CROP PROTECTION PROGRAMME

Integrating Pest Management and Soil Fertility Management
R 7503 (ZA 0353)

FINAL TECHNICAL REPORT

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Executive Summary

This programme development project aimed to draw up terms of reference and inform the CPP on research needs and on the developmental process of research, promotion and dissemination of technologies for the management of soil fertility and pest management. A needs assessment study was done in Ghana. It used vegetable systems as a model for study and linked to ongoing CPP, NRSP and FAO activities in Africa. The project was a consultative process involving farmers and other project stakeholders in Ghana, and E. Africa.

The study confirmed that there is a strong demand for research that integrates soil fertility and pest management. Although farmers have a basic understanding of pest and soil fertility issues, there is little understanding of interactions between pest and fertility management. These interactions can be complex and it is clear that if farmers are to benefit from technologies which exploit a better understanding of functional soil biology, derived from both strategic and adaptive research, a strong emphasis on the empowerment of farmers through improved knowledge will be required.

The project examined some very valuable approaches to improving farmer participation in the research process. The institutional infrastructure does exist in Ghana to facilitate such a research and development process, however scientific experts are few and concentrated in few institutions, while NGO's often lack the scientific technical expertise. There is a recognised need to strengthen the performance of local institutions and to facilitate data sharing.

Together with a sister project by NRI that focused on food crops systems in East Africa , a collaborative workshop was organised to bring together stakeholders from four East African countries and Ghana. The findings of both sister projects were amalgamated into a strategy for future research that identifies key research themes and establishes approaches required in addressing the interaction of fertility management and pest management in the farming systems of resource-poor farmers in developing countries.

Background

Soil fertility management interacts with crop health in a wide variety of ways, including the overall susceptibility to infection or attack (predisposition), the plant's tolerance to disease and capacity to produce yield despite pest attack and direct disease causation though nutrient stress. Soil amendments (*sensu lato*) can affect soil microbiota and consequent suppression of soil-borne pathogens and arthropod pests through competition, antagonism and parasitism. In resource-poor systems, soil fertility is in itself constrained by soil structure, availability of organic matter and competing uses for these organic sources. The soil biota constitute a major component of the biological diversity of agroecosystems which is responsible for key functions that maintain the integrity and productivity of the systems. In many situations, crop health and soil fertility interact as yield constraints and removing one constraint will not result in increased productivity unless the other is also addressed. Farmers naturally manage crops in a holistic manner and address both nutrient management and pest management as routine within farming operations. By so doing, they are establishing specific environments that influence the plants and the micro-environmental niches in which pathogens and pests interact with antagonistic and competitor organisms.

Intermediate and relatively low-input agricultural systems rely on the continuing function of the soil microbial community to maintain the integrity of the agro-ecosystem. However, this aspect is rarely explicitly addressed or quantitatively validated. Scientific research has frequently failed to take these interactions into account when addressing management of pests or of soil fertility from a single discipline approach. Research also often produces recommendations for specific domains that fail to take account of this interaction or of constraints on farmer's capacity to manipulate the system. As a result, farmers are provided with standard recommendations in a top-down approach that fails to equip them with appropriate technologies or empower them to make informed choices between available options. This problem was recognized in a recent workshop (TSBF, 1999), which concluded that despite significant advances in understanding the links between soil biotic function and agricultural productivity over recent years, this component of agri-biodiversity is treated as a 'black box' in agricultural research and development projects. However, efficient functioning of soil systems is implicit in the claims made for many of the cropping system technologies currently being advocated for improved and sustainable productivity in smallholder farms in Africa including agroforestry, reduced tillage, green manuring, intercropping, rotation and livestock-arable systems.

The concept of holistic management of a crop to produce healthy plants that are able to yield well and resist pest attack without reliance on pesticide inputs is central to the development of IPM farmer-field schools. These utilise principles of group experiential learning to empower farmers to adopt ecology-based management systems. This approach, pioneered by FAO and countries of South-East Asia, has more recently been implemented in parts of Africa, particularly in Ghana, Kenya and Zimbabwe. However, in many African systems pesticide abuse is not the main issue. Instead, resource-poor farmers (and extensionists) are faced with the problem of attempting to increase production from systems constrained by the interaction of water shortage, soil fertility and pests. This creates a requirement for these aspects to be addressed simultaneously in an integrated crop management approach. This has recently attracted considerable attention from soil scientists, who see the participatory learning approach as having value in disseminating messages regarding soil fertility management and through feedback mechanisms from such groups, enabling farmers to have more influence in determining research agendas.

The interrelationship of pest damage and soil fertility has been addressed in recent DFID-CPP funded projects concerned with the use of composts to recycle organic wastes in the Kumasi peri-urban region and their effects on crop health and productivity. Other aspects of soil improvement have been recently addressed through DFID NRSP-funded programmes concerned with improvement of soil fertility. In Ghana, these have included use of poultry manure in the Kumasi (Ashanti) Region and use of green manures in the Brong-Ahafo Region. A soil fertility workshop previously organized at Reading University under the NRSP and involving participants from Ghana and Kenya among other countries, concluded that integrated nutrient management was central to each of the target systems of DFID activities[1].

Project Purpose

The purpose of this project was to formulate a research strategy for the Crop Protection Programme for the integration of soil fertility and pest management, which addresses the development and promotion of environmentally benign strategies to improve the sustainable management of pests and soil fertility for the benefit of poor people.

In African soils the loss of soil fertility in increasingly intensive and often resource poor systems provides the vital context for the sustainable management of pests. Ecologically based studies of soil biota and the relationship between soil organisms and soil fertility and plant growth in tropical soils are very few and the biophysical and socio-economic variables which determine these relationships, are poorly understood. It is accepted that such studies, which will shed light on the functional interrelationships and management of the physical, chemical and biological character of tropical soils, present an important challenge to the

[1] DFID NRSP Annual Report 1997-98

research and development community. A major part of this challenge is the widespread demand for the integration of crop management practices in the context of the different livelihood strategies being pursued by different categories of farmers, including women and the resource poor. There is a growing body of evidence that suggests that this requires a committed farmer centred approach.

Research Activities

This programme development project consulted with farmers, researchers, extensionists and other stakeholders in those NRSP and CPP projects in Ghana, which addressed the development and adoption of technologies for the management of pests and soil fertility.

The following projects provided the core of the study although others were consulted by the international team which visited Ghana (see section …):

1.The use of composted urban wastes in integrated pest management systems to control pests and pathogens in peri-urban agriculture (R6941).

2. Integrated food crop systems project: development and promotion of improved techniques of water and soil fertility management for the sustainable production of crops on land in the humid forest belt (R6789).

3. Kumasi Natural Resources Management: Phase 2 (R6799).

4. Facilitating training activities of Ghana Organic Agriculture Network (GOAN).

5. The development of Farm Management Type Methods for Improved needs analysis (R6730).

6. National IPM programme (UNDP/FAO/MOFA project).

Consultation with UK based project leaders took the form of a questionnaire followed by a meeting facilitated by the UK project team at CABI Bioscience. This was followed by a visit to Ghana by an international team which consulted with Ghanaian project counterparts and other stakeholders to review research capabilities and activities in existing and recent research programmes, where the themes of pest management and soil fertility management interact and establish areas of complementarity. The project also aimed to review the developmental process of research, promotion and dissemination of technologies for the management of soil fertility and pest management. Inputs into this review process from farmers were solicited by an independent Ghanaian team with both integrated crop management and social science backgrounds. This team, which consulted with farmers involved in projects numbered 1, 2 & 6 above, reported directly to the project mission in January 2000.

A workshop took place in February 2000 under the auspices of the TSBF in Nairobi. This workshop provided a direct link with the sister programme development project led by NRI and identified with stakeholders the key issues and constraints with regard to successful research, dissemination and promotion of technologies for the integration of IPM and SFM.

The project had close links with the DFID NRSP and solicited direct inputs from NRSP programme managers both in the UK phase of the project and through involvement in the workshop in Kenya.

The project activities were undertaken through a multi-disciplinary team drawn from a range of institutions with relevant expertise and experience in this cross-cutting area; CABI

Bioscience, the Henry Doubleday Research Association (HDRA), the Tropical Soil Biology and Fertility Programme (TSBF) and various Ghanaian researchers and extensionists.

All of the planned activities and inputs were achieved.

Outputs

The outputs defined in the project memorandum for this project are as follows:

1. The relevance and potential impact of an integrated approach to soil fertilty and pest management in DFID-funded projects in Ghana documented
2. Strategies for the integration of soil fertility management and soil pest management in research, promotion and dissemination in the vegetable crop systems of Ghana developed
3. A framework prioritizing potential areas for DFID support to projects integrating soil fertility and pest management produced
4. Extrapolation of the framework to other crop systems particularly in E. Africa

The project contributed to outputs 1 and 2 through the Ghanaian project stakeholder consultations: A. Consultation with UK based project leaders; B. International mission to Ghana; C. In-country farmers survey. The project contributed to outputs 2, 3 and 4 through the collaborative workshop with the NRI sister project and the jointly produced strategy paper. This final report summarises the results of the Ghanaian project stakeholder consultations A, B and C, while full versions of specific outputs are attached as appendices (Appendix I, II and III respectively). The proceedings of the workshop and the full text of the strategy paper are attached in Appendix IV and V respectively.

A. SYNOPSIS OF THE UK PROJECT LEADERS CONSULTATION

The UK consultation was finalised at a meeting in December 1999 in which questionnaire responses were discussed and a card exercise was done to identify research constraints and priorities. Responses to the questionnaire were received from each of the projects listed above and each project was represented at the meeting (Appendix I). In addition a representation was received from CPP funded nematode biological control projects based in Kumasi. The following is a synthesis of the questionnaire responses and discussions.

<u>Farmer perceptions and management of soil fertility and pest issues</u>
There was general agreement that farmers in the vegetable systems have a basic understanding of soil fertility issues. For example, they recognise improved yields in response to fertiliser applications and can identify good soils largely based on soil colour, crop yield and quality. Farmers understand that levels of organic matter in soils are reducing, which leads to poorer soils, but, it was thought unlikely that farmers understand the concept of soil health and the relationships between organic matter and the physical and chemical properties of soils. Fallowing was the principal means of improving soil fertility. Fertilisers, that are attractive because of the quick response to application, are used by those that can afford them particularly in intensive peri-urban systems. Organic manures are under-exploited although there is growing interest in the use of chicken manure.

Farmers understanding and description of pest and disease problems were generally more precise for larger conspicuous pests. Wilting diseases were considered to be a most serious problem which farmers linked to underground insects, soil sickness or poor fertility.

It was generally agreed that farmers' knowledge of the interaction between soil fertility and pest management was minimal.

Constraints

Soil fertility and water conservation constraints were considered to be of primary importance and provide the context for integrated research, but the NRSP projects which largely informed this discussion would clearly have benefited from more pest management inputs, highlighting the need for a more integrated, holistic approach. For example, green manuring raised important pest management issues such as their role as alternative hosts for insect pests or as trap crops for nematodes. Furthermore the increased sustainability of vegetable production in seasonally dry river beds practised by farmers in Brong Ahafu was almost certainly due to the management of soil borne pests, an aspect appeared to be overlooked.

There are many important constraints to more organic approaches to vegetable production which need attention:

- Land tenure issues in relation to long term solutions
- The availability of organic materials and manures
- The cost of procurement of organic manures
- The poor perception of organic manures by younger men in intensive peri-urban vegetables
- The need to address the farmers understandable need for a quick fix solution, rather than a longer term improvement

Partnerships and processes

Farmers appear to have participated actively in the formulation of NRSP and National IPM programmes but less so in the CPP projects examined where better participation is required, with more emphasis on the economic viability of potential new technologies. The project on improved needs assessment (R6730) highlighted some very valuable approaches to improving farmer participation in the research process. NRSP experiences of linking with the Ghana Organic Agriculture Network were very favourable. It was recognised that the participatory development of new technologies in integrated crop management must combine a strong emphasis on the empowerment of farmers through the acquisition of new knowledge.

Researchable constraints

The following constraints and research needs were identified with regard to integrated crop management.

Constraints which impact on research:

1. Lack of a holistic approach
2. Few locally validated techniques.
3. Few extension personnel with broad knowledge and experience in participatory techniques
4. Availability of amendments and other inputs
5. Poor farmer knowledge of:

- pest and disease problems
- soil fertility/health problems.
- soil organic matter effects
- interaction of soil moisture status on pest management.
- soil borne beneficial organisms and impact of SFM practices on them.

CPP researchable constraints:

1. Unavailability of soil beneficials as biopesticides
2. Professional identification of soil-borne pests
3. Effects of soil fertility on weed suppression or enhancement
4. Surveys on soil beneficials and identification

Research needs:

1. Development of technologies for mass production of nematode biocontrol agents, both on-farm and by commercial companies.
2. Further testing of the nematode biological management strategy on farmers' fields where the biological control agents are added within specific crop rotations using less susceptible host plants.
3. Further investigate the integration of cultural methods of control with the biocontrol agents for the management of root-knot nematodes.
4. Management of bacterial wilt in a systems context.
5. Organic matter in relation to nematode biocontrol interaction.
6. Mode of action of organic amendments.
7. Chicken manure: rates, preparation and efficacy.
8. Understanding of non-nutrient effects of organic matter in small farmers' systems.
9. Research in development of tools/exercises to enhance knowledge of integrated crop management in farmer participatory research.
10. Specific function and management of a range of organic matter inputs.
11. Research to improve knowledge of functional biodiversity in soils.
12. Research to enable local adaptation of crop management practices based and a better knowledge of functional relationships of the physical, chemical and biological character of tropical soils.
13. Interaction of weed management and mulching.

B. SYNOPSIS OF THE INTERNATIONAL MISSION REPORT

<u>Partnerships</u>

The institutional infrastructure does exist in Ghana to facilitate the entire research and development process, however scientific experts are few and concentrated in few institutions, while NGO's often lack the scientific technical expertise. There is a recognised need to strengthen the performance of local institutions and to facilitate data sharing.

<u>Training and knowledge</u>

Although existing process-oriented integrated pest management and soil fertility management projects have achieved a great deal in the promotion of participatory learning, there are several opportunities for improvement including:

- Strengthening interactive and iterative learning
- Incorporating indigenous technological knowledge (ITK) and farmer innovations into the technology development process
- Achieving greater representation and better targeting of integrated pest management and soil fertility management information
- Improvements in reaching women
- Improving links to poverty alleviation
- Building flexibility
- Broadening the range of participatory learning tools
- In addition, schools and other community level institutions can be dissemination targets as well as farmers groups

It is vital that an objective assessment is made of the appropriateness and effectiveness of different social groupings as vehicles for integrated crop management promotion

<u>Research needs (CPP researchable constraints)</u>

The mission team identified the following areas of adaptive and strategic research:

- Optimisation of organic amendment methodology for pest control as well as soil fertility. (Important factors would be soil types, mixtures of organic amendments, organic-inorganic combinations, application rates, placement and timing),
- Biocontrol value of organic inputs by management and amendment. This should include work on vegetable nursery management, compost and manure management.
- Influence of soil fertility on post harvest storage and quality.
- Validation of farmers developments with neem.

Adaptive research is required for the development of a range of options suitable for farmers differing in location (rural versus urban), farming systems (intensive versus shifting), economic status (access to inputs), etc.

<u>Strategic research</u>

- Biology, chemistry and physics of the interactions of organic amendments and pest control
- Stimulation of Mycorrhizae by organic interventions and the interaction with soil-borne pests and diseases
- nematode biocontrol
- crop rotation and crop mixtures
- effects of different organic soil amendments and combinations
- role of cover crops – including possible role of cover crops as reservoirs of pest and diseases, organic-inorganic interactions
- improved, short-term fallows
- enhancement and maintenance of natural or introduced biocontrol agents
- selection of cover crops and varieties for antagonist and beneficial purposes

C. SYNOPSIS OF THE IN-COUNTRY FARMER SURVEY REPORT

The aim of the in-country farmer survey was to identify research gaps for the development, promotion and dissemination of technologies for integrated pest and soil fertility management. Farmers were interviewed on their perceptions and knowledge on soil fertility and insect pest and disease management, and their interactions with crop health. Farmers were able to differentiate soil fertility and soil borne pests and diseases problems. Major soil fertility management practices of farmers included shifting cultivation, crop rotation, application of chemical and organic fertilizers and the use of green manures with species such as *Crotalaria*, *Canavalia* and *Mucuna*. Knowledge of pests and diseases above and below ground was common to all the respondents. However, not many farmers controlled soil-borne diseases. In a few cases, farmers drenched the soil during the application of fertilizer solutions with pesticides in an attempt to salvage insect pests and disease problems. With regard to control of insect pests and diseases above the ground, the farmers applied a number of pesticides (chemical, biological including botanicals such as neem). Major pests identified included fruit borers, chewing caterpillars, aphids, thrips, leaf miners and whiteflies. Principal among the diseases were those of nematodes and fungi. Major production constraints confronting farmers were soil fertility management, water availability and diseases. The survey revealed that as a result of improved soil fertility management practices, problems such as secondary pest situations occur, e.g. the growth of green manure. In addition, insect resistance to pesticides and the possible introduction of noxious weeds were indicated to be a threat. With the exception of the compost project, which did not include training of farmers, farmers from the other projects had various levels of involvement in the formulation of the projects. Integration of pest management and soil fertility management was however only partially covered in the projects. There is therefore the need to link soil fertility and pest management.

Contribution of Outputs

The study has identified opportunities for future research to support the development of integrated crop management strategies that better meet the needs of resource-poor farmers in developing countries. The identified research areas are considered the most likely to result in improved and more sustainable cropping strategies for resource-poor farmers and includes recommendations for appropriate implementation of an integrated pest and soil fertility management initiative. The outputs will be disseminated through the CPP network of contacts as well as through project stakeholders in East and West Africa. Collaborative projects on integrated crop management will be formulated following the study outcome.

APPENDICES:

I. Report of consultation with UK based project leaders
II. Report of international mission to Ghana
III. Report of in-country farmers survey
IV. Proceedings of collaborative workshop on integrated pest and soil fertility management
V. Strategy paper

APPENDIX 1: Report of consultation with UK based project leaders

Participants in consultative meeting:

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Mark Holderness, CABI Bioscience
Richard Plowright, CABI Bioscience
Janny Vos, CABI Bioscience
Phil Harris, Henry Doubleday Research Association
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David Jackson, NRI
Jo Bourne, Institute of Arable Crops Rothemsted
John Gaunt, Institute of Arable Crops Rothemsted
Peter Dorward, Reading University
Simon Gowen, Reading University

Introduction

The UK consultation group is requested, through information from selected vegetable projects in Ghana, to identify research priorities and describe issues which constrain the research development and adoption of integrated crop management strategies (integrated pest and soil fertility management).

Project Background

Some of this information can be extracted directly from the project memorandum form.

1. Describe the background to the development of your project.
2. What are the objectives of your project?
3. What are the outputs of your project?
4. Describe the groups of people who are the intended beneficiaries of your project (if possible, their wealth status, geographical location, occupation(s), gender, ethnic composition, political and social organisation).

Farmer perceptions

1. In your project, do farmers differentiate between soil fertility problems and soil borne pests and disease?
2. Describe farmers soil fertility management practices and if possible describe their knowledge of soil fertility (i.e. knowledge of the value of organic matter, manures, fertilisers, soil structure).
3. Describe farmer's knowledge of pests and natural enemies (above and below ground) and pest management in your project. What pest management practices do farmers use?
4. What aspects of the interaction between soil fertility, pests and crop health are farmers aware of?

Constraints and research priorities

1. What were the major constraints to crop production which your project sought to address? Were other pest constraints identified during the study?
2. What are the constraints of any nature to improved pest management?
3. What are the constraints of any nature to improved soil fertility?
4. What was the nature of the integration, if any, of soil fertility and pest management components
5. In an experimental sense, were the main effects and interactive effects of pest management and soil fertility treatments examined?
6. What are the key research priorities or knowledge gaps in relation to the integration of pest and soil fertility management which can enhance the development of integrated crop management strategies?

Partnerships and processes

1. How were the beneficiaries involved in the formulation of your project?
2. Describe the stakeholders of your project, their linkages and roles.
3. Describe the uptake pathways for the outputs of the research, describe implicit assumptions and identify any constraints to uptake.
4. Describe the strengths and weaknesses of the partnerships and processes which were utilised in your project to enhance uptake by farmers and suggest ways these might be improved.
5. What are the advantages and disadvantages of developing a combined approach to pest and soil fertility management?

QUESTIONNAIRE RESPONSES

1. Development and promotion of improved techniques of water and soil fertility management for the sustainable production of crops in the humid forest belt. (R6789)

Implementing agency: Natural Resources Institute, Ministry of Food and Agriculture, Ghana.

Project background and objectives: PRA surveys in the Brong Ahafo region of Ghana indicate that farmers attribute poor vegetable yields and their quality to declining soil fertility in spite of increasing fertiliser use. The purpose of the project is to understand the main soil and water constraints limiting dry season vegetable - based systems and develop strategies for addressing them. This research area is wholly in line with ODA's strategy for the RNR Sector in Ghana.

Project outputs:
1. A better understanding about how farmers perceive constraints to vegetable crop production in the seed-bed and field in relation to soil fertility and soil water holding capacity. Estimated nutrient budgets will be drawn up with farmers using their knowledge together with soil and foliar analysis. These will assist the process of identification of nutrient limitations to crop growth and production.

2. Identification, through a combination of farmer's and researcher's knowledge of alternative strategies for removing the constraints in (1) above.

3. Results of on-farm and on-station trials testing alternative technologies for increasing availability of plant nutrients and improving soil water holding capacity.

4. Description of the effect of improved technologies on nutrient availability (measured by soil analysis) leading to preliminary recommendations for the integrated management of organic and inorganic nutrient sources as a means of improving soil fertility levels and water-holding capacity.

5. Analysis of the costs/benefits of new technologies in terms of labour use, inorganic fertiliser, water inputs, and crop productivity.

6. Manual outlining the concepts of soil fertility management and preliminary recommendations of the most promising improved techniques for use by extension services and non-government organisations involved in agricultural extension activities. Production of scientific paper for peer review.

Intended beneficiaries:
Dry season farmers will be the main beneficiaries from technologies that will improve the efficiency of inorganic fertiliser and water use. Dry season vegetable production is a comparatively new activity starting at about the time when cocoa yields fell in the early 80's when drought and severe bush fires destroyed many of the plantations. Farmers began to produce vegetables as an alternative to cocoa as the lead-in time was much sooner and ready markets assured adequate income. Farmers evolved a system of supplying plant nutrients through soil based fertiliser applications and foliar nutritional sprays. In spite of heavy applications, yields are said to be declining. The new technologies are expected to increase the efficiency of plant nutrient supply in a cost effective way. All participants in the marketing chain including farmers, traders and consumers will benefit from increased quantity and quality of products through improved opportunities for income generation and stimulation of the private sector. The Crop Research Institute, Soil Research Institute and Crop Services Department will be provided with research methodologies and experience and information on use and management of organic manures, and their combined use with inorganic fertilisers. Beneficiaries will not necessarily be limited to Ghanaians, but could include farmers from the region and beyond, through dissemination of suitable green manure seeds and composting technologies through trade and institutional networks. Subject matter specialists of the Extension Services and their front-line staff will benefit from the provision of manuals and participation in project activities.

Farmer perceptions:
1. Farmers are aware of soil pests affecting vegetable crops and seek to use fallow periods to reduce the effect of soil borne pests. There is not generally an awareness of the link between soil fertility and pest incidence.

2. Some of the better-off farmers use chemical fertilisers for dry season vegetable production. A typical routine is as follows: One week after transplanting tomato seedlings, 23:15:5 NPK mixed in equal amounts with ammonium sulphate applied in solution (5 litres of fertiliser dissolved in 210 litres water). One milk

can (130ml) applied to each plant. Later application dry , approximately 1 tablespoon full applied dry in hole made with stick. Solution of fertilser applied again, two months after transplanting when the first truss is fruiting.

Poorer farmers do not use any form of fertiliser, either inorganic or organic.

There was little knowledge of the use of organic manures before the implementation of the project. Since then farmers have been introduced to green leguminous manures, use of animal manures and composting. Trials have also been carried out using small amounts of inorganic fertilisers to supplement the organic treatments.

3. There is almost no association of pests and natural enemies. Typically the farmers who use chemical sprays for pest and disease control use a cocktail of Topsin, Cocide (a cocoa spray), Champion and Karate four times up to harvest time. Some farmers include a foliar nutrition spray of Plant Food (Grofil) with each application. Many farmers do not use sprays because they are either too expensive, not available or they do not have spraying equipment.

4. Farmers generally try to rotate or fallow the land to reduce the incidence of pests and diseases and maintain soil fertility.

Constraints and research priorities:

1. The main constraints addressed by the project related to soil fertility and improvement of soil water holding capacity. Nematode pests were identified as problems together with various insect pests such as white flies (virus transmission), bollworms, mites and thrips. Fusarium wilt and phytophthora are the main diseases present.

2. Constraints to alleviation of nematodes is the lack of available nematicides and how to use them. White flies are becoming resistant to chemical sprays. Danger to the sprayers in not realising the toxicity of some of the sprays being used and lack of protective clothing. Lack of knowledge of IPM technologies suitable for farmers to adopt.

3. Lack of animals in the project area are a constraint to availability of sufficient quantities of manure for wide scale application. Cost and availability of inorganic fertilisers. No widespread knowledge of composting and how it may be used. This is being addressed in the project.

4. Introduction of *Crotalaria juncea* as a green manure to act as a natural suppressant of nematodes. This was not fully tested due to lack of time and insufficient resources to carry out the trials.

5. No experimental effects between soil fertility and pest management was carried out.

6. Research priorities:

   Natural means for suppression of soil born pests especially nematodes.

   IPM methods for reducing incidence of white flies and virus transmission.

   IPM methods for reducing effects of bollworms on fruit.

   Control of Imperata grass weed and *Chromolaena odorata* in vegetable based systems.

Partnerships and processes:

1. Beneficiaries involved in initial PRA surveys, identification of constraints and development of testable technologies for on-farm and on-station trials. The project will also be in touch with internationally-connected organic agriculture and low-external input organisations, such as the Henry Doubleday Research Association and the Centre for Research and Information Exchange in Ecologically Sound Agriculture.
2. The main in-country target institution is the Unified Agricultural Extension service which through its network of extension workers and subject matter specialists can spread improved technologies to all similar areas. The project will work closely with the on-going IFCSP run by the RNRRS Crop Post Harvest and the

Crop Protection Programmes. The project will also establish links with the GTZ Sedentary Agriculture programme in Ghana/Brong Ahafo. NGO's active in agriculture in the area will be informed and involved, specifically the Ghanaian Organic Agriculture network. Regionally the project will link with the Conference des Responsables de Recherche Agronomique Africains, CORAF. This networking organisation, active throughout West Africa and in contact with 19 National Agricultural Research Organisations, has nine sub-networks, one of which focuses on improved techniques for vegetable production. The project will also be in touch with internationally-connected organic agriculture and low-external input organisations, such as the Henry Doubleday Research Association and the Centre for Research and Information Exchange in Ecologically Sound Agriculture.

3. The main promotion pathway for the project outputs will be through the Unified Agricultural Extension Services and NGOs such as members of the Ghanaian Organic Agriculture Network. This will be achieved through their participation in project activities and through targeting subject matter specialists and extension workers with the technical manual produced by the project. The SRI and Wenchi Farming Research Station will make use of the methodologies developed for mapping nutrient flows on-farm. The participation of farmers in compost/mulch and green manure trials and their evaluation will provide a route for direct adoption of technologies. Farmers groups will also be involved in assessing trials, including the on-farm testing of initially promising technologies.

i) Market studies carried out for project outputs.
The project concept note detailing potential activities and outputs has been discussed with the Regional Director of the Ministry of Agriculture, the Deputy Director general (heading research) of NARP, the head of research in SRI and the project manager of the IFCSP, who evaluated the relevance of the outputs to their perceived needs and prioritised project components.

ii) How outputs will be made available to intended users.
Outputs will initially go to the subject matter specialists in the MoFA as project technical reports and a manual (e.g. on methods of composting/mulching, selection and management of suitable green manure species). Widespread adoption of outputs such as green manures will depend on the development of delivery systems in collaboration with seed companies and farmer support networks. Vegetable farmers (beyond those involved in project activities) will receive outputs such as improved on-farm methods of compost preparation and mulching techniques from extension staff. Wider dissemination will be undertaken through regional networks such as the CORAF vegetable sub-group.

iii) Further stages needed to develop outputs.
It is unrealistic to expect that full recommendations for improving soil fertility and water holding capacity can be achieved in a three year project involving only two dry season vegetable cropping seasons. It is proposed to carry out a mid-term review of the project in September 1999 to consider extending the project for a further six in order to provide more sustainable results for the improved technologies.

iv) How will further stages be carried out and paid for.
Depending on the result of the mid-term review, an application to the FAI System of the NRSP will be made to extend the project and implement the recommendations of the review

v) Dissemination mechanisms.
Involvement of farmers, initially in assessment of on-station trials, then in designing and implementing on-farm trials will lead on-going dissemination of successful techniques. Practical findings from the research, including improved technologies for composting/mulching and the cultivation and management of green manures, will be disseminated via a manual for subject matter specialists and extensionists, Leaflets aimed at literate farmers will be produced on particularly successful and popular technologies. Contact with the local radio station and production of videos for farmers are avenues that will be explored in the proposed second phase. Scientific papers will be produced relating to strategic research findings.

4. The strength of the partnerships lay in the fact we were working directly with farmers, agricultural extension agents and MoFA officials. The project is still active and until results from on-station and on-farm trials have been analysed and dissemination outputs have been produced it is not possible to comment on the effects on uptake.

On-farm research work is costly in terms of human and logistical resources. Scientists from far away NARS often need provision of transport and overnight accommodation to carry out research of good quality. Local funding sources are not generally adequate to cover these costs.

Identification of target villages needs to be carefully carried out to ensure replicability and opportunities for dissemination of technologies to surrounding villages is adequately implemented.

5. The advantages of developing a combined approach to pest and soil fertility management lies in the fact that a holistic approach to crop production can be pursued. The disadvantage is the extra costs involved in setting up multidisciplinary teams to handle the different components both from the UK end and the in-country collaborators, particularly when funding is constrained.

2. KUMASI NATURAL RESOURCES MANAGEMENT PROJECT, R6799

Project Background

1. Describe the background to the development of your project.

Participants in the workshop on peri-urban interface research held in Kumasi in 1995 highlighted the need for research particularly in areas of land use, waste utilisation, environmental issues, agricultural intensification and employment and also the need to co-ordinate and make accessible data related to peri-urban natural resources. The Kumasi baseline studies (1996) identified the varying ability of individuals and groups in the communities to cope with and manage changes, in particular a general failure to intensify agriculture, issues of access to land and serious problems of under-development for many villagers (mainly women). The same study also highlighted development of responsibility for natural resource matters to the district level with an overview being taken by regional institutions. At both levels the need to strengthen the performance of the local institutions is recognised as well as the need to facilitate data sharing.
At the conclusion of the inception phase in September 1997 the local Consultative Panel reviewed the research findings. Emphasis was laid on the institutional constraints to NRM, the need for diversification of the economic base of the peri-urban area and research into the use of organic matter (integrated nutrient management). The need for increased dissemination outputs, in particular to the communities with which the project is involved, was stressed. A proposal for research into watershed management drafted by the lead research team was welcomed. This has been separately commissioned and funded.

The inception phase studies have shown that there is a real problem with the fertility status of the soil in the Kumasi peri-urban area, regardless of the farming system, and that this is related, *inter alia*, to low organic matter and phosphorus levels and high soil acidity. The studies have also shown that farmers are aware of the problem but are constrained in their ability to address the situation by financial and tenurial issues and to some extent by lack of knowledge of means to solve the problem. There is potential for the use of waste products generated by the city itself and livestock farms supplying the city to improve soil fertility status but this is largely unexploited.

The increased use of poultry manure is one of the major agricultural changes noted by respondents in our village characterisation survey (VCS) and suggests that there is likely to be a positive response from farmers to the trial and development of recommendations for use of organic manures as part of an INM strategy. It has been said that traditional organic inputs such as crop residues and animal manures cannot however meet crop nutrient demand over large areas because of the limited quantities available, the low nutrient content of the materials and high labour demands for processing and application (Swift et al 1997).

There have been positive indications from trials carried out by IBSRAM (Quansah et al 1997a) that poultry manure can be profitably used on maize and cassava in the Kumasi area, and those farmers who do use the material comment on its efficacy in terms of yield and high quality of produce.

Intensification of agricultural production that has been encountered in our studies does include relatively large-scale cereal production but is more commonly found in the vegetable systems in the valley bottoms or lower slopes and the finding of Harris (1997) that fertiliser use was higher in peri-urban than rural areas in the Kumasi region is undoubtedly related to the occurrence of the intensified vegetable farming system in the peri-urban area. The intensive vegetable farming system is characteristic, though not exclusive to, the peri-urban area and one for which the improvement of soil fertility and sustainable productivity seems a more readily and generally attainable goal than on the wider-scale bush-fallow food-crop system due to the anticipated greater incremental economic returns to (and hence acceptability of) INM techniques on vegetables compared to those of their use on field crops: both in the HDRA survey and our own any organic manure that is used tends to be applied on vegetables and/or backyard gardens. There is also evidence (HDRA survey) of some appreciation by some Ghanaian farmers of diminishing returns to increased amounts of fertiliser. Also, the total amount of organic manure available (which will be determined by these researches) is expected to be insufficient to benefit a significant proportion of the bush-fallow food-crop system.

Another source of organic manure is “black soil”, the product of decayed rubbish dumps, of which there should be a plentiful supply in the peri-urban region. Composted municipal waste, including human sewage, is produced on a large scale in Accra; the demand comes largely from institutions rather than individual farmers. Its use on vegetables in the Kumasi area has been investigatied by the associated CPP “Composts to Control Pathogens” project operating in the peri-urban area; crops showed good response to the compost. There is presently no local source of such material in Kumasi, yet there is great potential for the use of sewage wastes; however, cultural prejudices against its use are anticipated.

The HDRA report states that it has been suggested that secure land use rights are a fundamental requirement if farmers are to farm organically and security of tenure is less likely to be found in many of the vegetable cropping systems around Kumasi. The proposed research will need to bear this in mind in considering dissemination of the findings if otherwise positive results are obtained. A second factor which may act against the more widespread use of organic manures is that women have been found to be more rapid in adopting new low external input agricultural techniques in Ghana (qu. in Harris 1997); in peri-urban Kumasi it is mainly young men who are engaged in vegetable farming. Other negative factors to widespread adoption of INM may be the concern for hygiene and negative social stigmata attached to the handling of organic manure.

As an alternative INM technique, the use of cover crops such as *Mucuna* to improve and sustain soil fertility is under investigation by the NRSP FAI project on soil fertility in Brong-Ahafo. Although it has been surmised (Osei-Bonsu and Asibuo 1995) that where only short-term land tenure is available the investment in such cover crops is likely to be undertaken by only a few farmers, it may be that a demonstration of their value would encourage more of the landowners themselves to take up vegetable production.

2. What are the objectives of your project?
The project purpose is to achieve sustainable improvements in the productivity of priority natural resources in the Kumasi case study city-region. The research into agricultural productivity aims to inventorise resources, investigate appropriate INM practices and synthesise decision trees to aid adoption of appropriate practices.

3. What are the outputs of your project?
Under the soil fertility component are listed the following:

2.1 Review of peri-urban waste streams products for soil amelioration in the Kumasi peri-urban area.
2.2 An inventory of available resources with the potential to improve soil fertility within the Greater Kumasi City Region.
2.3 A review of the present and potential future use of and demand for these resources in the Kumasi peri-urban area, taking account of economic and socio-cultural factors and a range of potential uses.
2.4 Determination of farm-level nutrient flows in vegetable production systems, comparing the use of inorganic, organic and INM techniques.
2.5 In conjunction with the CPP Composts to Control Pathogens project, an assessment of appropriate-scale composts production for peri-urban farming systems.
2.6 Recommendations, including decision trees, to aid adoption of appropriate INM practices by peri-urban farmers.

4. Describe the groups of people who are the intended beneficiaries of your project (if possible, their wealth status, geographical location, occupation(s), gender, ethnic composition, political and social organisation).
In general:

- Residents in the peri-urban areas are expected to benefit to the extent that the better NR management system provided by these studies allows the more efficient control of and utilisation of the NR and urban resources.
- Research into individual livelihood strategies will focus on the problems and aspirations of more vulnerable groups so that their interests can be taken into account in development of management strategies.
- Peri-urban farmers are expected to benefit through development of technologies to improve agricultural productivity.
- Benefits will accrue to local planning and management institutions through the acquisition of improved information and management systems to allow them to improve NR planning.

More specifically, for the soil fertility component:

- Peri-urban vegetable farmers, some of whom are younger men and relatively wealthy members of their communities, growing their crops primarily for commercial gains but others of whom are women staying at home whose primary intention is to supplement the diet and income of their families some of these may form into loose associations to further their interests
- Ministry of Agriculture extension staff
- NGO (Ghana Organic Agriculture Association) staff

Farmer perceptions

5. In your project, do farmers differentiate between soil fertility problems and soil borne pests and disease?

   Yes, but there is little awareness of soil-borne pests and diseases, although nematode attack is recognised as being caused by worms which they cannot see. Soil fertility is assessed by colour, position on the soil catena, and experience with yields of crops grown on that soil. The general decline in soil fertility in recent years is recognised to be associated with the reduction of the fallow period and the increase in wildfires. The ability of both inorganic and organic fertilisers to remedy the soil fertility problem by supplying nutrients is recognised, but the concept of "soil health" in any general sense has not been mentioned by any of our participating farmers, at least at the outset of our work with them.

6. Describe farmers soil fertility management practices and if possible describe their knowledge of soil fertility (i.e. knowledge of the value of organic matter, manures, fertilisers, soil structure).

   The first recourse to the soil fertility problem is to maintain fallow periods. In the absence of this possibility, inorganic fertilisers are the preferred option, which it is believed have the advantage of relatively obvious, immediate and predictable effects, whereas organic manure may be slow-acting, unpredictable (if misused) and harbour diseases and weed seeds. All these are observations made by farmers in one of our PRA studies and agree with those of Harris (1997) for the HDRA in the Kumasi region. There is a preference for the use of exogenously-derived short-term fertility restorers such as inorganic fertilisers since they are in concentrated form, thus reducing transport costs, and simple to use. However, as has been pointed out (Allison & Harris 1996), if a farmer does not have cash to buy fertiliser then organic composting is his only chance to improve the fertility of his land. The removal of subsidies on fertilisers is thus an encouragement to the adoption of techniques using local resources.

   Locally available organic manures are spurned because their value is not realised and because their use involves use of scarce labour or cash resources for transporting the material. One means of reducing the transport costs would be to compost the material, or ensure that it is sufficiently well rotted before application so as also to avoid the risks of scorching which farmers sometimes remark upon as a reason that they do not use manure.

   Apart from realising that organic manures are longer-acting than inorganic, farmers do not, as far as I am aware, have a knowledge of their effect on soil structure, water retention, etc.

   The Mucuna trials have shown that soil temperatures are lowered and soil moisture retained more using the cover crop and this has been reflected in yield improvements of vegetables.

7. Describe farmer's knowledge of pests and natural enemies (above and below ground) and pest management in your project. What pest management practices do farmers use?
   We have not gone into this in any great depth (perhaps we should!) but the obvious pests such as crickets, ground squirrels, termites, beetles and ants are those which get the blame for much of the pest losses. We have not come across any farmers with any deeper understanding of the causal agencies. When we suggest what we think these are I don't think they believe us!
   Their normal recourse is to use massive amounts of sprays, principally 'Karate' and 'Dithane', also DDT powder. In the rainy season it ias common for them to spray twice a week or even more often, and the pre-harvest with-holding period is, we suspect, not observed. Weeding is still done by hand in vegetable production.

8. What aspects of the interaction between soil fertility, pests and crop health are farmers aware of?
   I do not believe that there is any in-depth awareness apart from the general understanding that a heavily fertilised crop may withstand pest attack better.

Constraints and research priorities

9. What were the major constraints to crop production which your project sought to address? Were other pest constraints identified during the study?

   Soil fertility decline and the lack of use of organic manures. Our trials of tomatoes were decimated in the first season by an attack of suspected wilt, *Pseudomonas solanacearum*, thought to have either been seed-borne or due to the fact that the variety used was particularly susceptible to the disease, which was probably endemic to the area.

In the cover crop trials, the *Mucuna* provided a haven for grasshoppers, which in one farmer’s case ruined several attempts at replanting tomatoes planted straight into the cleared mulch.

10. What are the constraints of any nature to improved pest management?
The attitude that chemicals are the best and only recourse. Though through working with the GOAN we understand that the use of neem powder is becoming popular with some farmers (not those with whom we have worked on our project).

11. What are the constraints of any nature to improved soil fertility?
Declining fallow periods; wildfires; transport of organic manures; costs of inorganic manures; lack of knowledge or understanding of integrated approaches.

12. What was the nature of the integration, if any, of soil fertility and pest management components
The same chemical treatments were applied to all plots. However, even with the severe disease infestation in the first season of trials, the plots to which poultry manure alone was applied out-yielded those to which inorganic or a mixture of inorganic and poultry manure was applied.

13. In an experimental sense, were the main effects and interactive effects of pest management and soil fertility treatments examined?

    Not within the mandate of this project.

14. What are the key research priorities or knowledge gaps in relation to the integration of pest and soil fertility management which can enhance the development of integrated crop management strategies?

    The philosophy and possibilities of an integrated approach are not well known to farmers. The extension service needs to re-think its approach, which is still centred on quick fixes, which is of course what the farmer wants. Besides research and knowledge constraints, there is no premium for organically grown fresh produce, at least in the Kumasi area, which would encourage such an approach.

Partnerships and processes

15. How were the beneficiaries involved in the formulation of your project?
Extensive PRA’s and meetings were held at all stages of the project.

16. Describe the stakeholders of your project, their linkages and roles.

    Researchers have worked together with Ministry of Agriculture extension staff and farmers in the field, especially on the poultry manure and *Mucuna* trials. These farmers have mainly been the younger, male, small-scale commercial farmers. The trials were researcher-designed and led, though in the case of the *Mucuna* the farmers had more influence in the practices employed. The aim has been to reach a concensus of appropriate practices which can be extended to other farmers. A workshop bringing together poultry and vegetable farmers was held to attempt to bring the supply and demand sides of the equation together.

    With the compost sub-project the researchers have spent less time in the field and the NGO (GOAN) staff have worked with the farmers on trial-demonstrations on communal and individual bases with the farmers, who in this case are largely female.

17. Describe the uptake pathways for the outputs of the research, describe implicit assumptions and identify any constraints to uptake.

    We have, as mentioned, worked with the Ministry of Agriculture and the GOAN. We have used written and mass broadcasting (local radio) media to disseminate the project findings. Project staff have attended scintific workshops in UK and Ghana. We have assumed that the extension staff, quite a large number have been briefly involved in a short poultry manure campaign, will have had some opf the ideas rub off on them. We have assumed that people listen to the local radio and take in the discussions; indications are that many do.

18. Describe the strengths and weaknesses of the partnerships and processes which were utilised in your project to enhance uptake by farmers and suggest ways these might be improved.

With the poultry manure vegetable farmers we got too much involved in subsidising their crop husbandry by paying for operations they should have normally borne the cost of themselves. This was against expatriate experience but following local advice! The result has been that in some cases unsubsidised operations have not always been carried out as well as subsidised ones. And there has been some carping from farmers that they want even more money. Otherwise, the scientists and farmers have had a good relationship, though there is sometimes the feeling that the scientists belittle the extensionists’ contributions. The involvement of the dynamic senior extensionist whom we obtained in the later stages of the project would have been better at an earlier stage, to lend credibility to their efforts.

No such problems have arisen with the NGO, GOAN, who have been keen and dedicated, providing good value for money throughout.

19. What are the advantages and disadvantages of developing a combined approach to pest and soil fertility management?
    The advantages are all those which you mention in your paper – sensitivity, sustainability and so on. The disadvantage is that it is much more difficult to teach and to convince farmers when what they need is immediate solutions to immediate problems.

3. NATIONAL IPM PROJECT GHANA – VEGETABLE COMPONENT

Project Background

In Ghana, a pilot project on Farmer Field Schools (FFS) in Integrated Pest Management (IPM) in rice was completed successfully in 1996. The Government of Ghana is now expanding IPM/FFS training to other parts of the country and to other crops within the framework of a National IPM Programme for Ghana.

In May 1997, a consultative workshop was organised during which recommendations were made and a plan-of-action for the expansion of FFS training in Ghana. This included both a national programme and a sub-programme tailor-made for five districts selected for UNDP assistance. Under the UNDP assisted sub-programme, activities on vegetable IPM/FFS were initiated.

1. What are the objectives of your project?

The immediate objectives of the national IPM programme are:

a. Create an extension capacity to train about 1400 farmers annually in FFS
b. Empower small-scale farmers to make crop management decisions by themselves based on an understanding of the agro-ecosystem and economy of their fields and capable of growing a healthy crop with a minimum of pesticides and minimum dependency on research and extension services.

2. What are the outputs of your project?

The vegetable IPM/FFS started off with a national survey on crop practices in vegetables. A follow-up workshop was held in January 1998 to make a work plan for a 6-months vegetable IPM trial validation period. A study tour was conducted by 3 of the future vegetable IPM master trainers to the Cambodia IPM programme in February 1998. The vegetable IPM validation trials were done at Ashaiman from February till August 1998. A vegetable IPM Training-of-Trainers (TOT) curriculum development workshop was held at the Dawhenya irrigation project site. The major objective of the workshop was to discuss results of the pre-TOT validation trials, derive appropriate trials and a curriculum for the forthcoming vegetable TOT in Weija. As such, the results of the validation trials were used as the basis for the curriculum of the subsequent season-long vegetable IPM TOT course in Weija from September till December 1998. The vegetable IPM TOT focuses on two crops: tomato and cabbage. Participants include 30 national extension staff and NGO village workers, and 4 extension staff from Malawi. Since the TOT, graduates have run farmer field schools (FFS) in their respective districts. Early 2000 an FFS evaluation mission is planned to monitor the FFS by TOT graduates and plan further follow-up.

Describe the groups of people who are the intended beneficiaries of your project (if possible, their wealth status, geographical location, occupation(s), gender, ethnic composition, political and social organisation).
The ultimate target beneficiaries are the farmers trained at FFS. They will produce in a more sustainable, cost-effective and environmentally sound manner. Trained farmers will achieve substantially higher net incomes. They will no longer be ignorant about pests and diseases and no longer depend on pest control advice of pesticide dealers, which generally serve the dealer more than the farmer. Occupational health hazards associated with the use of pesticides will be grossly reduced through minimal and more selective use of pesticides. Trained farmers will become resources for their communities and facilitate access to extension.

The most important group of immediate beneficiaries are the field staff of extension services. Trained extension staff will have become IPM experts and will have acquired new skills to conduct FFS training. They will get better response from farmers which increases their motivation. Trained staff already took initiatives to develop an IPM/FFS approach for cassava and cowpea.

The third beneficiary is the Government. Based on the results of the first round of IPM/FFS training in rice conducted in 1995-1996, such training is expected to increase yields by at least 25%. In 1994 (latest figure), the government imported about 280.000 mt of rice at a cost of US$ 54 M. Rice is mainly grown in irrigated areas and therefore are a relatively easy target for IPM/FFS. Eventually, increased yields may contribute to savings on imported rice.

Last, but not least, the general public will benefit from reduced health risks. Tomatoes and cabbages produced by trained farmers are far less likely to contain dangerous levels of pesticide residues. The price of cabbage has gone up because of decreased production as a result of uncontrollable diseases and pests. It is envisaged that this situation will be reversed.

Farmer perceptions

3. In your project, do farmers differentiate between soil fertility problems and soil borne pests and disease?

Yes, after the training, farmers are aware of specific constraints due to soil fertility or due to soil borne diseases. I am not sure about their awareness before the training.

4. Describe farmers soil fertility management practices and if possible describe their knowledge of soil fertility (i.e. knowledge of the value of organic matter, manures, fertilisers, soil structure).
   Farmers in general apply a so-called 'starter solution' after transplanting vegetables, which is a solution of chemical fertilisers (urea) in water. On average, 1 side dressing is applied afterwards. Through training, farmers have become aware of the benefits of using organic fertilisers, such as (mature) manure and compost, as well as of applying balanced fertilisation in split applications.

5. Describe farmer's knowledge of pests and natural enemies (above and below ground) and pest management in your project. What pest management practices do farmers use?
   In general, only chemical pesticides were used by farmers before training. After training, farmers became aware of the difference between pests and beneficials and have learned about using biopesticides and botanicals as well as of application only after observation of the field situation through agro-ecosystem analysis.

6. What aspects of the interaction between soil fertility, pests and crop health are farmers aware of?
   After training, farmers have become more aware of the impact of a healthy, well growing crop on production. The IPM training includes soil fertility management and during agro-ecosystem analysis, due attention is given to the soil.

Constraints and research priorities

7. What were the major constraints to crop production which your project sought to address? Were other pest constraints identified during the study?
   Farmers knowledge levels and understanding of agro-ecosystems, based on which informed decision-making can take place. In the case of tomato, the unavailability of heat tolerant varieties posed a problem on tomato production during the off-season.

8. What are the constraints of any nature to improved pest management?

   Biological control products are not widely available.

9. What are the constraints of any nature to improved soil fertility?
   Soils are generally poor. Organic fertilisers (manure, compost) are not available in all districts.

10. What was the nature of the integration, if any, of soil fertility and pest management components
    The IPM project is targeting 5 districts from different agro-ecological zones, for poverty reducing activities. Those selected 5 districts (Afram plains, Bongo, Juabeso-Bia, Bangme West and Accra Metropolitan Assembly) are facing problems of sustaining the use of their natural resource bases. Growing population pressure, combined with inadequate knowledge of the farmers in soil management and conservation, are considered the major factors contributing to declining soil fertility, soil erosion, acidity, compaction, toxicity, alkalinity / salinity. It was therefore realised that soil fertility needed to be addressed in the IPM project. The following activities were included in the IPM TOT training curriculum for extension staff to be used need-based in training of farmers in FFS:

a. Basic soil characterisation (texture, colour, organic matter, compaction, depth and land form)
b. Land preparation (soil tillage, conservation tillage, mulching, limited tillage)
c. Soil sampling and soil testing (fertiliser dosages and efficiency)
d. Soil fertility management (plant nutrient deficiency identification, understanding of plant nutrients, organic vs inorganic, fertiliser application methods, preservation and improvement of soil organic matter)
e. Soil and water conservation practices (identification of soil erosion)

11. In an experimental sense, were the main effects and interactive effects of pest management and soil fertility treatments examined?

A good example is the fertiliser study, done in the TOT to compare use of organic and inorganic fertilisers. In the treatment with compost, applied in plant holes, root-knot nematodes did not or hardly cause problems. In the treatment with only inorganic fertilisers, the infestation with nematodes was worst. In the treatments with compost or manure mixed with top-soil, the nematode infestation was intermediate. Participants learned from this study that the above ground crop performance and production was caused due to an interaction of both plant nutrition and plant health.

12. What are the key research priorities or knowledge gaps in relation to the integration of pest and soil fertility management which can enhance the development of integrated crop management strategies?

1. Beneficials in soils and biological processes are not well known.
2. Impact of various mulches on crop growth and health are not well known.
3. Simple soil testing kits are not available to extension and farmers.

Partnerships and processes

13. How were the beneficiaries involved in the formulation of your project?
PRAs were done to assess farmers problems and practices; during curriculum development workshops, farmers representatives, extension and researchers were present.

14. Describe the stakeholders of your project, their linkages and roles.
All the beneficiaries are stakeholders and are linked through the training activities of the project.

15. Describe the uptake pathways for the outputs of the research, describe implicit assumptions and identify any constraints to uptake.
The uptake pathway for outputs of research (by farmers, extension, researchers) is the farmer field school in which discovery-learning and sharing of experiences are major ingredients. Assumptions are that extension staff are sufficiently trained and capable to conduct farmer-participatory and non-formal exercises for new technologies. A constraint is that FFS is a relatively long and intensive training process, reaching less farmers than other less intensive methods of farmer training.

16. Describe the strengths and weaknesses of the partnerships and processes which were utilised in your project to enhance uptake by farmers and suggest ways these might be improved.
Strengthening of linkages between extension – farmers – researchers is key in a national IPM programme. In this specific project however, there were no funds for supportive research by the research community, which may be seen as a weakness.

17. What are the advantages and disadvantages of developing a combined approach to pest and soil fertility management?
Advantage: farmers are dealing with a complex ecosystem in which both pest and soil fertility management are major factors. Through an integrated approach, more balanced and therefore sustainable crop management can be achieved. A disadvantage may be the complexity of an integration as perceived by researchers and extension (not by farmers as they are daily dealing with both). The training background of research and extension is generally discipline oriented, which does not prepare staff for an integrated approach.

4. FARM MANAGEMENT AND IMPROVED NEEDS ANALYSIS

This project is linked in Ghana to the NRSP project 'Development and promotion of improved techniques of water and soil fertility management for the sustainable production of crops in the humid forest belt. (R6789)'

Notes from meeting held at Egham 17 December 1999

The focus has been on developing socio-economic and participatory methods. Project objectives were to develop and disseminate simple tools, namely causal diagramming and participatory budgetting, to help farmers and researchers quantify and analyse the use of resources in farms and households to:

i) Identify researchable constraints affecting farmers.

ii) Explore the effect of individual interfaces/solutions.

iii) The use of methods on farm trials where farmers are using these methods to record results and then to analyse and evaluate these results.

Farmers recognised that poor soil fertility was linked to disease. They are familiar with dry manure but not out of season green manure. Farmers are more interested in food supply and labour before cash, and first look at their budget before being introduced to green manure. They are then asked if they can bring it into their system. The timing of activities were important. Farmers identified that they would like to plant the green manure in October and plant tomatoes in April to July. Benefits would be reduced cash outputs on fertilizers. Importantly a lot of costs and risks would be identified. It would be labour intensive as it was a time of the year when the ground would be hard. They would identify the costs, risks and benefits and then take it forward on farm trials. In one village there were many different practices, some farmers were irrigating, flat planting, mound planting etc. It is a highly complicated system with a lot of variation within a small area. The complexity of the system makes the research much more challenging. Firstly, we have been able to address considerable flexibility and variability in their systems. Secondly we have to address the criteria and constraints as to whether the farmers think it important with regard to innovation, profit etc. At the end of the day the farmers decide on whether they adopt any of these methods. A manual is being published on this, and also a report on the green manure exercises. Extending the generic aspects is very important. Can you take what you know in one place and transfer it 10 miles down the road? This was part of the reason for having links with the NRSP programme in doing work in Asia and Africa. Specific technologies will be difficult to transfer. The farmer field school approach is also a methodology where farmers were in groups sharing experiences.

J. Vos thought their methodologies could be used in a wider area. Farmers are all making difficult decisions, why? The process needs to be separated from the technology. You can leave the farmers groups to do a type of testing for themselves.
M. Holderness thought it interesting that all were doing very similar things and we could bring this altogether. We have a researcher and they need to have a voice back to DFID as a need to consider these things as a holistic issue. The Natural Resources Adviser based in Accra would be very interested in the discussions we have had during this meeting. J. Vos thought it a bit early to involve him as this was just a first step in this programme. Helen Wedgewood would be involved in Ghana.

5. GHANA ORGANIC AGRICULTURE NETWORK (GOAN)

Facilitating the demonstration and training activities of the Ghana Organic Agriculture Network

Background

Through HDRA's Tropical Organic Agriculture Advisory Service and Tree Seed Distribution Programme there is huge demand from small-scale farmers, NGOs and other organisations who find it difficult to access to global information sources on organic and sustainable farming and agroforestry. Need to provide global information which is widely available through international databases but agree that there should be a strong element of local interpretation of the information.

Working with a number of Ghanaian farmer groups who had contacted HDRA for information, the need for the establishment of an information network in West Africa was emphasised. This would be an information and extension service that could provide the essential elements of local interpretation, on-site demonstration and training. The Ghana Organic Agriculture Network (GOAN) was formed in 1995 with the help of HDRA by a number of NGOs, each of whom are responsible for long term activities with farmers and other groups in their regions; with the aim of providing the above services through a national centre and local sub-centres.

The service also aims to facilitate the establishment of tree nurseries, carry out large scale compost production through municipal waste recycling, initiate and participate in scientific research into organic practices, facilitate the training of extension officers in organic agriculture and foster direct communication links between farmer groups and international bodies or government and educational bodies within the country.

HDRA continues to assist GOAN in the running of an organic agriculture and agroforestry resource centre in Kumasi, providing information, sharing expertise and seeking funds.

Objectives

1. To relocate and expand the existing Resource Centre for collecting, processing and disseminating information on organic agriculture and agroforestry.

2. To expand GOAN's information and advisory service for farmers, self-help groups, NGOs, education establishments and other interested parties across Ghana.

3. To set up and run demonstration farms at each of nine sub-centres. These will feature as visual displays and training sites for farmers, NGOs, schools and other interested parties. Each will link with government extension services and research bodies.

4. To train and equip representatives from each of the sub-centres and other GOAN members for running training workshops through meetings in Kumasi and/or in other regions of Ghana.

5. To carry out training workshops at each of the sub-centres with farmers, NGOs, schools and other groups. These will involve teaching, discussion and practical training on organic and sustainable agriculture and cover a wide range of practices including soil fertility building, composting, intercropping, agroforestry, natural pest and disease control, weed control, organic livestock management and so on.

6. To carry out capacity building and evaluation workshops to include all GOAN members.

7. To produce extension literature for distribution to farmers and schools throughout Ghana, covering various aspects of organic agriculture including those listed above.

8. To carry out extensive educational campaigns and activities across Ghana, including radio and TV advertising and to build on existing and establish new links with government departments, research and education establishments.

9. To continue to promote in-country, South-South and North-South linking between organisations.

10. To collate feedback information on the success of the regional network, advisory service, demonstration and extension activities and to make this information available to assist in future projects.

Outputs

1. Relocated and fully functioning Resource Centre concerned with global information on organic agriculture and agroforestry.

2. Global information on safe and sustainable farming methods more widely available to farmers, NGOs, self-help groups, educational establishments, government agricultural departments and extension officers and other interested individuals through the expanded Advisory Service.

3. Nine demonstration sites set up and open to the public and available for running training workshops.

4. Representatives from each of the sub-centres and at least 30 individuals from other GOAN member groups equipped to run training workshops within one year.

5. At least 600 farmers trained in various aspects of organic agriculture each year, through training workshops at the sub-centres.

6. Extension literature covering four different topics of organic agriculture produced, in English and a number of local languages, and distributed to around 1,500 farmers each year.

7. At least 600 students and teachers given education in organic agriculture each year through seminar days held at ten different schools.

8. At least 3000 farmers expected to adopt some aspect of improved sustainable farming practices by the end of three years.

9. Feedback information from the project will be made available through HDRA's extensive network of international contacts.

Beneficiaries

- Both rural and peri-urban, resource poor farmers and NGOs.

- Women - generally lowest income earners and cannot afford to purchase inputs. Therefore benefit most from adoption of an organic approach to farming which utilises most efficiently the resources available. Women constitute around 25% of those attending the general meetings in Kumasi - lack of time that women have available for such activities & low literacy rate among women. However, at member organisation level women constitute over 60% of farmers actively involved in programmes.

- School children and college students - help ensure future of sustainable methods of farming.

- All sectors of community benefit more reliable food supply and improved nutrition.

- Other agencies, research and governmental organisations, and others concerned with sustainable agriculture, improving food production and security, environmental protection, health hazards through chemical misuse, fair trade in organic foods and other related issues.

- Other like-minded southern based organisations outside Ghana who will use the centre as a working model.

Farmer perceptions

1. Soil fertility problems/pests and diseases

Farmers knowledge in soil fertility though traditional is enormous. They have their own means of determining soil fertility and are able to decide when soil is fertile enough to continue cropping the land or leave it to replenish its fertility (ie: rotational bush fallow system). Some of the techniques are the presence of earthworm cysts, the growth of plants and the fruiting and yield from the crops.

Though there are some bases upon which the farmers determine the soil borne pests and diseases, it is not all the time that they are able to differentiate between soil fertility problems and soil borne pests and diseases. For instance, farmers may find it difficult to assess whether paleness of their crops is due to some nutrient stress or to disease/pest infestation.

2. Soil fertility management

Farmers appreciate the fact that fertile soils boost crop production. Therefore when they cultivate their farms for a period of time, they leave the land "to rest" to replenish its fertility (ie the basis of rotational bush fallow system). The traditional farmer scarcely uses any soil ameliorant, e.g. mature, to improve the soil.

However, some farmers do have some knowledge in the ability of fertilizers and manure to improve crop yields. This has resulted from the promotional strategies of the 'green revolution'. Also the increasing awareness being created by NGOs. The knowledge of the value of organic matter, soil structure and to some extent manure is very limited. Still farmers burn their newly cleared lands and crop residues, their immediate sources of organic matter. It is important to state that farmers who have received some form of education from NGOs (GOAN) have their knowledge however improved.

3. Pests and natural enemies

Generally, farmers lack knowledge on natural enemies and see all insects as pests to their crops. Even with pests, farmers' knowledge about growth cycles, eating habits and mode of infestation is lacking. Though there exist a number of indigenous knowledge practices in pest management, farmers scarcely use these. What has been common practice is the calendar spraying of crops (mostly vegetables and cash crops) with pesticides. When there is pest build-up and the farmers could no longer contain the situation, he/she only leaves the land/farm for another parcel of land for cropping.

It can however be appreciated that intercropping/mix-cropping and rotational bush fallow systems are a means of managing pests.

Where there had been training by NGOs and the government IPM programme, farmers recognise the importance of natural enemies and also use botanical preparations (like neem) for pest management.

4. Interaction between soil fertility, pests and crop health

Farmers actually don't recognise interactions between soil fertility, pests and crop health. Their practices on soil fertility management could however be linked to healthy crop production but not related to pest management. Thus education and training on these are important.

Also, from findings of 'Organic farming in sub-Saharan Africa: farmer demand and potential for development' survey 1995-1997;

It is often assumed that farmers have a comprehensive wealth of indigenous knowledge about soil fertility management and pest control. This is often not the case. This study showed that farmers were often not optimising the natural resources at their disposal, nor did they necessarily have a clear idea why they were carrying out certain practices. As traditional slash and burn fallowing systems become insufficient, farmers commonly lack the appropriate skills to convert their farming systems to become more productive, yet sustainable. Furthermore, the predominance of agrochemical use over the last 20 years, or so, has meant that traditional knowledge has largely been lost. Also, non-traditional crops, which are associated with pests of which there is no traditional knowledge, are widely grown.

The long-term benefits of organic fertilizers are often not clearly appreciated by farmers. In the Ghana forest zone, the majority of farmers were aware that manure is of benefit to crops but not of the longer term effects of manure on soil fertility. In areas where educational level low farmers lack the basic 'agricultural science' knowledge about soils, plants and the benefits of cropping patterns.

Compost and green manures were highlighted as areas where training was required in Ethiopia, Ghana and Kenya, and agroforestry, crop rotation and composting were specifically highlighted in Ghana.

Constraints and research priorities

1. Constraints to crop production

Increasing population pressure on land has resulted in shortened fallow period of farm lands (from 15-20 years to 1-5 years), clearing of new forest for cultivation leading to deforestation and environment degradation and continuous cropping of the same piece of land
year after year (Sedentary Farming System). The above coupled with farmers' practices of burning the trash and farm residue and non-application of organic matter have resulted in sharp and continued decline in soil fertility.

The introduction and promotion of pesticides as the only effective way for pests and disease control without the necessary education on their use and effects on health and the environment has resulted in their abuse and pest resistance and build-up. It was to address these problems that GOAN was initiated.

2. Constraints to improved pest management

The effectiveness of farmer training programmes in pest management cannot be overemphasised. Lack of resources and capacity to carry out these training/educational activities at the farmers/community level have been a constraint. Also the farmers readiness to use already prepared/formulated "pesticides" (for its convenience) without the requisite training/knowledge to handle these pesticides has led to pest resistance and build-up.

3. Constraints to improved soil fertility

Lack of resources and personnel to carry out decentralised practical demonstrations. The high labour requirement for compost making and scarcity of manure are also constraints. The problem of carting manure to the farm where the farm is located at a distant. The land tenure system also discourage tenants to invest in long term soil fertility management methods.

4. Integration of PM and SFM

Farmers use intercropping and land rotation as strategies to maximise the use of soil nutrients and to avoid pest build-up. However, there are no conscious efforts to link soil fertility to pest management. Each is looked at separately.

5. Examination of PM and SFM

There has not been any such examination yet, though GOAN intends doing such analysis in future.

6. Key research priorities or knowledge gaps

- Identification and documentation of indigenous knowledge and examination of their efficacy on relevant crops and pests with farmers.

- Use of plant materials (e.g. leaves of gliricidia) as folial fertilizers can be researched into to establish which plants (parts) can be use in this way, how much at what time on which crops and their effects on pests and natural enemies.

Also, findings of 'Organic farming in sub-Saharan Africa: farmer demand and potential for development' survey 1995-1997;

In most cases the view among farmers was that government extension and research services had little to offer in the way of organic technologies for soil fertility maintenance. There was also little evidence of NGO work among the random sample of farmers interviewed. Extension officers themselves, in Kenya and in Ghana mentioned a lack of knowledge and training in organic techniques.

There were no reported cases of the promotion of natural pest control by either private or governmental institutions among the farmers interviewed in Ghana. The emphasis for pest control is very much put on pesticide use.

Partnerships and processes

Beneficiaries involvement

Each of the NGOs involved with the establishment of GOAN are responsible for long term programmes of work with farmers and local people in their regions, including extension, demonstration, on-farm research and other activities. HDRA has also been collaborating with some of these groups for several years. GOAN has been in close collaboration with many more groups since its establishment in 1995. The farmers linked with GOAN member NGOs are involved in discussions on planning and execution of activities through local meetings in each region.

Stakeholders

GOAN members groups, farmers, communities, MOFA, Research institutes, educational establishments, international NGOs and research bodies.

The project is managed and staffed by local participants. Other members of the community are actively involved in meetings to assess local needs and at all stages of project planning and implementation. Both male and female members of GOAN responsible for planning and carrying out the workshops among farmers in their regions. Agricultural extension workers and personnel from research and educational establishments also involved in the formulation and implementation of programmes.

Uptake pathways

Kumasi Resource Centre, Sub-centres, demonstration farms, open days, training workshops, school days, media, links with other NGOs (national and international), links with research and educational establishments,

Assumptions: target groups willing to take part, willing to adopt technologies promoted, demonstration farms successful, sufficient farmer/public interest.

Constraints: policies, institutions, markets, other incentives contrary to methods promoted (eg: those offered by agrochemical Co.s)

The activities of GOAN to date have stimulated an increased interest in sustainable agriculture among the NGOs involved and the local groups with which they work, and many others including government officials, extension officers and research personnel. Attendance at workshops carried out to date has exceeded numbers planned for due to high demand!

Strengths and weaknesses of partnerships and processes

Selection of farmers and other participants for the training workshops is carried out at the regional level in collaboration with the MOFA extension officers, Women in Agricultural Development (WIAD) and GOAN member organisations in the area, who have been working with the people for many years. For regional workshops, farmers are selected within a 30 mile radius from the sub-centres. A number of the open days and workshops are specifically aimed at women. The topics covered are completed on a daily basis so those who would not be able to leave their farms for three days are able to attend. The workshops for women are mostly led by women. Selection of students and teachers for the school seminars will be done in collaboration with the Agricultural Science Teachers Association of Ghana.

Thorough work plan maintained to ensure that local people are able to utilise the information provided through literature provision, visual demonstration and participatory training, at an appropriate level for immediate incorporation into local training programmes. Involves a follow-up system to monitor the implementation of information, and to assist with further advice should problems be encountered. Peer review from relevant national and international organisations will also provide valuable feedback concerning the appropriateness and effectiveness of GOAN’s work.

Combined approach to pest and soil fertility management

Advantages: increased understanding by farmers of interactions that exist and hence of the farming ecosystems generally, more efficient use of resources (and finances?), more sustainable system.

Disadvantages: complex and necessitates increased education, farmers attracted by alternative ‘quick fix’ approaches (a constraint rather than disadvantage).

6. BIOLOGICAL CONTROL OF ROOT-KNOT NEMATODES: GHANA 1996-99

Background

Previous work has suggested that root-knot nematodes are a common constraint in vegetable production in most areas of the country, particularly in the Brong Ahafo region where vegetables are the major crops.
Apparently, farmers generally account for the presence of galls on the roots due to poor soil fertility rather than infection by a soil-borne pest.
The only currently used method of control is chemicals which are expensive and not widely available.
The biological control agents *Pasteuria penetrans* and *Verticillium chlamydosporium* have shown considerable potential in small scale trials to control populations of root-knot nematodes (*Meloidogyne* spp.).

Objectives

Deployment and establishment of biocontrol agents for control of root-knot nematodes in vegetables.

Integration of the biocontrol agents with cultural control methods and host plants that are less susceptible to nematode damage:

Test the efficacy of organic amendments for the control of root-knot nematodes with or without the biocontrol agents:

- Poultry manure
- *Panicum maximum*, a fodder grass commonly grown in Ghana.

Test the efficacy of the biocontrol agents when applied to tomatoes grown continuously compared with application within rotations of brassicas and tomatoes.

Outputs

Ten isolates of *V. chlamydosporium* were obtained from soils from the Brong Ahafo Region, these were screened and the most promising biocontrol agent selected for further testing.

The amount of fungus in the soil was greater where poultry manure or mulch had been added but the number of infected eggs was not affected.

Application of poultry manure or mulch resulted in less damage to the plants by the nematodes than in the untreated plots.

In pot tests, the greatest reduction in nematode populations was where both biocontrol agents were applied together with the mulch or poultry manure.

Greater reductions in numbers of egg masses on the roots were observed where the biocontrol agents had been applied within crop rotations rather than in continuous tomato crops (91% and 87% respectively compared to the untreated tomato plants) at the end of the fifth crop cycle.

Dissemination of information.

Beneficiaries

Smallholders, market-gardeners and consumers.

Future research priorities

Development of technologies for mass production of both biocontrol agents on-farm and by commercial companies.

Further testing of the biomanagement strategy on farmers' fields where the biological control agents are added within specific crop rotations using less susceptible host plants.

Further investigate the integration of cultural methods of control with the biocontrol agents for the management of root-knot nematodes.

7. DFID CPP Project ZA 0193: The use of composted urban wastes in integrated pest management systems to control pests and pathogens in peri-urban agriculture.

Project Background

Some of this information can be extracted directly from the project memorandum form.

1. Describe the background to the development of your project.

- The project was developed to assist in addressing a two-fold problem in Ghana. Firstly, the need to reduce problems in the disposal of large volumes of lignocellulosic and human wastes in peri-urban regions and reduce health hazards due to insanitary direct disposal of untreated human wastes into local water courses. Secondly, loss of agricultural soil structure and fertility had led to problems of erosion, reduced crop yields and increased susceptibility of crops to pests and diseases in peri-urban regions. There was therefore an impending need to increase yields through improved soil fertility and reduced losses due to pests & diseases. The enhancement of naturally-occurring microbial biocontrol agents (antagonists, parasites, etc.) in the soil microflora by the appropriate use of composted organic wastes is known to mitigate the detrimental effects of soil-borne pathogens, namely fungi, bacteria and nematodes. This may occur both by direct biocontrol effects and through the enhancement of plant growth (and hence tolerance to root damage) resulting from improved soil fertility. The Accra Waste Management Department had already completed a successful 11 year project (funded by GTZ) to deal with solid and liquid organic wastes, resulting in the development of new organic composts based on a variety of substrates including sawdust.

2. What are the objectives of your project?

- The primary objectives were to determine the relative prevalence of plant pests and diseases caused by fungi, nematodes and bacteria in horticultural crops of the Kumasi peri-urban region and to assess the impact of an available compost, prepared principally from sawdust and human wastes and developed by the Accra Waste Management Department, on soil fertility, pests and diseases and crop growth and yield. Socio-economic considerations were addressed through the NRSP and technological barriers and pathways to the development and uptake of appropriate-scale composting processes for the Kumasi area determined. Data from the studies was collated and a report prepared on the feasibility and potential value of composts for the reduction of disease losses and improvement of crop yields in the Kumasi area, with a view to pursuing a second phase of research.

3. What are the outputs of your project?

- Integrated research team operational in Ghana.
- Field pest and disease incidence determined and identified to species level.
- Determination of the effects of composts on crop yields and disease incidence.
- Feasibility and acceptability of appropriate scale compost production determined.
- Potential impact of composts on soil fertility and crop losses assessed for the Kumasi area.

4. Describe the groups of people who are the intended beneficiaries of your project (if possible, their wealth status, geographical location, occupation(s), gender, ethnic composition, political and social organisation).

- ***Resource-poor smallholder farmers and small-scale growers in the Kumasi area, through improved crop productivity and reduced losses of yield and quality to diseases.***
- ***All groups of urban dwellers in the Kumasi area, through more efficient waste disposal (cessation of the practice of disposing of untreated night soil in local rivers), reduction of pollution and improved fresh produce supply.***
- ***Counterpart organisations, in Kumasi in particular, through training and technology transfer.***
- Research outputs would have applications to other comparable peri-urban situations.

Farmer perceptions

5. In your project, do farmers differentiate between soil fertility problems and soil borne pests and disease?

- Generally yes, at least with respect to (insect) pests. However some soil borne diseases, depending on their nature, may be attributed to soil fertility problems, ‘sickness’ (a term used by farmers themselves) spreading through the soil or insects that they have observed in or around the roots and lower stem.

6. Describe farmers soil fertility management practices and if possible describe their knowledge of soil fertility (i.e. knowledge of the value of organic matter, manures, fertilisers, soil structure).

- Farmers are aware of fertilisers, manures and composts but only apply the former two. Although a RRA study carried out as part of the project concluded that there were no social constraints to their use (even those prepared from night soil), key concerns that need to be addressed are financial (costs of purchase, transportation and labour) and/or related to a lack of understanding of compost properties and potential uses. Five types of compost and fertiliser were referred to by farmers. Inorganic fertilisers (NPK) are preferred as farmers are familiar with their use, they are convenient and are perceived to have a relatively rapid effect. They prefer fast acting composts to treatments that gradually build up soil nutrient levels.

7. Describe farmer's knowledge of pests and natural enemies (above and below ground) and pest management in your project. What pest management practices do farmers use?

- Farmers can recognise and describe many of the more common insect pests, although this applies more to larger pests such as beetles, caterpillars and borers, are aware of the damage they can and do cause and do rank them accordingly. They can also describe particular diseases and pest/disease complexes, but apply local names that may encompass a number of pests/pathogens causing similar symptoms (e.g. plant wilt). They have little knowledge of 'beneficials'. Application of a mixture of chemical pesticides (by spraying) is the main means of pest and disease control. Although farmers are aware of the limitations of control by pesticides, they have little knowledge of chemical specificity with regard to individual pests and diseases. Farmers appear to have little access to crop protection information.

8. What aspects of the interaction between soil fertility, pests and crop health are farmers aware of?

- Farmers are not generally aware of potential benefits of composting in controlling pests and diseases.

Constraints and research priorities

9. What were the major constraints to crop production that your project sought to address? Were other pest constraints identified during the study?

- Poor soil fertility and the detrimental effects of vegetable pests and diseases (as the project did not target specific pests and diseases, the latter part of the question is not applicable).

10. What are the constraints of any nature to improved pest management?

- These are numerous, but key constraints include: inaccurate pest diagnosis and limited knowledge of pest nature; insufficient resources (funding or otherwise) to investigate pest constraints and to develop, evaluate and disseminate new or improved management technologies; insufficient demand for pest management technologies; pest management given low priority by farmers; lack of (farmer) resources for sustainable adoption of technologies (e.g. through changes in 'livelihood'); poor dissemination of information relating to pest management opportunities; insufficient training provided in use of appropriate management practices; potential benefits of pest management not clearly demonstrated, particularly to farmers.

11. What are the constraints of any nature to improved soil fertility?

- Again numerous and similar to above, including: inaccurate problem diagnosis; insufficient resources (funding or otherwise) to investigate fertility constraints and to develop, evaluate and disseminate new or improved soil fertility management practices; insufficient demand for new or improved fertility management technologies; fertility management given low priority by farmers; lack of (farmer) resources for sustainable adoption of technologies to enhance fertility (e.g. through changes in 'livelihood'); poor dissemination of information relating to opportunities for improving soil fertility; insufficient training provided in use of appropriate management practices; potential benefits of pest management not clearly demonstrated, particularly to farmers.

12. What was the nature of the integration, if any, of soil fertility and pest management components.

- Integration was achieved through the utilisation of compost by farmers to increase soil fertility while simultaneously improving plant vigor, reducing the detrimental effects of pests and diseases and thereby improving yields. No practices specifically developed for, or aimed at, pest management were included. Subsequent proposed research (part of phase II of project) would investigate possibilities for adapting and improving the compost's properties to further enhance it's pest and disease management potential (e.g. by including antagonist biocontrol agents) while maintaining or enhancing its potential to improve soil fertility.

13. In an experimental sense, were the main effects and interactive effects of pest management and soil fertility treatments examined?

- No. Only variable factors assessed related to type of soil amendment and rate of application were assessed.

14. What are the key research priorities or knowledge gaps in relation to the integration of pest and soil fertility management that can enhance the development of integrated crop management strategies?

- Knowledge of the combined effects of integrating the two components on production constraints, crop growth and yield and, in particular, the mechanisms by which these effects (whether beneficial or detrimental) are brought about.

Partnerships and processes

15. How were the beneficiaries involved in the formulation of your project?

- An NRSP Peri-urban Interface Research Workshop was held in Kumasi, Ghana, in August 1995. Waste management was identified in the workshop as a priority area and there was also evidence that local institutions were keen to pursue research on composts and were well placed to do so through a multi-disciplinary programme. Discussions held at the workshop between the project leader (Dr Joan Kelley, CABI Bioscience) and many of the project beneficiaries (direct and indirect) resulted in the preparation and submission, to DFID CPP, of a project concept note for research on development and utilisation of organic composts in the management of soil-borne pathogens. Dr Mark Holderness (CABI) made a subsequent visit to Ghana, funded by DFID, to establish linkages with relevant scientists and institutions, to determine institutional needs and to assess pathogen constraints to production in the peri-urban systems of Kumasi. The findings of this visit and related activities led to the submission to DFID, by CABI Bioscience, of a full project memorandum. This was developed in close consultation with the ultimate project partners and beneficiaries (including Kwame Nkrumah Univ. of Science & Technology and Crops Research Institute, Kumasi, NRI and Henry Doubleday Research Association, UK).

16. Describe the stakeholders of your project, their linkages and roles.

- The primary and ultimate stakeholders in the research were farmers (group 'A') themselves who were involved in several one-one and group appraisals on various aspects of soil fertility management and pest and disease management. Fields trials were also established on-farm to study the effects of composting on soil fertility, pest and diseases prevalence and plant growth and yield.

- Numerous other (secondary) stakeholder groups were also involved, whose roles included:
  B. Local District Agricultural Extension Services – field surveys (farm and farmer), farm trial establishment and routine monitoring, facilitating day-to-day interaction with farmers.
  C. Local Council – Kumasi Municipal Waste Dept: Development of composting plant in Kumasi.
  D. Accra Municipal Assembly composting plant: Production and delivery of compost studied in project.
  E. Local University (Kwame Nkrumah Univ. of Science & Technology, Kumasi): undertook majority of in-country research.
  F. Local NARS (Crops Research Institute, Kumasi) - undertook major components of in-country research.
  G. UK ARI - Henry Doubleday Research Association: soil analyses.
  H. UK ARI - NRI: socioeconomic research (RRAs).
  I. Bureau of Integated Rural Development, Kumasi: socioeconomic research (RRAs).
  J. UK ARI – CABI Bioscience: project development and management, active participation in research activities.
  K. DFID and NR International: project funding, monitoring and assessment.

- Direct linkages (X) that were clearly identified between these stakeholder groups are summarised in the table below (? = unknown)

	A	B	C	D	E	F	G	H	I	J	K
A											
B	X										
C											
D			?								
E	X	X	X	?							
F	X	X	X	?	X						
G	X	X	?	?	X	?					
H	X	X	?		X	?	X				
I	X	X	?		X	X	?	X			
J	X	X	X	X	X	X	X	X	X		
K							X	X		X	

17. Describe the uptake pathways for the outputs of the research, describe implicit assumptions and identify any constraints to uptake.

- Both the Kumasi and Accra Waste Management Departments were actively involved in the project from its initiation while extension services in the Kumasi area were actively involved in the field research as the project progressed. It was anticipated that, following a second, three-year phase of more comprehensive research, compost technologies would have been made available at the scale most appropriate to local needs, whether centralized or village scale. Crop protection applications would also be disseminated through further farmer-participatory research, field days and local extension agents. Unfortunately funding for this second phase of research could not be secured and, as such, final project targets could not be met. Nevertheless, the phase one research did show that use of the compost could result in increased soil fertility and enhanced crop growth and yield, and could alleviate the impact of pests and diseases. Specific outputs of the first phase (one year) of the research were successfully disseminated by various mechanisms, including District Agricultural Extension Services, research publications and reports and farmer-participatory trials.

18. Describe the strengths and weaknesses of the partnerships and processes that were utilised in your project to enhance uptake by farmers and suggest ways these might be improved.

- For the most part the partnerships and processes utilised in the project were strong and, had the project progressed to a second phase as anticipated, would have been expected to lead to successful uptake of the overall research outputs, particularly the utilisation of new and improved composts by farmers. Two weaknesses that can be identified, and that perhaps could and should be addressed, concern (i) the use of UK based scientific staff for project activities who were not involved in project development or research undertaken in the earlier stages of the project; (ii) problems relating to levels of funding for, and relations between, a component of the overseas project team.

19. What are the advantages and disadvantages of developing a combined approach to pest and soil fertility management?

- Soil fertility management by farmers can and does have an obvious effect on plant nutrition and plant growth and vigour. However, it can also have a significant influence on the soil microbiota, including the prevalence and activity of soilborne pests and pathogens and those beneficial organisms that may help to reduce their potentially damaging effects. Conversely pest management approaches, such as burning and removal of trash, can have a significant effect (usually detrimental) on soil fertility. As such, and where possible, soil fertility and crop health (particularly in relation to management of soilborne pests and diseases) should not therefore be considered in isolation but treated as one and as part of an IPM or ICM ‘package’. This in itself reflects the attitude of farmers themselves, who tend to view and manage their crop holistically (partly to reduce costs and labor inputs) and who would, presumably, be more receptive to improved management strategies based on this approach. It should also be remembered that resource-poor farmers, such as those that this project seeks to assist, often cannot afford or have access to pesticides for pest control and rely heavily on cultural management practices, including improvements in soil fertility.

Appendix III: Report of in-country farmers survey

Integrating pest management and soil fertility management

Report of an in-country survey on farmers' knowledge and perceptions 17 – 24 January 2000

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EXECUTIVE SUMMARY

A survey was conducted on vegetable systems as a model with consultations with stakeholders in NRSP and CPP projects in Ghana and in the UK where soil fertility and integrated pest management research are practiced. The aim was to identify research gaps for the development, promotion and dissemination of technologies for soil fertility and insect pest management. Farmers were interviewed on their perceptions and knowledge on soil fertility and insect pest and disease management, and their interactions with crop health. Constraints to crop production and resultant constraints from improved soil fertility and pest management were also investigated. In addition, partnerships and processes involved in the formulation of the projects, uptake pathways and training methodologies were also covered in the survey. Farmers were able to differentiate soil fertility and soil borne pests and diseases problems. Major soil fertility management practices of farmers included shifting cultivation, crop rotation, application of chemical and organic fertilizers and the use of green manures with species such as *Crotalaria*, *Canavalia* and *Mucuna*. Knowledge of pests and diseases above and below ground was common to all the respondents. However, not many farmers controlled soil borne diseases. In a few cases, farmers drenched the soil during the application of fertilizer solutions with pesticides in an attempt to salvage insect pests and disease problems. With regard to control of insect pests and diseases above the ground, the farmers applied a number of pesticides (chemical, biological including botanicals such as neem). Major pests identified included fruit borers, chewing caterpillars, aphids, thrips, leaf miners and whiteflies. Principal among the diseases were those of nematodes and fungi. Major production constraints confronting farmers were soil fertility management, water availability and diseases. The survey revealed that as a result of improved soil fertility management practices, problems such as secondary pest situations occur, e.g. the growth of green manure. In addition, insect resistance to pesticides and the possible introduction of noxious weeds were indicated to be a threat. With the exception of the compost project, which did not include training of farmers, farmers from the other projects whose farmer counterparts were interviewed had various levels of involvement in the formulation of the projects. Integration of IPM and SFM was however only partially covered in the projects. There is therefore the need to link soil fertility and pest management. Based on the results, recommendations have been made to address this gap. This however can only be achieved through a well planned project specifically designed to address IPM*SFM issues.

Contents

Introduction and background

Vegetables constitute an important component in diet and are cultivated in every continent to satisfy consumer demands. The high demand in recent years has given rise to intensive cultivation with the resultant problems of soil fertility, insect pests and diseases among many others. Attempts to salvage the above problems have also created many environmental issues of great concern worldwide.

The concept of holistic management of a crop to produce healthy plants that are able to yield well and resist pest attack without reliance on pesticide inputs is central to the development of IPM farmer-field schools. These utilise principles of group experiential learning to empower farmers to adopt ecology-based management systems. In Africa, resource-poor farmers (and extensionists) are faced with the problem of attempting to increase production from systems constrained by the interaction of water shortage, soil fertility and pests. This has in Ghana (and elsewhere) attracted considerable attention from soil scientists, who see the participatory learning approach as having value in disseminating messages regarding soil fertility management and through feedback mechanisms from such groups, enabling farmers to have more influence in determining research agendas.

Most projects established in the past targeted soil fertility management or pest management without a serious effort of linking the two. To improve crop production in a sound and sustainable manner, there is the need to integrate IPM and SFM.

The interrelationship of pest damage and soil fertility has been addressed in recent DfID-CPP funded projects concerned with the use of composts to recycle organic wastes in the Kumasi peri-urban region and their effects on crop health and productivity. Other aspects of soil improvement have been addressed recently through DfID-NRSP funded programmes concerned with improvement of soil fertility. In Ghana, these have included use of peri-urban compost in the Ashanti region (Kumasi) and use of green manures in the Brong-Ahafo region. Also in the Greater Accra region, farmers have used cow dung and poultry manure to improve soil fertility.

The objective of the in-country survey was to interview farmers involved in the above projects to identify gaps in the implementation of pests and soil fertility management, in order to derive researchable constraints in the area of IPM * SFM integration.

The results are to be presented to the CPP to inform the CPP on research needs on the developmental process of research, promotion and dissemination of technologies for the management of soil fertility and pests. It used vegetable systems in Ghana as a model for study and it consulted with farmers and other stakeholders in NRSP and CPP projects in Ghana and in the UK involved in projects where soil fertility and pest management research is integrated.

Terms of reference

The in-country survey team was requested to visit 3 projects:

1. National IPM project
2. Kumasi compost project
3. Integrated food crop systems project

Per project, the following issues were to be explored during interviews with farmers who had been exposed to that project:

FARMER PERCEPTIONS

1. Do farmers differentiate between soil fertility problems and soil borne pests and disease?
2. Describe farmers' soil fertility management practices and if possible describe their knowledge of soil fertility (i.e. knowledge of the value of organic matter, manures, fertilisers, soil structure).
3. Describe farmer's knowledge of pests and natural enemies (above and below ground) and pest management. What pest management practices do farmers use?
4. What aspects of the interaction between soil fertility, pests and crop health are farmers aware of?

CONSTRAINTS

1. What are the major constraints to crop production?
2. What are the constraints of any nature to improved pest management?
3. What are the constraints of any nature to improved soil fertility?

PARTNERSHIPS AND PROCESSES

1. How were farmers involved in the formulation of the project?
2. Describe the uptake pathways / training methodology used in the project.

Methodology

The survey looked at gaps in the practical integration of IPM and SFM by farmers that were exposed to projects focusing on IPM or SFM but did link IPM and SFM to a certain extent. The survey targeted farmers who were trained or had benefited from the selected projects. It must be stated that the Kumasi peri-urban compost project did not train farmers. The respondents were inhabitants of the villages where the experiments were located.

Farmer groups ranging from two to five were interviewed. In addition, individual farmers were also interviewed, ranging from five to eight individuals per project.

Results

1. NATIONAL IPM PROJECT (NIPMP)

Background information

The team visited three sites namely Weija, Dzorwulu and Mataheko. Each site operate under different land use systems. Farmers at Weija produce their crops under irrigation. Those at Dzorwulu do intensive management of the land. These are basically urban gardeners while those at Mataheko operate under subsistence conditions. The observations below are summaries of the interviews at these three sites.

Major vegetable cultivated by farmers under this project in the various locations include pepper, cabbage, tomato, okra, cauliflower, sugar beat, cucumber, onions, carrots, lettuce, sweet pepper, tinda and some other leafy vegetables.

Farmer perceptions

- *Differentiation between soil fertility problems and soil borne pests and diseases*

Farmers interviewed were aware of the differences between soil fertility and soil borne pests and diseases. They were aware that poor growth of plants resulted from lack of nutrients in the soil due to continuous cropping and lack of rotation. Knowledge of farmers on certain symptoms of plants attributed to lack of nutrients in the soil was good. The farmers were aware of nematode diseases, and could differentiate them from lack of soil nutrients. Also, farmers were aware that some insects inhabited the soil and caused damage to their crops. The farmers indicated that some soils could be high in organic matter and yet produce an unhealthy crop. They attributed this to possible attack by insect pests and diseases. Some farmers also indicated that the growth of certain plants were indications of poor soil fertility.

- *Farmers soil fertility management practices and knowledge of soil fertility*

Farmers normally cultivate their vegetables during the rainy season. In Weija however, they cultivate the vegetables on irrigated lands during the dry season. Generally, these farmers have poor perceptions and knowledge of soil related problems since they still practice some form of shifting cultivation. However, farmers in Dzorwulu who cultivate the land throughout the year have very good knowledge of soil fertility management systems.

Some farmers did not use external sources of organic matter or chemical fertilizer because of its bulkiness, distance from source to their farms and high prices.

Some farmers however applied organic manure or chemical fertilizer to boost growth. Farmers who apply organic matter complained of difficulty in getting the organic manure. Poultry manure was said to be readily available and farmers frequently applied this source of organic matter.

Except for farmers in Dzorwulu, who practice intensive cultivation system, all the other farmers depend mostly on the shifting cultivation system as a major means of replenishing soil fertility. When the soil fertility is exhausted, the farmers move to new areas of good soil fertile. The land is fallowed for between one and three years in order to regenerate its fertility. Normally no soil replenishing legumes plants are planted.

In the intensively cultivated lands at Dzorwulu, farmers also practiced the intercropping system. This is based on the assumption that plants differing in root depths will absorb nutrients from different soil depths. Consequently, these farmers intercrop by taking into consideration the root system and plant architecture. Normally, the plants differing in root size and structure are intercroppped. For example carrots and cabbages are intercropped.

Farmers rotate their crops based on the knowledge of possible disease and pests and nutrients uptake requirements of previously cultivated crops. For example, sweet pepper is cropped after carrot. This is done to reduce pest and disease incidence and maintain soil fertility.

The farmers, being beneficiaries of the farmer field schools were aware of the role and importance of organic matter to their crops. Some of the readily available organic materials used included cow-dung and poultry manure.

- *Farmer's knowledge of pests and natural enemies (above and below ground) and pest management*

Below ground:
The respondents were well aware of diseases and insect pests in the soil. Underground insect pests listed by the farmers are termites, crickets, grubs (larval forms of beetles), and red and white ants. The termites were reported to be commonly associated with pepper. According to the farmers, the red and white ants destroy the roots of the vegetables cultivated.

The level of control of soil borne diseases and insect pests as indicated by the farmers is shown below in table 1.

Table 1. Level of control of soil borne insect pests and diseases (NIPMP)

Insect pests		**Diseases**	
Yes	No	Yes	No
25%	75%	37.5%	63.5%

Generally, fewer farmers controlled insect pests and diseases in the soil.

Table 2 below indicates pesticides used by farmers under the National IPM project to control soil borne insect pests.

Table 2. Pesticides used to control soil borne insect pests (NIPMP)

Name of pesticide	**Rates**	**Frequency**
Karate	40ml/knapsack	As and when necessary
Actellic	Not specified	
Neem seed solution	**2 Milo tins/knapsack**	Twice a week

The farmers indicated to drench the soil with these pesticides.

With respect to the diseases, the farmers had various ways of managing them. Some farmers grew maize after a vegetable crop to reduce the incidence of nematodes. Others applied Furadan to the soil around the plant at transplanting. Some farmers also reported to apply poultry manure and neem seed solution to mitigate the problem of diseases.

None of the farmers knew about any natural enemies of the insect pests that inhabit the soil.

Above ground:
All the farmers under this project were aware of insect pests and diseases above the ground. Insect pests and diseases observed by farmers are listed in table 3 below.

Table 3. Insect pests and diseases above the ground (NIPMP)

Insect pests	**Diseases**
Caterpillars (borers), aphids, Mirids, grasshoppers, Thrips, leaf miners, *Plutella xylostella*, *Hellula undalis* and *Ceratitis capitata*.	Curling of leaves, *Septoria* spp., fungal and viral (suspect)

The caterpillars were indicated to attack tomato. In Ghana *Helicoverpa armigera* is the main lepidopteran borer of tomato. The thrips were said to associated with onions while *P. xylostella* and *H. undalis* infested cabbage and related Cole crops. *C. capitata* was said to attack pepper.

All the farmers interviewed applied pesticides to control insect pests above the ground. Some 12.5% did not control the disease problems on their crops. Pesticides applied against insect pests above the ground are listed in tables 4a.

Table 4a. Pesticides applied to control insect pests above ground

Name of pesticide	**Rates**	**Frequency**
Neem seed solution	50g/l	Weekly
Neem leaves + pepper	80g/l	Weekly
Decis (Deltamethrin)	10 ml/knapsack	Twice a week
Karate (now replaced with Decis)	40ml/knapsack	Weekly
Dipel 2X (biopesticide)	15g/knapsack	Weekly

With respect to diseases table 4b summarizes the pesticides applied for their control.

Table 4b. Pesticides applied to control diseases above ground

Name of pesticide	Rates	Frequency
Topsin Benlate Kocide Dithane M-45 Champion K-4 Neem seed	Not specified ,, ,, ,, ,, ,, ,, 30g/knapsack not specified 50g/l	Fortnightly In most cases as and when necessary

Farmers also indicated to use Superflos, which is a plant hormone (growth promoter). It was claimed to alleviate the disease problems as a result of the vigorous growth experience by its application.

All the respondents had knowledge about natural enemies in pest management. Among those listed were dragonflies, spiders, ants, preying mantids, coccinellid beetles and lizards.

- *Awareness of the interaction between soil fertility, pests and crop health*

Farmers normally rested the land between 1 – 3 years and allowed native weeds to grow on their lands. They judged the poor fertility status of their soils by poor crop growth and indicator plants such as grasses. Farmers were of the opinion that they could reduce soil disease problems by applying some organic matter.

Constraints

- *Major constraints to crop production*

The major problems of farmers were:

1. Water availability and soil fertility management
2. Low organic matter content of the soil
3. Unpredictable rainfall pattern. Irrigation is only available in few areas (Irrigation projects)
4. Fluctuating market prices for agricultural produce
5. Lack of certified true seeds for most farmers outside Accra
6. Lack of easy access to water for irrigation purposes.

From the protection standpoint, diseases were noted as the most serious constraint to crop production.

Weeds were identified as a constraintd to production in the Weija and Mataheko areas. Common weeds listed by the farmers included *Cyperus* spp., Buffalo grass and *Euphorbia hirta*.

- *Constraints of any nature to improved pest management*

Neem was indicated to be less potent on tomato fruit borers and pests of onions and cucumber. In addition some farmers complained about the time spent in preparing the extracts of neem. This prompted the farmers to switch to Dipel 2X (a bio-pesticide) and in some cases Karate (a chemical insecticide) because of the quick knockdown effect. The Karate is now being replaced by Decis, which is claimed to have a low persistence level. Neem seed extract was also noted to affect cauliflower at the early stages of its growth as well as hardening lettuce leaves.

The non-effect or less efficacy of neem as stated by the farmers was probably due to the use of lower concentrations. On the other hand, its effect on cauliflower and lettuce was likely to be due to higher concentrations.

The use of the same concentration of neem seed extract to control insect pests of vegetables under this project needs to be revised. Different concentrations of pesticides are required to effectively control different insects. Secondly, farmers should be taught the mode of action of common pesticides used by them; especially the botanicals and *Bacillus thuringiensis* based biopesticides. This would enable the farmers appreciate what they are doing and what they should expect after application. For example, neem could act as an insect repellant, an anti-feedant and an insecticide depending on the concentration used as well as the target pest.

- *Constraints of any nature to improved soil fertility*

These include:

Lack of adequate organic matter for application. The long distance at which cow-dung and/or poultry droppings have to be carted to farmers plots.

Farmers also complained about the bulkiness and foul smell of the available organic materials.

Farmers were anxious about the possibility of introducing grasses to their plots, when they apply cow-dung.

Farmers were aware of the importance of soil structure through ploughing and proper tillage methods. However, they lacked proper implements to adequately till the land.

Most farmers are not aware of the importance of soil texture and structure in crop productivity. Except farmers in Dzorwulu, perceptions on soil properties such as soil texture and structure were generally poor. For example, some farmers think black soils are richer in organic matter.

Few farmers knew that with increased soil organic matter content, certain crop diseases could be avoided or controlled.

Partnerships and processes

- *Farmers involvement in the formulation of the project*

With respect to the NIPMP, farmers were involved from the beginning of its formulation. A national survey was conducted to gather baseline information from the farmers on vegetable cultivation and production constraints. Subsequent to this, a series of workshops were organized to discuss the survey results, design experiments and discuss experimental results after their execution. During the workshop a series of decisions were taken with the active participation of farmers.

- *Uptake pathways / training methodology used in the project*

Selection of farmers was either through associations or communities, taking the farming system of the area into consideration.

Farmers were trained mainly through the method of adult education (experiential learning). The farmers and researchers/trainers went to the field together to gather information on factors militating against the production of their crops (mainly on diseases, insect pests and weeds) as well as beneficial arthropods. Collections of these samples were taken for Agro Eco-Systems Analysis (AESA). Based on results of the AESA, the farmers/trainers deliberated on decisions best suited for management of the diseases, pests and disease problems on hand. The farmers were also taught how to identify beneficial arthropods for a better appreciation of what goes on in their farms.

2. KUMASI COMPOST PROJECT (KCP)

Background information

It is worth mentioning that this project did not directly deal with farmers. It was a researcher managed project and investigated the use of compost to control insect pests and diseases. The project applied compost prepared by a sewage company and focused on soil fertility and integrated pest and disease management. However, farmers from the villages (Daaku and Swedru) where the experiments were sited were interviewed.

Vegetables grown by the farmers included tomato, cabbage, pepper, okra and eggplant.

Farmer perceptions

- *Differentiation between soil fertility problems and soil borne pests and diseases*

Farmers were aware of soil fertility problems and attributed this to poor performance of their crops. They could differentiate between soil fertility problems and soil borne insect pests and diseases by their knowledge of insects that inhabit the soil and diseases such as nematodes. Their knowledge about the above problems was rather low.

- *Farmers soil fertility management practices and knowledge of soil fertility*

Most of the farmers interviewed did not appreciate the importance of soil texture and structure to crop growth. This may be due to the fact that these farmers cultivate vegetables during the rainy season when the soil is quite soft. Farmers could not differentiate between soils that are rich in or poor in organic matter. The farmers described their land as being more sandy and were generally aware of soil fertility problems. They attributed poor soil fertility to poor crop growth. Most farmers knew about the value of organic matter in crop growth.

The farmers indicated that the organic matter content was low and as a result added some amendments. Both organic manure (poultry manure) and chemical fertilizers were applied to the soils by the farmers.

The farmers also appreciate the importance of soil structure, because they realized the good yields of crops on the researcher compost plots as compared to what they grow. They fallowed their lands but for less than two years. The farmers allowed weeds to occupy land during the fallow period.

- *Farmer's knowledge of pests and natural enemies (above and below ground) and pest management*

Below ground:
Knowledge about soil borne diseases and insect pests was common to all the farmers interviewed.

Insect pests commonly observed underground as stated by farmers are termites, millipedes, crickets, grubs (larval forms of beetles), centipedes and red ants. The farmers were aware that a host of diseases inhabit the soil but could identify only nematodes.

With regard to control of soil borne diseases and insect pests, none of the respondents indicated to do so. A few farmers (less than 10%) mentioned lizards and toads as natural enemies to the insect pests in the soil.

Above ground:
All the farmers interviewed had a good knowledge of insect pests and diseases above the ground. Common among these insect pests and diseases as observed by farmers are listed in table 5.

Table 5. Insect pests and diseases above the ground (KCP)

Insect pests	**Diseases**
Caterpillars (armyworms and borers), aphids, whiteflies, grasshoppers, *Podagrica* spp., leaf miners, *Plutella xylostella*, *Hellula undalis*, *Nisotra* spp. and grasshoppers	Fungal diseases (*Fusarium*, *Alternaria*, *Septoria,* damping off), curling of leaves, flower abortion,

All the farmers apply pesticides to control insect pests above the ground. However, some 10% did not control the disease problems on their crops. Pesticides applied, their rates and frequency against insect pests above the ground are shown in tables 6a.

Table 6a. Pesticides applied to control insect pests above ground

Name of pesticide	**Rates**	**Frequency**
Karate	40mls/knapsack	Fortnightly
Dipel 2X (biopesticide)	15g/knapsack	Weekly
Cymbush	25mls/knapsack	Weekly

Here, the farmers complained about armyworms (*Spodoptera* spp.) in addition to the borer (*H. armigera)*. The farmers also complained about *Podagrica* spp. and *Nisotra* spp. on okra. *P. xylostella* and *H. undalis* were reported on cabbage while whiteflies and aphids were said to attack tomato.

With respect to diseases, table 6b summarizes the pesticides applied for their control.

Table 6b. Pesticides applied to control diseases above ground (KCP)

Name of pesticide	**Rates**	**Frequency**
Furadan	Not specified	once
Dithane M-45	,, ,,	
Kocide	½ pkt/knapsack	monthly on others but weekly on tomato

About 75% of the respondents had knowledge about spiders and surphid flies as natural enemies to the insect pests on their crops. Spiders are general feeders while the surphids mainly attack aphids.

- *Awareness of the interaction between soil fertility, pests and crop health*

Farmers interviewed knew about the collective effects of the above factors but had very little knowledge about the actual interactions. This is not surprising because the compost project did not train the farmers. The project was researcher managed and tested mainly the effect of compost on diseases and pests.

Constraints

- *Major constraints to crop production*

Soil fertility was listed as the most serious constraint. This was followed by water availability since these farmers depended on only rainfall.

With respect to crop protection, diseases were mentioned as the most serious constraint. Weeds competing with crop production in these areas include *Cyperus* spp., other grasses, *C. odorata* and *Euporbia hirta.*

- *Constraints of any nature to improved pest management*

Farmers were not aware of any constraint to improved management of their crops. This project did not train farmers and therefore was not exposed to any improved management practices.

- *Constraints of any nature to improved soil fertility*

Although there are a lot of poultry droppings in Kumasi, these farmers were not using them. The main reason was due to the cost of transporting the manure over long distances.

Partnerships and processes

- *Farmers involvement in the formulation of the project*

As stated above, this project was researcher managed and did not have any farmer involvement.

- *Uptake pathways / training methodology used in the project*

None.

3. INTEGRATED FOOD CROP SYSTEMS PROJECT (IFCSP)

Background information

Farmers trained under this project cropped vegetables such as cabbage, tomato, pepper, eggplant and okra. This project had three facets with funding from three donors. These were agronomy/soil fertility, protection and post harvest handling. The survey gathered information on the agronomic/soil fertility and protection components. The main objective of the agronomy/soil fertility project was to introduce cheap and available technologies within farmer's immediate environment to improve upon soil fertility with the ultimate aim to increase crop yield. The protection aspect focused on identification of diseases, insect and weed pests associated with vegetable production and to a limited extent their natural enemies.

Farmer perceptions

- *Differentiation between soil fertility problems and soil borne pests and diseases*

The interrelations among the above was known to all the farmers interviewed. Farmers were aware of the soil fertility needs as they expressed them during the survey. Their knowledge of insect pests and diseases and damage to crops also confirms this.

- *Farmers soil fertility management practices and knowledge of soil fertility*

All the farmers interviewed knew about soil fertility problems. They described their soils as being loamy. They however indicated that the organic matter content was low.

As a result of the low organic content of the soils, the farmers applied various methods to improve upon the soil fertility. There were however a few farmers who said they did not add any organic matter but applied chemical fertilizer. Organic manure used by the farmers was poultry manure while others planted green manure as taught by the IFCSP. The absence of seed inoculation with the specific rhizobia made effective dinitrogen fixation by these legumes doubtful. The only positive contribution was the addition of organic matter to improve the structure of the soil. The farmers also practiced shifting cultivation as a means of regenerating fertility. The majority of the farmers fallowed the land for up to two years and used indicators such as poor crop growth and the colour of the soil to determine the fertility of the soil.

- *Farmer's knowledge of pests and natural enemies (above and below ground) and pest management*

Below ground:
All the farmers interviewed had knowledge about soil borne diseases and insect pests below the ground. Underground insect pests listed were termites, crickets and red ants. Among the diseases, nematodes were mentioned by about 90% of the respondents while some 10% listed nematodes as well as damping off. Table 7 is a summary of the level of control of soil borne diseases and insect pests.

Table 7. Control of soil borne insect pests and diseases (IFCSP)

Insect pests		**Diseases**	
Yes	No	Yes	No
60%	40%	20%	80%

The majority of the respondents (60%) managed the insect pests in the soil. Only 20% attempted to control the diseases.

Of the 20% who indicated to control the diseases, some reported to use *Crotalaria* spp. as a trap crop to reduce nematode infection. Others used treated seeds while the rest uprooted and burned the diseased crops. Pesticides used to control insect pest in the soil are indicated in table 8 below together with their rates and frequency.

Table 8. Pesticides used to control soil insect pests (IFCSP)

Name of pesticide	**Rates**	**Frequency**
Polythrine Karate Dursban	30 ml/knapsack (young plants) 50 ml/knapsack (old plants) 40 ml/15 l	Weekly for tomato and two weekly for okra and eggplant

According to the farmers, they mixed the insecticides with a fertilizer solution before application. The majority of the farmers used Polythrine (table 8). Only a few farmers indicated to use Karate and Dursban to control the insect pests in the soil. Some respondents also applied neem seed powder to control the soil borne diseases. They used it to dress the seeds before nursing.

None of the respondents under this project indicated to have any knowledge about natural enemies in the soil. As stated above the emphasis on protection was not on insect pest management though chemical pesticides (mainly) were applied to mitigate insect pest and disease problems.

Above ground:
All the farmers trained under this project had a substantial knowledge about insect pests and diseases above the ground. Common insect pests and diseases listed are indicated in table 9.

Table 9. Insect pests and diseases above the ground (IFCSP)

Insect pests	**Diseases**
Lepidopteran fruit borers, aphids, whiteflies, grasshoppers, *Podagrica* spp.	Fungal diseases (*Fusarium*, *Alternaria*, *Septoria*, curling of leaves, blackening of stems, flower abortion,

Eggplant was reported to perform poorly after one season of growth. All farmers indicated to control the insect pests and diseases above the soil. The fruit borers were mainly *H. armigera* on tomato. *P. uniformis* was reported on okra.

Farmers mainly applied chemical insecticides (table 10a and b).

Table 10a. Pesticides applied to insect pests above ground (IFCSP)

Name of pesticide	Rates	Frequency
Karate	Not specified	Not regular
Thiodan	20mls/ks	Weekly/fortnightly
Polythrine	30ml/15l young plants 50mls/l old plants	Weekly for tomato and two weekly for okra and eggplant
Cimethoate	not indicated	twice a week

Diseases on the other hand were controlled by use of fungicides, botanical pesticides (biocontrol) and by use of plant growth hormones (table 10b).

Table 10b. Pesticides applied to control diseases above ground (IFCSP)

Name of pesticide	Rates	Frequency
Dithane M-45 and M-22	Rates varied from farmer to farmer	Varied
Growfol (plant food)	Indicated to use small amount	
Stomp	Not specified	
Benlate/Benomil	,,	
Kocide	,,	
Neemol	,,	

According to the farmers, the Growfol helped open up the curls in the diseased leaves.

Even though the respondents had knowledge about spiders, they did not know their contribution to pest management. It was however learnt from one farmer that the GTZ-ICP Project in Sunyani had introduced the use of natural enemies to some farmers.

- *Awareness of the interaction between soil fertility, pests and crop health*

Farmers had knowledge of the above factors acting together to affect their crops. They were aware that certain insects are vectors of some diseases. They also knew that poor soils were more susceptible to diseases.

Constraints

- *Major constraints to crop production*

The major factors militating against crop production in this area were soil fertility and water availability.

From the crop protection standpoint, diseases were ranked as the most important constraints to production of vegetables. Major weeds identified in this area were mainly grasses such as *Cyperus* spp. and *Imperater cylindrica*. Broad leaved weeds include *C. odorata*, *Euphorbia hirta*, *Centocema* spp.

- *Constraints of any nature to improved pest management*

-Development of pesticide resistance, particularly to the Diamondback Moth when pesticides are used continuously.
-Sometimes despite the addition of fertilizer, crop yield remained the same (need for soil testing; ion exchange, mineral imbalances etc),
-Cost of inputs
-Extra labour
-Introduction of green manure has given rise to some new insect pests.

- *Constraints of any nature to improved soil fertility*

Some farmers complained about the difficulty in getting poultry manure as well as the cost of transportation. Perhaps this is why the IFCSP introduced the use of green manure to certain areas of the region where animal manure is scarce.

Partnerships and processes

- *Farmers involvement in the formulation of the project*

The farmers provided valuable information during initial surveys conducted by staff from the Ministry of Food and Agriculture (MoFA), local scientists and scientists from Natural Resources Institute (NRI) from the United Kingdom. The final formulation of the project was based on farmers' inputs resulting from the surveys. Unlike the NIPMP, the IFCSP did not organize any workshop prior to the commencement of the project.

- *Uptake pathways / training methodology used in the project*

Farmer beneficiaries of the project were selected during the initial surveys conducted. Contacts were made through the Agricultural Extension Agents (AEA's) of MoFA at the various districts, who then recommended some vegetable farmers to respond to the survey questionnaire. These initial contact farmers also recommended others colleague farmers within their localities to the survey team.

The project identified the various ways to improve upon soil fertility management in the four districts surveyed. Even though the farmers were aware of the availability of animal manures, only a few applied them in soil fertility management. These technologies were however introduced to the farmers in addition to the use of green manure such as species of *Mucuna*, *Canavalia* and *Crotalaria.*

In each district, farmers were presented with the various soil fertility options. This was then demonstrated on small plots with farmers' practice as control. AEA's visited regularly to tend to the experiments while project staff visited and collected data at fortnightly intervals. In addition to each data collection, farmers' perceptions on the improved soil fertility options being demonstrated were also recorded. The farmers were then given the chance to choose either the improved technology or continue with their old methods. A greater number of the farmers appreciated the improved technologies introduced by the project. The adoption level is however yet to be established.

CONCLUSIONS AND RECOMMENDATIONS

Farmers have a good knowledge about the insect pests and diseases below and above the ground but do very little to control the underground diseases and pests. The most serious constraint to production from the protection point of view is diseases. With the exception of the National IPM project, the others did not teach the farmers about the use of natural enemies.

It must be emphasized that the projects visited were either more inclined to IPM or SFM but not their integration as this project seeks to introduce in Africa. For example, the NIPMP in Accra emphasized on IPM (use of neem, mainly); the KCP in Kumasi sought to address SFM problems as in the case of the IFCSP based in Sunyani. There is the need to address the integration of IPM*SFM in all attempt to produce higher yields and healthy food crops in a sustainable and environmentally safe condition. A proper integration of soil fertility, insects and weed pests, and disease management is expected to increase farmer profits in an overall attempt to alleviate poverty in Africa.

As noted, some farmers use chemical fertilizers to maintain soil fertility. Although on the average chemical fertilizers are available, most farmers complain about the high cost of these chemical fertilizers. Perhaps there is also the need to integrate the use of chemical and organic fertilizers in SFM to reduce cost, pests and disease incidence, and improve upon growth and yield.