Acephate	OP
Curacon, Calfos	Profenofos	OP
Conquest	?	?
Cypercal*	Cypermethrin + Profenofos	Pyrethroid + OP
Sherpas*	Cypermethrin + Dimethoate	Pyrethroid + OP
Deltaphos	Deltamethrin + Triazophos	Pyrethroid + OP
Decis*	Deltamethrin	Pyrethroid
-	Endosulfan	Organochlorine
Cotalm D	Cypermethrin + Dimethoate	Pyrethroid + OP
Kinikini	Cyfluthrine + Malathion	Pyrethroid + OP
Karate	Cyhalothrin	Pyrethroid
Kuzitrin	?	?
Cymethoate	Cypermethrin + Dimethoate	Pyrethroid + OP
Pawa	?	?
Chemothrin	?	Pyrethroid?

* Insecticides normally recommended for use on cowpea in Benin

Relatively few significant differences between the treatments were observed in infestation levels (Table 12) and yield differences were seen in only three villages, all in Borgou. Thus overall, despite some differences in dates of first sprays against *M. vitrata*, the Traps treatment – albeit constituted differently in Borgou as compared Zou and Mono – produced similar results to conventional farmer practice.

Table 12. Summary of significant infestation and yield differences* in the on-farm scaling-up trials in Benin, 2004.

Dept & village	*M. vitrata* infestations		Pod sucking bugs	Yield
	Flowers	Pods		
Zou				
Oké-owo	**Traps**	ns	ns	ns
Oké-okounou	ns	**Traps**	ns	ns
Rongbondjin	**FP**	ns	ns	ns
Mono				
Glolihoué	ns	ns	ns	ns
Koyihoué	ns	ns	ns	ns
Domi	ns	ns	ns	ns
Borgou				
Tissarou	ns	**Traps**	**Traps**	ns
Padè	ns	ns	ns	ns
Kassakou 1	**FP**	**FP**	ns	**Traps**
Borodarou	ns	ns	ns	**FP**
Sinanwongourou	**FP**	**FP**	ns	**FP**

*'Traps' indicates the relevant value was significantly higher ($P < 0.05$, t-test) for the treatment involving traps than for the FP treatment; 'FP' indicates the converse. N.B. there were no significant differences at any site in respect of thrips or aphids.

Trials in Ghana

The treatments chosen by farmers for both the Traps and FP treatments in each village are summarised in Table 13 and further details on the conventional insecticides mentioned are tabulated in Table 11.

In Ashanti region, in the two villages overseen by CRI, farmers chose only botanical pesticides for controlling insect pests in the 'Traps' plots, while the farmer practice plots were treated with a range of conventional insecticides. In each case 3 – 5 (usually four) applications of the respective treatment were given. Substantial numbers of moths were trapped in traps around the two villages and the trap threshold was reached in both cases. However, only in one village did it appear to be the trigger for the first application of botanical pesticides; in the other, for unknown reasons, there was a two week delay between attainment of the threshold and the first application.

In Brong-Ahafo, in the GOAN villages, botanicals were also used exclusively in the 'Traps' fields with recommended conventional pesticides in the FP plots (four sprays in each case). However, as in 2003, trap catches were close to zero and the threshold of two moths per trap was never reached. Hence decisions on pesticide applications were made without reference to traps.

No significant differences between the treatments were observed in respect of infestation levels or yields in any of the four villages. Thus the Traps treatment (utilising only botanical applications) produced similar results to farmer practice involving generally equal numbers of sprays.

Short reports from CRI and GOAN of the 2004 field activities are reproduced as Annexes 8 and 9. The GOAN report noted earlier conclusions concerning the tediousness of botanical pesticide preparation and recommended an earlier start to similar programmes in future, in order to avoid difficulties in land preparation. The CRI report concluded positively, with:

> "The trials in the chosen locations appear to have been very successful. Participant farmers and their associates have shown high level of confidence in the effectiveness of the technology and are willing to adopt it. Adoption on a long term basis will however be achieved only if the concerns of farmers about the availability of the pheromones and good quality botanical formulations that ensure their effectiveness against major cowpea pest through out the year are addressed."

Table 13. Summary of insecticide treatments used in on-farm scaling-up trials in Ghana, 2004 (sprays applied to all six fields unless indicated otherwise).

			1st spray		**2nd spray**		**3rd spray**		**4th spray**		**5th spray**	
Dept & village	**Treat.**	**Thresh-old**	insecticides	dates	insecticides	dates	insecticides	dates	insecticides	dates	insecticides	dates
Ashanti (CRI)												
Dromankuma-Bonyon	Traps	22 Oct	Papaya leaf	23 Oct	Neem seed	30 Oct – 19 Nov	Neem seed	12 – 21 Nov	Neem seed	2 Dec (3 fields)	-	-
	FP	-	Cymethoate Karate, Cypercal	16 – 30 Oct	Cymethoate Kuzitrin, Cypercal	23 Oct – 7 Nov	Cymethoate Kuzitrin, Cypercal	31 Oct – 14 Nov	Cymethoate Cypercal	9 – 20 Nov (5 fields)	-	-
Hiawoanwu	Traps	13 Oct	Papaya leaf	26 – 27 Oct	Neem seed	5 Nov	Neem seed	10 Nov	Neem seed	19 Nov (3 fields)	-	-
	FP	-	Pawa, Cypercal, Chemothrin	18 - 23 Oct	Pawa, Cypercal, Kuzitrin	25 – 30 Oct	Cymethoate Cypercal, Kuzitrin	1 – 6 Nov	Cymethoate Cypercal, Kuzitrin	8 – 15 Nov	As 4th	17 – 22 Nov (3 fields)
Brong-Ahafo (GOAN)												
Derma-Ankaase	Traps	None	Papaya leaf, Need seed, leaf	25 Oct	Papaya leaf, Need seed, leaf	4 Nov	Papaya leaf, Need seed, leaf	14 Nov	Papaya leaf, Need seed, leaf	21 Nov	-	-
	FP	-	Decis	7 – 24 Oct	Decis	14 – 31 Oct	Decis	22 Oct – 11 Nov	Decis	1 – 21 Nov	-	-
Derma-Tougyakrom	Traps	None	Papaya leaf, Need seed, leaf	23 Oct	Papaya leaf, Need seed, leaf	2 Nov	Papaya leaf, Need seed, leaf	12 Nov	Papaya leaf, Need seed, leaf	19 Nov	-	-
	FP	-	Karate	8 - 14 Oct	Karate	18 - 24 Oct	Karate	28 Oct - 4 Nov	Karate	5 - 12 Nov	-	-

* unspecified.

Assessment of potential for transmission of technologies from participating to non-participating farmers – year 2

The report for this activity (in French) is given at Annex 11.

The PRONAF project (which includes government research and extension organisations) and several other NGOs have operated in the survey areas and it was thus not surprising to find that nearly all farmers in Benin reported having benefited from information on new agricultural technologies. PRONAF was cited as a source by 88 – 98% of farmers across the three departments. Other farmers were also noted as a source by 73% of farmers in Mono, but the proportion was much less in Zou (27%) and Borgou (8%). In Borgou 98% (all but one) of farmers reported also receiving information from an NGO (presumably OBEPAB). In Ghana (Brong Ahafo and Ashanti only), some 75% of farmers said they had benefited from new technologies. A major source (65%) were various NGOs operating in the area, but 78% also reported speaking of new technologies with other farmers. In Benin such farmer-to-farmer transmission was almost completely dominated by discussions between close relatives, whilst in Ghana neighbours were the most important single source (42%), though relatives (28%) and friends (25%) were also significant.

In both countries radio, television and places of religious association were scarcely mentioned as sources of information. Strangely, 9% in Ghana reported the internet as a source of agricultural information (although small internet cafés are common in the major towns).

In comparison to the figures above, preferred sources of information were given as in Table 14, below.

Table 14. Different methods of technology knowledge diffusion suggested by cowpea farmers in Bénin and Ghana.

Methods of diffusion	% of farmers BENIN (n=160)	 Ghana (n=124)
Local radio	9	18
Farmer-to-farmer groups	71	50
FFS-style training	30	20
Places of worship	30	11

Logit analysis showed that the three key factors positively affecting the probability of farmer-to-farmer diffusion of technological information were literacy or level of education, membership of a local farming or village association and previous FFS training.

Dissemination of recommendations and trap/botanicals package

English versions of the two posters (for farmers) and training leaflets (for trainers and extensionists) are given as Annexes 12, 13 and 14, respectively.

In Ghana, CRI had 100 copies of each of the posters printed in Ashanti-Twi, the dominant language of southern and central Ghana. One thousand copies of the training leaflet were also printed in English. Distribution was among the four project villages, to Ministry of Food and Agriculture and extension service staff, as well as to GOAN. Further copies are being held for later distribution to possible new locations.

In Benin, although translations were made of the posters into Fon, Adja and Idatcha for distribution in the centre and south of the country, and into Dendi and Bariba for the north, these were not printed due to the excessive costs involved (a minimum print-run of 300 of each poster/translation was demanded by the print company). A compromise was thus reached to print and distribute only French language versions (French being the most universally spoken and understood language, nationwide) and IITA had printed 300 copies of each of the posters and 500 copies of the tri-fold leaflet.

Output 3: Local/regional systems of manufacture and distribution of pheromone traps and lures, and of botanical insecticides, developed on a pilot-scale

<u>Assessment of social and economic feasibility of supply</u>

Assessment of farmers' willingness to pay for cowpea technologies

As previously noted, the assessment of farmers' willingness to pay for pheromone traps, lures and botanical pesticides was covered as part of the "Assessment of farmers' views concerning practical aspects of traps and botanicals", carried out under Output 1, the relevant reports for which are given at Annexes 6a – d.

The survey gathered estimates from farmers concerning the prices they would be willing to pay for traps and lures. Unfortunately, the results presented do not distinguish between figures provided by participant and non-participant farmers. Although there was substantial variability in the figures, in Benin the mean suggested price for traps was of the order of US$5 and for lures the mean figure was $0.80. In Ghana there was a substantial difference in the figures given by farmers in the two villages – in Derma the mean figure for traps was $1.12, whilst in Ejura it was $3.63; in both villages suggested prices for the lures were slightly less than $1. These figures compare with previously estimated costs of fabrication, including lures, in Benin of CFA 2230 = $4.2 (FTR for previous project phase, R7441) and it should be noted that prices for trap materials are higher in Benin as all such materials are imported into Benin, whereas most are manufactured, and are therefore cheaper, in Ghana. Provisionally therefore, it would seem that many farmers would be willing to pay more than the estimated costs of production.

Assessment of the preferred mechanisms of supply

The assessment of the preferred mechanism(s) of supply of the new technologies, was carried out during year 2 under the "Assessment of potential for transmission of technologies from participating to non-participating farmers" as part of Output 2 and the relevant report is at Annex 11. This shows that as regards current local providers of agricultural inputs such as seeds, fertilisers and pesticides, three main sources reported in Benin were village (42%) and local farmer (19%) associations, together with outlets of AGROP (the national network of farmer associations). These distribute products originally coming from state or private sector sources. In Ghana the main sources cited were a variety of local NGOs (62% of farmers), with many noting GOAN in particular (although this may not be typical, given that GOAN do not work in many villages), with small numbers mentioning cowpea and maize growers' associations. Local commercial vendors, which certainly exist, were not mentioned in Ghana which suggests that the figures in this respect are not typical of the wider market. In both countries, agricultural inputs are nearly always bought on credit, with payment made after harvest. In Benin many products (aimed at the cotton sector, but frequently used on other crops) are acquired at state-subsidised prices. A key finding was that in general farmers wished to purchase the new technologies, such as pheromone traps, lures and botanical pesticides, through the same, existing providers as noted above.

Economic profitability analysis of the technologies

The report of the study on the profitability analysis of the use of various cowpea technologies is shown at Annex 16.

The study considered a total of 18 production systems, but six of the most representative, including two which incorporated pheromone traps and botanical pesticides, were discussed in detail. From the results, it was concluded that the financial profitability[5] of cowpea production depended on three key factors: firstly the type of variety cultivated (local or improved), secondly the phytosanitary method, fertilizer and the type of labour (hired or family) used and thirdly the output price on the market. Indeed, the type of variety cultivated, and the level of the intensification (phytosanitary method, fertilizer) determined the yield and hence the value according to market price.

The improved varieties possessed a higher yield potential than the local variety and this effect dominated much of the analysis. The type of labour was the key element for the production cost and the use of the family labour reduced financially the production cost. Finally, the output price played an important role for producers to make their activity profitable. But this price was not constant, it fluctuated. When the price was lower many production systems suffered reduced profits or were not profitable at all. Conversely, when the price was higher profitability increased across all production systems.

Two production systems stood out as the most financially profitable even with low output prices. These were:

- Improved variety KVX 396-18 + Cotton Insecticides + Farmers' Practices
- Improved variety KVX 61-1 + Cotton Insecticides + Farmers' Practices

Cowpea production was profitable for small farmers under the systems in which farmers had adopted at least one new technology particularly the improved variety (with high yield). Cotton insecticides probably assisted financial profitability due to their availability at subsidised prices, compared to recommended pesticides. The use of pheromone traps and botanicals was associated only with local, unimproved varieties and was only profitable at high (CFA 450) market output prices. None of the production systems studied combined traps and botanicals with improved varieties. Clearly however, the adoption of pheromone traps and botanicals would be more financially profitable in cowpea systems with improved varieties having high yield potential. In this regard it is significant that pheromone traps only accounted for 4% of the total production cost in IPM production systems.

Economic analysis of farming systems of cowpea production showed that four systems of cowpea production were socially profitable[6]. These systems were:

- Improved variety KVX 396-18 + Cotton Insecticides + Farmers' Practices
- Improved variety KVX 61-1 + Cotton Insecticides + Farmers' Practices
- Local variety Mahouna + Sherphos + Cypercal + Farmers' Practices + Fertilizer NPK
- Local variety Noussovi + Deltaphos + Farmers' Practices + Fertilizer NPK

The environmental and health gains linked to pheromone traps and botanicals were not taken into account in this social profitability analysis. If these gains are computed, the comparative advantage of such cowpea technologies will be very much higher. Note that it's difficult to take into account these gains. As with financial profit, the adoption of pheromone traps and botanicals would be more socially profitable in cowpea systems with variety that had a high potential of yield such improved variety.

[5] Private or financial profitability is defined as the difference between observed revenue and costs. As an economic measure, it demonstrates the competitiveness of the agricultural system, given current technologies, prices for inputs and outputs, and policy.

[6] Social profits measure efficiency and provide a measure of comparative advantage. In addition, comparison of private and social profits provides a measure of efficiency. A positive social profit indicates that the country uses scarce resources efficiently and has a static comparative advantage in the production of that commodity at the margin. Similarly, negative social profits suggest that the sector is wasting resources, which could have been utilized more efficiently in some other sector.

One recommendation to arise from the study was that to be more financially profitable for small farmers, pheromone traps and botanical insecticides need to be introduced in improved systems (i.e. with new varieties having high yield potential). Pheromone traps would contribute substantially to minimizing the cost of phytosanitary treatments and thus could increase the profit of small farmers.

Output 4: Re-examination of the pheromone blend of *Maruca* to improve its effectiveness in Nigeria and Burkina Faso

Results for the multi-site pheromone blend trials are shown in Table 15.

Catches at Kano, Nigeria and at Tamale in Ghana were too low for formal statistical analysis but showed no obvious variation among the four blends tested. Similar low catches have been observed at both locations previously (with the standard blend). These results confirm these observations and indicate that no beneficial effect was obtained by addition of the E10-16:OH compound to the blend.

At the IITA station near Cotonou catches were only slightly higher, although they were just sufficient for ANOVA to be carried out in respect of the males. Results confirmed the original finding, several years ago, of the superiority of the 'standard' 3-component blend over the EE-10,12-16:Ald main component alone. In this case the addition of the E10-16:OH compound had no effect, positive or negative, on catches.

In contrast to the original blend experiments conducted at IITA, the trial at Savè found that all four blends attracted similar numbers of both males and females, while that at Bobo-Dioulasso (Burkina Faso) actually found that the EE-10,12-16:Ald main component alone produced significantly higher catches than the 'standard' blend or either blend including the novel E10-16:OH compound. Taken together the results from Bobo-Dioulasso suggest that E10-16:OH actually inhibited catches, whereas the compound had a neutral effect at IITA-Cotonou.

As has been observed at trapping locations in northern Benin, the catches at Bobo-Dioulasso showed a marked predominance of males over females (M:F ratio = 19.4), compared to other locations were the ratio was much closer to one.

In summary, the results highlighted geographic variability in pheromone blend response over a large part of West Africa, while unfortunately the putative new component did not improve catches in areas where poor results have been obtained previously – at least in the blend proportions used in this case. The trial did serve to indicate an effective 'blend' - EE-10,12-16:Ald – for use in Burkina, an area where hitherto no trapping activities have taken place.

Table 15. Mean catches per trap during the pheromone blend tests at five sites in West Africa in 2004 (5 replicates; results for total catches over entire trapping period).

Site	Treatment (blend)	Females ± SE	Males ± SE
Bobo-Dioulasso (Burkina Faso)	1 'Standard'	0.60 ± 0.24	13.20 ± 2.52 B
	2 EE-10,12-16:Ald	2.00 ± 1.26	40.00 ± 6.96 A
	3 EE-10,12-16:Ald + E10-16:OH	1.00 ± 0.77	12.40 ± 4.88 B
	4 'Standard' + E10-16:OH	0.40 ± 0.40	11.40 ± 2.54 B
	5 control	0.00 ± 0.00	0.60 ± 0.40 C
	overall M:F ratio 19.4		
Kano (Nigeria)	1 'Standard'	0.00 ± 0.00	0.60 ± 0.24
	2 EE-10,12-16:Ald	0.40 ± 0.24	0.20 ± 0.20
	3 EE-10,12-16:Ald + E10-16:OH	0.20 ± 0.20	0.20 ± 0.20
	4 'Standard' + E10-16:OH	0.20 ± 0.20	0.40 ± 0.40
	5 control	0.20 ± 0.20	0.00 ± 0.00
	overall M:F ratio 1.4		
Savè (Benin)	1 'Standard'	12.20 ± 1.39 A	13.80 ± 1.36 A
	2 EE-10,12-16:Ald	11.60 ± 0.93 A	13.80 ± 1.46 A
	3 EE-10,12-16:Ald + E10-16:OH	14.60 ± 2.06 A	12.20 ± 1.66 A
	4 'Standard' + E10-16:OH	11.80 ± 1.77 A	17.00 ± 2.07 A
	5 control	0.20 ± 0.20 B	0.00 ± 0.00
	overall M:F ratio 1.13		
IITA-Cotonou (Benin)	1 'Standard'	0.80 ± 0.80	2.40 ± 0.51 A
	2 EE-10,12-16:Ald	1.00 ± 0.77	1.00 ± 0.77 B
	3 EE-10,12-16:Ald + E10-16:OH	0.40 ± 0.40	0.60 ± 0.24 B
	4 'Standard' + E10-16:OH	0.40 ± 0.24	2.60 ± 0.51 A
	5 control	0.00 ± 0.00	0.00 ± 0.00
	overall M:F ratio 2.54		
Tamale (Ghana)	1 'Standard'	0.80 ± 0.49	1.40 ± 0.98
	2 EE-10,12-16:Ald	1.00 ± 0.77	0.80 ± 0.37
	3 EE-10,12-16:Ald + E10-16:OH	0.80 ± 0.37	1.00 ± 0.45
	4 'Standard' + E10-16:OH	0.80 ± 0.37	0.60 ± 0.40
	5 control	0.40 ± 0.24	0.20 ± 0.20
	overall M:F ratio 1.05		

Means within column groups followed by a common letter were not significantly different (P > 0.05, LSD following ANOVA of log10-transformed data). The absence of letters indicates no ANOVA was attempted due to low values. Controls were omitted from the analyses of male catches from IITA and Savè.

CONTRIBUTION OF OUTPUTS TO DEVELOPMENTAL IMPACT

Output 1: Recommendations developed for the combined use of botanical or conventional insecticides, and pheromone traps, to control *M. vitrata* and early season pests

This output was completed: recommendations for use of pheromone traps for determining the timing of applications of botanical or conventional insecticides have been developed which are compatible with normal farm activities and can form the basis for future uptake. Specifically, the recommendation is to deploy 5 – 6 traps in cowpea fields distributed around a village and the threshold date determined as that date when the cumulative average catch of two moths per trap is reached. The recommendation is then to spray within three days of the trap threshold, but farmers are free to decide collectively the best control agent to apply for each field – botanical or conventional pesticide – and when to apply it, taking account of the overall pest situation.

Output 2: Uptake increased for pheromone traps and best package of botanical/conventional insecticides for controlling the pest complex

Substantial progress was made on this aspect, although not as extensive as originally planned. Although the trap and botanical technologies were only used within the context of project- or PRONAF-initiated FFS, and although the number of farmers was fewer than planned, approximately 500 farmers in 26 villages now have detailed experience of the technologies. These farmers will form a core market for future commercial development. New institutional partnerships (with OBEPAB, CRI and GOAN) were forged in two new regions to aid uptake of technologies and instructional materials were produced to facilitate this.

Output 3: Local/regional systems of manufacture and distribution of pheromone traps and lures, and of botanical insecticides, developed on a pilot-scale

Regrettably, little progress towards full, large-scale commercialisation of supply or manufacture of technologies was possible, nor was sensitization of the regulatory authorities to specific characteristics of pheromone traps or botanicals – partly due to the PL's unavailability for travel due to medical problems. However, farmer production of traps for self-consumption was successfully carried out and a short-term supply route for lures (through PRONAF) has been identified, with many farmers expressing willingness to pay economic costs. In the longer-term farmers wish to make purchases of traps, lures and botanical pesticides through existing providers.

Output 4: Re-examination of the pheromone blend of *Maruca* to improve its effectiveness in Nigeria and Burkina Faso

This was successfully carried out and results will allow future expansion of trap use to Burkina Faso, although the findings have still not provided an effective pheromone blend for use in the key area of northern Nigeria.

Publications arising from the project

1. ADETONAH, S., COULIBALY, O., DOWNHAM, M.C.A., ENDAMANA, D., ADEOTI, R. & TAMÒ, M. (2003). Farmers' perceptions of cowpea yield losses due to *M. vitrata* (Fabricius) (Lepidoptera: Pyralidae) in Benin (West Africa). <u>Annales des Sciences Agronomiques du Bénin</u> 1(6): 1-20.*

2. RUREMA, D.G., ATACHI, P., TAMO, M., DOWNHAM, M.C. & DATINON, B. (2003). Relation entre les infestations larvaires et les vols des adultes de *Maruca vitrata* (Fabricius) (syn. : *M. testulalis* Geyer) (Lep : Pyralidae) dans les cultures de niébé (*Vigna unguiculata* (L.) Walp) sous l'attrait des phéromones. <u>Annales des Sciences Agronomiques du Bénin</u> 1(6): 61-75. [In French]**

3. DOWNHAM, M.C.A., TAMÒ, M., HALL, D.R., DATINON, B., ADETONAH, S. & FARMAN, D.I (2004). Developing pheromone traps and lures for *Maruca vitrata* (F.) (Lepidoptera: Pyralidae) in Benin, West Africa. Entomologia Experimentalis et Applicata 110, 151-158.

*N.B. Previously reported in FTR of R7441 as 'in preparation'. Although the nominal publication date is 2003, this was not in fact published until early 2005. **N.B. Previously reported in FTR of R7441 under same title as "Proceedings of the Second International Workshop of the African Network of Research on Bruchids: recent developments in crop pre-and post- harvest pest management practices in Africa. November 12-17, 2001 Cotonou, (BENIN)". Although the nominal publication date is 2003, this was not in fact published until early 2005.

Internal Reports

NRI reports for three separate project visits by M.C.A. Downham and two by A. Cherry to Benin and Ghana.

Other Dissemination of Results

1. DOWNHAM, M.C.A, COULIBALY, O., TAMÒ, M., DATINON, B., ADETONAH, S. AND AITCHEDJI, C. (2003). Enhancing Management of *Maruca vitrata* using Pheromone Traps and Botanical Insecticides. Oral presentation to annual planning workshop of the *Projet de Niébé pour l'Afrique* (PRONAF), International Institute of Tropical Agriculture, Cotonou, Benin, 28 April – 2 May, 2003.[Powerpoint file]

2. BRAIMAH, H., DOWNHAM, M.C.A., & COULIBALY, O. (2003). Implementing pheromone traps and other new technologies for control of cowpea insect pests in West Africa through farmer field schools - Planning Workshop for Ghana (DFID project R8300). Crops Research Institute, Kumasi, Ghana 8 – 9 July 2003.

3. DOWNHAM, M.C.A, COULIBALY, O., TAMÒ, M., DATINON, B., ADETONAH, S. AND AITCHEDJI, C. (2003). Enhancing Management of *Maruca vitrata* using Pheromone Traps and Botanical Insecticides. Oral presentation to Planning Workshop for Ghana (DFID project R8300). Crops Research Institute, Kumasi, Ghana 8 – 9 July 2003. [Powerpoint file]

4. ASANTE, S.K. (2003). Implementing pheromone traps and other new technologies for control of cowpea insect pests: experience of SARI during previous project phase. Oral presentation to Planning Workshop for Ghana (DFID project R8300). Crops Research Institute, Kumasi, Ghana 8 – 9 July 2003. [Powerpoint file]

5. ADIMADO, S. (2003). Relevant Experience of the Ghana Organic Agriculture Network (GOAN). Oral presentation to Planning Workshop for Ghana (DFID project R8300). Crops Research Institute, Kumasi, Ghana 8 – 9 July 2003. [Powerpoint file]

6. ADIMADO, S. & DAVISON, M. (2004). Untitled interview on botanical pesticides and pheromone traps in Ghana. WrenMedia/Agfax. Ghana. [Syndicated radio interview] [National/International]. Audio available at http://www.agfax.net and http://radio.oneworld.net/article/frontpage/251/4907. Transcript already held by CPP (Benedikte Siderman-Wolter)

7. INTERNATIONAL INSTITUTE OF TROPICAL AGRICULTURE, NATURAL RESOURCES INSTITUTE & CROPS RESEARCH INSTITUTE (2005). Installing pheromone traps for *Maruca vitrata* [Extension poster][100 copies each in English, French, Ashanti-Twi, Fon, Adja, Idatcha, Dendi, Bariba].*

8. INTERNATIONAL INSTITUTE OF TROPICAL AGRICULTURE, NATURAL RESOURCES INSTITUTE & CROPS RESEARCH INSTITUTE (2005). Using pheromone traps for *Maruca vitrata* [Extension poster][100 copies each in English, French, Ashanti, Fon, Adja, Idatcha, Dendi, Bariba].*

9. INTERNATIONAL INSTITUTE OF TROPICAL AGRICULTURE, NATURAL RESOURCES INSTITUTE & CROPS RESEARCH INSTITUTE (2005). Pheromone traps for the legume podborer, *Maruca vitrata*: An early warning system for *Maruca* infestations [Extension training leaflet][100 copies each in English, French, Ashanti, Fon, Adja, Idatcha, Dendi, Bariba].*

*Not previously reported.

Listing and reference to key datasets generated

- DOWNHAM, M.C.A. & ADETONAH, S (2004). Results in Excel spreadsheet form of questionnaire surveys of farmers to establish the potential for farmer-to-farmer transmission of information on traps and botanicals. Natural Resources Institute/International Institute of Tropical Agriculture.*
- DOWNHAM, M.C.A. & ADETONAH, S (2005). Results in Excel spreadsheet form of questionnaire surveys of farmers to assess their views on with respect to possible routes of supply. Natural Resources Institute/International Institute of Tropical Agriculture.*
- DOWNHAM, M.C.A. & DATINON, B. (2004). Results in Excel spreadsheet form of on-station trials of trap threshold trials. Natural Resources Institute/International Institute of Tropical Agriculture.*
- DOWNHAM, M.C.A. & ASANTE, S.K. (2004). Results in Excel spreadsheet form of a comparison of botanical pesticides for control of cowpea pests. Natural Resources Institute/Savanna Agriculture Research Institute.*
- DOWNHAM, M.C.A. *et al.* (2004 and 2005). Results in Excel spreadsheet form of FFS trial data from PRONAF, OBEPAB, CRI and GOAN, each for 2003 and 2004 seasons. Natural Resources Institute/International Institute of Tropical Agriculture.*

Further Work and Uptake of Outputs

A further CPP-funded phase of the work has been approved until January 2006 to build upon project outputs in Benin and central Ghana and to extend them Burkina Faso. It is planned to address some of the deficiencies encountered during the reported project – notably in respect of a dissemination workshop. The current phase of PRONAF ends June 2006 but IITA are currently confident of a further 3-year funding phase (this time including Ghana) from IFAD.

IITA are in discussions with the Gatsby Foundation to fund a cowpea biocontrol project which could include a component to develop effective *M. vitrata* pheromone traps for northern Nigeria. Funding from USAID to IITA is also possible to develop a network of light traps for *M. vitrata* (to assist with ecological studies) and pheromone traps would be included in this work.

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