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.

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).


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


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 fertility 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.

**Farmer perceptions and management of soil fertility and pest issues**

Farmer perceptions and management of soil fertility and pest 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.

Farmer 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 Ahafo 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.
5. Organic matter in relation to nematode biocontrol interaction.
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.
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.

B. SYNOPSIS OF THE INTERNATIONAL MISSION REPORT

Partnerships
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.

Training and knowledge
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

Research needs (CPP researchable constraints)
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.

Strategic research
• 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
Annex 1. Extract from;


4.3 Ghana - Forest zone

4.3.1 Introduction

Kumasi and Tarkwa lie in the forest zone of southern Ghana which can be divided into two zones depending on rainfall. Kumasi (Ashanti region) lies in the moist semi-deciduous forest region were annual rainfall varies from 1400 to 1650 mm. Tarkwa (Western region) is found further south in the wet evergreen forest zone where rainfall varies from 1,780 to 2,000 per annum. The farming system is dominated by the mixed cropping of tree (cocoa and oil palm) and food (cassava, maize, yam, cocoyam, plantain) crops. Sole cropping of commercial vegetables, rice and maize is also common. Sheep, goats and chickens are owned by most households but cattle numbers are very low.

The Ashanti region (104 persons/km$^2$) was first opened up for cocoa production in the 1920’s as farmers migrated from the Eastern region where cocoa crops had been devastated by swollen shoot disease. The Western region (59 persons/km$^2$) is considered to be the newest, and last, area to be opened up to agriculture with migration starting in the 1960’s and still continuing today. Farmers migrated to this last ‘agricultural frontier’ to establish cocoa farms as land became scarce, soils poor and rains less in the other regions of the forest zone. These cocoa farms are seen as an investment and security for future generations of the family.

4.3.2 Farmer characteristics

40 male and 40 female farmers were interviewed. The age distribution of farmers interviewed and their education level are shown in Tables 9 and 10. There was a significant difference in the educational level of the male and female farmers with male farmers having greater access to middle school education.

<table>
<thead>
<tr>
<th>Age</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-39</td>
<td>36</td>
</tr>
<tr>
<td>40-59</td>
<td>51</td>
</tr>
<tr>
<td>60+</td>
<td>13</td>
</tr>
</tbody>
</table>

Ninety % of farmers hired labour on a casual basis. This labour is used primarily for initial land clearance prior to cultivation and for weeding of the growing crop.
Thirty three % of farmers were using credit facilities. This was usually from family and friends and was without interest. However, a few farmers had borrowed from money lenders with 50-100% annual interest rates.

Table 10. Educational level of farmers interviewed in Ghana (forest zone).

<table>
<thead>
<tr>
<th></th>
<th>None</th>
<th>Primary</th>
<th>Middle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male (%)</td>
<td>30</td>
<td>12</td>
<td>58</td>
</tr>
<tr>
<td>Female (%)</td>
<td>55</td>
<td>17</td>
<td>28</td>
</tr>
<tr>
<td>Significance</td>
<td>NS</td>
<td>NS</td>
<td>p&lt;0.01</td>
</tr>
</tbody>
</table>

Forty two % of farmers had some form of additional income. The men were involved in trading, construction and the brewing of local alcohol. The women also traded and processed local foodstuffs such as cassava and palm oil. All these activities were 'part-time'. Only one farmer had an additional full-time income as a teacher.

4.3.3 Land acquisition

Land may be acquired from three sources, inherited, rented or sharecropping. Seventy eight % of farmers cultivate family land. All land traditionally belongs to the chief and farmers can obtain land direct from the chief or, more commonly, from the head of the family. Often a gift and/or yearly sum of money is required for permission to farm the land. Title deeds to the land are not gained but usufructory rights, either in the form of a long term lease, or guaranteed security to the land whilst a crop (particularly cocoa) is being cultivated, is given.

Twenty four % of farmers rent land. This was found to be most common in the peri-urban areas where land shortages can exist. The total area of land rented varied from 0.4-4 ha (1-10 acres) but the average plot size within this was 0.4 ha (1 acre). Although the renting agreement could be established on a yearly basis, renting plots of land per season appeared to be more common.

Fifteen % of farmers were involved in share-cropping. Although terms and conditions vary considerably the concept is based on the reasoning that the harvest is distributed according to the inputs of land, labour and materials by the farmer and the landowner. Sharecropping is most common in the rural areas and usually applies to the establishments of cocoa plantations where the harvest is shared between the tenant farmer and landowner.

It is interesting to note that of the 22% of farmers who were not farming family land, none were both renting and sharecropping land, but rather either one or the other.

4.3.4 Farm characteristics

Farms consist of cropped land, either food or plantation tree crops, and fallow land. Table 11 shows significant (p<0.001) differences area of farms, cropped land and fallow land between peri-urban and rural areas.
Table 11. Farm size and land use of the farms surveyed in the forest zone of Ghana

<table>
<thead>
<tr>
<th></th>
<th>Mean farm size (ha)</th>
<th>Cropped land (ha)</th>
<th>Fallow land (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peri-urban</td>
<td>3.2</td>
<td>2.4</td>
<td>0.8</td>
</tr>
<tr>
<td>Rural</td>
<td>8.8</td>
<td>5.2</td>
<td>3.6</td>
</tr>
</tbody>
</table>

The farm can also be divided into the main farm, which is usually some distance from the homestead, and the homegarden. Homegardens refer to small growing areas in close proximity to the homestead and are a common feature in this zone. Where the village is made up of a nucleated cluster of houses, these gardens are planted by those who live on the periphery of the village, although it is possible for people living in the centre to acquire land on the periphery. If the village is made up of scattered households then each will have its own homegarden. Plantain and bananas, with coconut in the wetter areas, are the most common crops, with additional vegetables, food and tree crops also planted. However, if annual crops are planted the garden needs to be fenced against freely grazing animals. The main constraints to the development of such gardens is lack of suitable land, the threat of destruction by animals, and the time involved in garden establishment and maintenance. They are seen as a source of immediate food which can be used in the household or gained easily when the farmer is sick. The women are responsible for attending to these homegardens.

On the main farm three main soil types were identified by the farmers which affect where crops are grown. Marshy soils are flooded in the wet season and remain moist during the dry season. They are suitable for crops such as sugar cane and rice which high water requirements and for dry season vegetable production to minimize the need for irrigation. If no marshy land is available, dry season vegetables are located as close as possible to a water source. The soils are too moist for maize and cassava but are often intercropped with plantain, banana and colocasia. Sandy, red soils with a low fertility were considered suitable for maize and cassava production. Black clay soils of higher fertility are used for all crops except maize and cassava.

4.3.5 Cropping system

There are three main categories of crops; perennial tree crops, vegetables and staple food crops. Cocoa and oil palm are the two main commercial plantation crops. Forty six % of farmers interviewed grew cocoa of whom 89% were in rural areas. Twenty five % of farmers grew oil-palm, the majority of whom were found around the wetter areas of Tarkwa.

Vegetables grown for household purposes include garden egg, tomato, okra and pepper. Cabbage, lettuce, carrot, green pepper and onion were grown more for sale. Maize, rice, plantain, banana, cassava, cocoyam, yam, cowpea and groundnuts were grown as staple crops both for home and commercial use.

Commercial food and vegetable production is not limited to peri-urban areas. Farmers in rural areas also have access to markets as long as the road network allows urban ‘middlemen’ to come and collect the produce on local market days. However it does mean that the farmer has less bargaining power and receives lower prices than his peri-urban counterpart.
Mixed cropping is a common feature of the farming system. The main mixes found were; cocoa and food staples; plantain and other food staples; maize and cassava. Due to this high level of intercropping, the use of crop rotations is minimal and hard to identify.

### 4.3.6 Soil fertility management

#### 4.3.6.1 Inorganic fertilizers

##### 4.3.6.1.1 Use

Forty three % of farmers used fertilizer of whom 76% applied this fertilizer to vegetable crops, the remainder was used on oil palm, maize and yam. The percentage of farmers using fertilizer was significantly (p<0.01) higher in peri-urban than in rural areas, reflecting the greater intensity and commercialization of vegetable production closer to the market centre. Fertilizers were generally not used on food crops such as yam, cassava or plantain as these are more for home consumption and it is widely acknowledged that fertilizer affects the taste and storage characteristics of these crops. The awareness of potential negative effects of fertilizer on the soil was very low. The only evidence being found with some farmers in peri-urban Kumasi were fertilizer use is the most intensive.

#### 4.3.6.2 Rotational bush fallowing

Rotational bush fallowing is an integral part of the farming systems in the forest zone. The fallow interval can be affected by a range of factors including soil nutrient status, crop type and labour availability. The interval ranged from 1 to 8 years on the farms surveyed. Forty eight % of farmers reported a general fallow management of 3 years or less, and 30% 4 years or more. Twenty two % of farmers reported that they didn’t fallow. These were farmers who were either renting land on a seasonal basis, or sharecropping, in which case all land is gradually put under cocoa.

There was no significant difference in the fallow period between the peri-urban and rural areas even though farm sizes in the latter are significantly larger. Although a number of reasons could contribute to this, the main reason would seem that by maintaining short fallow intervals the farmer is able to minimize the cost of land clearing in terms of hired labour/machinery. Although land would still have to be cleared more often, this lighter workload could be covered by family labour rather than hired labour/machinery.

The length of the fallow interval can be affected by crop type. Dry season vegetables produced on marshy areas or land near to a water source receive fertilizers and this was seen as a means to allow longer cropping periods and shorter fallow intervals for vegetable land.

The nature of the vegetation is assessed by the growth of weeds, size of trees, and condition of the soil, which should be dark and soft when a cutlass is pushed in. These are used as indicators to ascertain whether an area had rested sufficiently to cultivate. Farmers choosing land to rent also look at these characteristics to determine the soil nutrient status of the land.
Clearance of fallow land for land preparation begins in March/April, for the major season, and in August/September for the minor season. Land preparation involves slashing the bush, felling the trees, allowing the material to dry and finally burning all trash. If the trash is not well burnt the first time, either because of rainfall or incomplete drying of trash, then farmers gather the remains of trash into piles and burn again. The main benefits of burning perceived by the farmers are shown in Table 12.

Table 12. Reasons cited for burning.

<table>
<thead>
<tr>
<th>Reason for burning</th>
<th>% of farmers citing reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access to farm / ease of planting</td>
<td>71</td>
</tr>
<tr>
<td>Improved soil conditions</td>
<td>10</td>
</tr>
<tr>
<td>Improved yield</td>
<td>26</td>
</tr>
<tr>
<td>Time / labour saving</td>
<td>29</td>
</tr>
<tr>
<td>Weed control</td>
<td>28</td>
</tr>
<tr>
<td>Pest + disease control</td>
<td>18</td>
</tr>
<tr>
<td>Traditional practice</td>
<td>5</td>
</tr>
</tbody>
</table>

There are some instances when burning is not done, if the major season clearance is carried out too late or the rains come early, or, more typically, in the minor season when vegetation is still wet and farmers report that there is less sunshine to dry it out. In these cases the farm is cleared as best as possible to facilitate work and the crops are planted.

It was generally appreciated by the farmers that if the trash from land clearance was left as a mulch to decompose rather than burnt it would be beneficial and help sustain yields. However they felt that this would be labour consuming as land would have to be re-cleared after the trash had decomposed since more growth would take place. Some farmers had experimented with such methods and others agreed that such a system could be possible on short, 2-year fallow land with crops such as plantain, cassava and cocoa, although vegetables and maize would possibly suffer.

4.3.6.3 Organic soil inputs

4.3.6.3.1 Animal manure

Table 13 shows the ownership of livestock among the farmers interviewed in this zone, excluding two farmers with flocks of over 500 poultry. Some farmers in the area had cattle, pigs and fish but numbers are very few and none were included in the sample interviewed. There were significantly (p<0.001) more sheep/goat owners in rural (73%) than in peri-urban (30%) villages.

The livestock graze freely during the day, although there are instances where they may be restricted if crops are threatened. In these cases the animals are often fed with cassava and plantain peels from the house and vegetation such as plantain and cassava leaves and grasses are cut for them from the farm. The animals are usually housed/tied up for the night.
Livestock manure is available from the farmer’s own sheep/goats and chickens and from large scale commercial poultry farms.

Manure from the sheep, goats and chickens was applied to the home garden. This may be directly to an already established plot or after first heaping on a rubbish dump which might then be used for growing crops. None of the farmers interviewed took the manure to the main farm.

4.3.6.3.2 Black soil

Black soil is the term given to the resulting material after the rubbish dumps have decayed. These dumps vary in size from small household heaps to communal village ones. In addition, depending on the size and location, the proportion of its various contents vary. From observation only these included animal manure, human excreta, with the dump often used as a toilet by both children and adults, household refuse, organic matter such as peelings and food scraps, and inorganic material including cans and plastic bags. A home-garden is usually cultivated on such an area after sufficient decomposition to take advantage of the fertile soil. If the home-garden consists primarily of tree crops the farmer may continue to dump household refuse under the trees to decompose and fertilize the soil. However if there are vegetable and other food crops are grown, there is concern for hygiene and a new dump site is likely to be started. Black soil is rarely dug up and carried to be applied to another area. It was only used by those planting shrubs and trees around the house or school compound or occasionally used to nurse tree seedlings.

There appeared to be very little control over what is added to communal dumps and it was difficult to ascertain the rights to such a resource. However, if the dump is on a particular farmer’s land, that farmer has the rights to grow crops there. It was apparent that local laws affecting black soil management and use vary considerably from village to village.

4.3.6.3.3 Poultry manure from commercial farms

The availability of this manure depends on location. Large scale poultry farms occur all around Kumasi with a particularly high concentration around the Akropong, Akwaba and Korforidua areas. There was little evidence of such farms around Tarkwa. Six % of farmers used poultry manure, the majority of whom are in Korforidua (peri-urban Kumasi).

Poultry manure was recognised as being good for tree crops, both on the farm and in the home-garden, owing to its slow release properties as compared with fertilizers. In such cases

<table>
<thead>
<tr>
<th>Livestock</th>
<th>% farmers owning</th>
<th>Number owned</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheep and/or goats</td>
<td>49</td>
<td>2 - 35</td>
<td>12</td>
</tr>
<tr>
<td>Poultry</td>
<td>69</td>
<td>2 - 45</td>
<td>14</td>
</tr>
</tbody>
</table>
the fresh manure would be allowed to decompose for 3 to 6 months before use. However its use on vegetables is not popular. Those farmers who had experimented with poultry manure on vegetables complained that the manure did not release its nutrients within the 3 month growing season of the crop, decreasing yields. In addition, that it encouraged soil pests and diseases and increased post harvest losses as the vegetables become more prone to decaying.

4.3.6.3.4 Constraints to manure use

The majority of farmers were aware that manure is of benefit to the crops since they see homegarden crops doing well. However, appreciation of the longer term effects of manure on the soil fertility and the possibility of its use in combination with fertilizers were not apparent. Since the home-gardens continually receive manure all year there is no scenario by which farmers can assess how yield is maintained once manure application ceases. Table 14 shows the main constraints to the general use of animal manure, including commercial poultry manure, and black soil on the main farm.

Table 14. Constraints to the use of manure in the Ghana Forest zone.

<table>
<thead>
<tr>
<th>Constraint</th>
<th>% of farmers citing constraint</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Manure</td>
</tr>
<tr>
<td>Availability</td>
<td>28</td>
</tr>
<tr>
<td>Transport (cost, mode)</td>
<td>24</td>
</tr>
<tr>
<td>Labour/ time consuming</td>
<td>18</td>
</tr>
<tr>
<td>Social reasons</td>
<td>6</td>
</tr>
<tr>
<td>Lack of knowledge</td>
<td>5</td>
</tr>
<tr>
<td>Not traditional</td>
<td>5</td>
</tr>
<tr>
<td>Other*</td>
<td>5</td>
</tr>
</tbody>
</table>

*Other: farm is too big; the soil is already fertile; no implements to carry manure; makes crop unhealthy for consumer.

Because of the virtual absence of cattle, the low management regime of sheep/goats, and heavy rainfall which washes away exposed manure, relatively small quantities of manure can be collected relative to the size of the farm, and a negative attitude to its use develops.

Problems related to transport include both the cost of transport of poultry manure to the farm and the general transport of manure around the farm. Often distances from the household to the farm are large and the use of any form of draught power or ownership of implements such as wheelbarrows is non-existent. Also, owing to the bimodal high rainfall pattern, paths are easily overgrown making access difficult.

The labour required and time taken to collect the manure and carry it to the farm is also seen as a major constraint. Considerable social stigma is attached to manure handling since it is often mixed with human excreta and other rubbish. Only children dig such material and an adult doing so would be considered mad and laughed at. Poultry manure is also considered to be dirty and smelly, requiring protective clothing if used.
4.3.6.3.5 Plant matter

The use of plant material during the clearing of bush fallow has been discussed above. In addition, there is some use of crop residues and weeds cleared from the growing crop. Owing to the absence of large areas of mono-cropped cereals, the quantity of crop residues is generally low. The benefit that crop residues and weeds have on the soil was clearly recognized by the farmers interviewed and they are left to decompose and fertilize the soil. The plant material is left scattered on the soil, or gathered around another crop as a mulch. For example, maize trash is gathered around cassava and other residues are gathered around tree crops.

4.3.6.3.6 Other organic soil inputs

Due to the absence of cattle, the low level of livestock management and abundance of grazing land, zero grazing units and subsequently liquid manure pits did not exist. The use of green manures, human sewage and other urban wastes were not encountered.

4.3.6.2 General constraints to organic soil fertility management

The promotion and understanding of organic technologies for soil fertility maintenance are generally very low amongst the extension staff. There was also little evidence of NGO group work among the random sample of farmers interviewed.

4.3.7 Pest control

4.3.7.1 Pesticides

4.3.7.1.1 Use

Seventy one % of farmers interviewed used pesticides, of whom 54% sprayed cocoa, 40% vegetable crops and only 12% used pesticides on other crops. Pesticide use is dominated by a small number of chemicals (Table 15).

Pesticides are mainly used on cocoa plantations and commercial vegetables, with the same chemicals often being applied to both crops. Cocoa is sprayed two or three times a year. The number of applications to a vegetable crop ranges from two to eight within a growing season. The actual number of applications seemed to depend on the farmers’ financial position and the most commonly quoted rates were two, three and four times per season.

Insecticides and fungicides are applied together, with little evidence of farmers differentiating between them. This situation is exacerbated by the fact that although farmers may be able to identify the main insect pest, albeit with a local name, disease recognition is almost non-existent. Fungicides are commonly associated with other functions such as stimulating flowering, fruiting and ripening, and improving physical structure. As a result the chemicals are often mixed and the cheaper chemicals are applied on a regular basis as a preventative measure with the more expensive chemicals only being used when a serious insect or disease problem occurs.
Table 15. Percentage of farmers who sprayed (n = 57) using particular pesticides.

<table>
<thead>
<tr>
<th>Pesticide</th>
<th>Type</th>
<th>Crop</th>
<th>% of farmers spraying</th>
</tr>
</thead>
<tbody>
<tr>
<td>DDT*</td>
<td>Insecticide</td>
<td>Cocoa/ veg</td>
<td>49</td>
</tr>
<tr>
<td>Karate (cyhalothrin)</td>
<td>Insecticide</td>
<td>Veg</td>
<td>37</td>
</tr>
<tr>
<td>Copper based products including copper</td>
<td>Fungicide</td>
<td>Cocoa/ veg</td>
<td>23</td>
</tr>
<tr>
<td>hydroxide and copper oxychloride</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dithane M-45 (mancozeb)</td>
<td>Fungicide</td>
<td>Veg</td>
<td>21</td>
</tr>
<tr>
<td>Name not known</td>
<td></td>
<td></td>
<td>11</td>
</tr>
<tr>
<td>Other**</td>
<td></td>
<td></td>
<td>16</td>
</tr>
</tbody>
</table>

* in reality Gamalin 20 and Unden 20 (linadane and popoxur)
** Actellic (pirimiphos-ethyl); Thiodan (Endosulfan); Champion (chloridazon)

A picture of pesticide overuse and misuse was presented. The farmers are aware of this but blame the privatisation of the pesticide supply industry. In Kumasi chemicals are now bought from the central market, often in unmarked containers and farmers may identify a particular chemical only by its smell.

Pesticide spraying is either done by the farmers themselves (49%) or another person is recruited (51%). This can be a male relative, labourer or cocoa extension officer. Women farmers rely more significantly (p<0.001) on hired labour than male farmers. Seventy nine % of women farmers hired labour compared to only 30% of male farmers. Whereas male farmers would always use a knapsack sprayer (either owned or hired) female farmers who applied their own pesticide did so on small vegetable patches and used either palm fronds or cassava leaves to apply the chemicals.

Eighty % of farmers using pesticides indicated that they had suffered symptoms which they attributed to pesticide application. The most common complaints were itching and rashes. Other complaints were weakness or debilitation, nausea and loss of appetite, coughing, headaches, drowsiness and damage to eyes. Generally farmers felt that pesticides are harmful but not fatal because ‘the concentrations used at spraying are too low to seriously affect the sprayer’.

The reported level of utilization of protective clothing and equipment falls a long way short of minimum recommendations. Only 51% of farmers using pesticides indicated that they considered that they were taking some form of precaution (Table 16).

A majority (70%) of farmers appreciated that pesticides could be harmful to the consumer, especially if the harvest interval was too short. Harvest intervals maintained by farmers in the forest zone ranged from 3 days to 4 weeks, however the majority marketed their products 1 week after the last spraying with pesticide. The effect on the consumer as perceived by the farmers was that the increase in both the variety of and susceptibility to disease within the general population can be attributed to increased pesticide use.
Table 16. Precautions taken by farmers in the Ghana forest zone during pesticide spraying.

<table>
<thead>
<tr>
<th>Precaution</th>
<th>% of those farmers who spray taking precaution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long sleeved top and/or trousers (old farm clothing)</td>
<td>61</td>
</tr>
<tr>
<td>One or more items of protective articles (hat, gloves, boots)</td>
<td>39</td>
</tr>
<tr>
<td>Mask (handkerchief over mouth/nose; cotton wool in nose)</td>
<td>33</td>
</tr>
<tr>
<td>Others (e.g. drinking or smearing skin with palm oil)</td>
<td>19</td>
</tr>
</tbody>
</table>

4.3.7.2 Organic pest control

The farmers knowledge, use and perceived benefits of natural pest control were all low. Thirty eight % of farmers interviewed were aware of the use of wood ash to control pests, but only 13% actually employed this technique. Four % were aware of the use of plant extracts as alternative pesticides (neem leaves, pepper, local plants) but none were using them. Physical measures such as traps, fencing, hunting, dogs or scarecrows, were used by 22% of farmers against small mammals, birds and rodents which are common in the rural areas. Sixteen % perceived weed control, intercropping and rotation to be contributing to pest and disease control.

4.3.7.2.1 Constraints to the use of natural pest control

A major constraint appeared to be the extremely limited knowledge of any non-chemical control strategies for diseases and insect pests. It is often assumed that farmers have a great wealth of knowledge concerning traditional or indigenous pest control. However, in this zone there was little evidence that this is the case. Several reasons may account for this. Traditional pest control was not part of collective community knowledge; the predominance of the use of pesticides over the last 20 years has meant that traditional knowledge has been lost; and small mammals, rodents and birds were the major pests in the past rather than the insects associated with commercial vegetable production of today.

Where alternative pesticides, such as ash are known, its use as a natural pesticide is limited by the fact that it is associated with small scale household vegetable production and not considered an effective enough deterrent against insects to be used on a commercial vegetable crop.

Despite concerns about the economic cost of their use, there was satisfaction with pesticides, these being perceived as effective, quick acting, and giving the product a marketable look.

Many farmers in this zone felt that there were no effective alternatives to pesticide use; that the crop varieties they were cultivating were ‘foreign’ and therefore not strong enough to grow in the local environment without the use of pesticides.

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

Hand weeding was the main method of weed control undertaken by all farmers. It is usually carried out three times a year using a combination of hoe and cutlass. The hoe is used when crops are grown close together, as in a pure stand of maize, when a cutlass would damage the plants. The cutlass is, however, the main implement used as a hoe would damage the tubers of crops such as yam, cocoyam and cassava. Fallowing is also seen as a method of weed control since continuous cropping encourages weed growth. The mulching effect of crop residues, weed trash and cocoa litter fall are also recognized as suppressing weed growth.

However, farmers in the forest zone reported an increasing problem with weeds. As fallow periods shorten and the soils become more degraded, the land is invaded by ‘hard’ grass weeds as opposed to the ‘softer’ and more manageable forest weeds. Hired labour is usually used for weeding. However, as the cost of labour increases, farmers are now considering herbicides to be a cheaper and more effective option. Whereas fertilizer and pesticides are associated with a particular crop type, herbicides are used on a much broader scale.

Twenty six % of farmers interviewed used herbicides, predominantly on pure stand maize or vegetables and predominantly in peri-urban areas. Some farmers who didn’t use herbicide reported concerns that herbicides could kill their crop and weed residues would kill future crops. The main herbicides used were Gramoxone (paraquat dichloride), Roundup (glyphosate) and Atrazine (alachlor atrazine), all non-selective general herbicides.

4.4 Ghana - Savannah zone

4.4.1 Introduction

Tamale, the administrative capital of the Northern region, lies in the Guinea Savannah zone of northern Ghana. The Guinea Savannah is characterised by an annual average unimodal rainfall of 1100 mm. The Northern Region has an average population density of 20 persons/km$^2$ and is inhabited by numerous tribes of differing religious, political and cultural values. However around Tamale the Dagomba are the most dominant tribe living in large extended households.

4.4.2 Farmer characteristics

The sample comprises of 20 male and 20 female farmers. Their age and educational status are shown in Tables 17. Owing to the extremely high percentage of farmers having not received any education (95%), there was no gender distinction in the educational level of male and female farmers (5% to primary level).

Table 17. Age distribution of farmers interviewed in the Ghana savannah zone.
<table>
<thead>
<tr>
<th>Age</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-39</td>
<td>42</td>
</tr>
<tr>
<td>40-59</td>
<td>28</td>
</tr>
<tr>
<td>60-79</td>
<td>12</td>
</tr>
<tr>
<td>Not known</td>
<td>18</td>
</tr>
</tbody>
</table>

There is a strong tradition among the Dagomba culture whereby junior members of the household learn agricultural practices from elder members by both serving them and copying what is done in the field. This results in a good knowledge of local conditions and how a job is done, but limited understanding of the scientific reasoning behind why a task is done. Owing to the low school attendance, children make a significant contribution to the farm work at all times of the year, not just during weekends and holidays.

4.4.3 Farm characteristics

The farming household comprises of the head of the household (or landlord) and his dependent men (sons, junior brothers, nephews, grandsons) and dependent women (daughters in law, unmarried daughters, nieces and granddaughters). The farm is made up of the main household farm and the individual plots of the dependent men and women within the household. There is a traditional taboo among the Dagomba that women are not allowed to use a hoe and thus their traditional input into the farming system is limited. In reality this taboo is not so strong today. However it results in a clear dominance of men within the farming system which was hard to bypass when wishing to talk to women farmers. To overcome this hurdle women who farmed their own plots were targeted for the female sample. Therefore the survey concentrated on two aspects: the family household farm and female dependants individual plots

4.4.3.1 Household farm

Information on household farms was obtained from male landlords (14), female landlords (3), sons of landlords (6) and wives of landlords (3). Land is traditionally held by the chiefs and leased to the head of the family according to the household’s needs. The user gains usufructory rights that can be passed onto the next generation (male) as long as the land is being cropped. If land becomes fallow for a substantial period of time, it can revert back to the chief. Consequently, it is common for families who have limited labour to sub-lease land to relatives or neighbours for token amounts so that land can remain in the family. The family head usually gives the chief a small gift as a sign of respect

The landlord makes all decisions concerning the management and activities of the household farm. However, as junior men become older and more experience the landlord may begin to consult them and eventually pass on some authority to the senior young man when the landlord himself becomes too old to farm. The household farm must supply all food required to feed the household. Consequently food staples take priority on the farm, with maize considered the most important, and cash crops takes second place.
The household farm consists of the compound farm, which is located next to the homestead and the bush farm which is some distance away. The compound farm is usually 0.4-0.8 ha (1-2 acres) and cropped predominantly with maize. Crop choice is also linked to the grazing regime of the animals. When the compound farm is being cropped, all small stock are either housed or tied to stakes in grazing areas not far from the house and brought vegetation. There is no one to watch the compound farms since all labour is required on the main bush farm. Consequently only a short season crop such as maize can be grown, as if the animals are restricted for too long this increases the labour demand. Naturally this requires a community effort. Therefore, compound farms are not cultivated until the chief of a village starts his and announces the restriction of animal movement. Once the crop is harvested, the animals are released. Consequently, if any longer season crops are grown they would be consumed. In Damanguli (peri-urban) the last chief had recently died and a new one had not yet been installed. Consequently the compound farms had not been cultivated for that year. In Dungu (peri-urban), since grazing land for the animal is so restricted, there are hardly any compound farms and those who have them must fence them as the animals are allowed to roam free.

The bush farm is cultivated first owing to its importance for providing a diversity of short and long season crops. The main crops grown are cereals: maize, sorghum, millet and rice; legumes: groundnuts, beans and cowpeas; root crops: yam and cassava; and vegetables: tomatoes, pepper, okra and indigenous leaves (bra, ayoyo)

Crops are usually grown in mixed stands of two or three crops, except for rice and cotton which tend to be grown alone. Maize and sorghum is the most common intercrop followed by a maize and groundnut mix. Root crops are also intercropped, but less commonly.

The average farm size is 4 ha (10 acres) with 2.4 ha (6 acres) cropped and 1.6 ha (4 acres) fallow. No significant difference was found in household farm size between the peri-urban and rural areas. However, it was clear that in peri-urban areas, land shortages do exist. In these areas, after the landlord has reclaimed any land he might have lent out, the sons may be instructed to look for more land in the rural areas from tribal kinsman. These sons will either settle there or crop the land only in the rainy season and return to Tamale during the dry season to look for work. This creates migrant or semi-migrant communities in the rural areas.

In the rural areas it is possible for farmers to request more land from the chief once the soil on their land has become too degraded for agricultural production. Consequently the cost involved in hiring labour or tractors for clearing, ploughing and cultivating land is the limiting factor rather than the availability of the land itself.

Those young men with their own plots are obliged to work on the household farm as a priority and can only work on their own plot in the early mornings or late evening. However the harvested crop is entirely theirs and will often be sold for cash.

The traditional taboo concerning women’s role in farming does not apply to widows. Of the three female landlords interviewed, two were widows who had moved out to rural areas and attached themselves to a tribal kinsman and set up female-headed compounds. The third was a widow who managed the farm with her sons but in reality made few of the decisions. These cases are not common since women are usually married quickly after being widowed.

4.4.3.2 Female dependants’ personal farms
Information on female dependants’ personal farms was obtained from wives of landlords (11), sisters of landlords (2) and daughters of landlords (1). The majority of women cultivated small vegetable gardens of pepper, okra, tomato and indigenous vegetable leaves such as bra and ayoyo on their husband’s or son’s farms as a contribution to the household food production. However, the survey attempted to target those women who had their own farming plots the food/profits from which could be considered as their own. Sixty four % of female dependants with their own farms were found in the peri-urban villages and it was noticeable that examples of this were rare or absent in the rural areas. The average farm size was 1 ha (2.5 acres) with 0.64 ha (1.6 acres) being cropped. The majority of these women started their farms in the last few years so that they could generate a private income to buy clothes etc. for their children and themselves. Previously they traded or processed shea nut oil. For a woman to cultivate her own farm she has to get the permission and support of the landlord, since the main household farm still takes priority for her labour. The women grow groundnuts with another crops such as maize, beans or vegetables because the groundnuts can easily be sold for cash.

Seventy eight % of farmers hire labour, primarily for weeding, but also for hoeing and sowing. Women are likely to hire children to work on their plots since they are cheaper to employ. Credit is taken by 28% of the farmers and is obtained from cotton buying companies. Fifty % of farmers have an additional source of income.

4.4.4 Soil fertility management

4.4.4.1 Inorganic fertilizers

Fifty eight % of farmers interviewed used fertilizer on the household farm. Twenty nine % of women with plots used fertilizers. The fertilizer use on different crops is shown in Table 19.

Table 18. The use of fertilizers on crops in the savannah zone of Ghana.

<table>
<thead>
<tr>
<th>Crop</th>
<th>% of farmers using fertilizers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>84</td>
</tr>
<tr>
<td>Sorghum</td>
<td>26</td>
</tr>
<tr>
<td>Rice</td>
<td>21</td>
</tr>
<tr>
<td>Groundnuts</td>
<td>21</td>
</tr>
<tr>
<td>Cotton</td>
<td>21</td>
</tr>
</tbody>
</table>

The previously mentioned importance of maize is reflected in the farmer’s choice of crop to which fertilizer is applied. The cotton buying companies provide seed, fertilizer, pesticides and ploughing services to cotton farmers. However, farmers complained that the returns to labour were lower than for crops such as maize. Consequently, a proportion of fertilizer provided for cotton is in fact applied to maize crops.

The availability and supply of fertilizer did not seem to be a problem in itself, mostly due to the presence of the cotton companies. It was apparent that the farmers around Tamale relied on fertilizer for the growing of food staples for household consumption. Consequently the
removal of fertilizer subsidies had a substantial effect on the subsistence orientated farming system. There were a number of farmers who had previously used fertilizer but had now stopped. The majority of those farmers still using fertilizer had reduced their usage considerably and were struggling to continue buying it. It was apparent that the reduction in fertilizer use within the farming system as a whole was leading farmers to begin to maximize their organic resources.

Of those farmers who were using fertilizer, or who had stopped recently due to the price increase (total 26), 50% said soil was not affected; 31% indicated that there was a diminishing return with increasing amounts of fertilizer; and 19% indicated that fertilizer increased weed growth or that its application without rains hardened the soil.

4.4.4.2 Rotational bush fallowing

No significant difference was found in the fallow regime between peri-urban and rural areas. The R value (years cropped/(years cropped + years fallowed)) x 100 ranged between 55 and 65, i.e. the cropping period is between 1 and 1.5 times that of the fallow interval.

Each season, prior to land preparation, farmers gather the cereal residues and other large matter that could impede cultivation into heaps and burn the individual heaps. This only occurs if the field is to be hoed by hand. If tractor ploughing is to be used, no gathering or burning takes place unless the field was previously fallow, in which case stumps and bushes are removed and burnt.

Reasons for burning were given as: to give ease of access (52%), the ash fertilizes the soil (28%), it deters pests especially snakes and rodents (20%). Traditionally fire plays an important role in Dagomba life, culturally with a traditional fire festival, and agriculturally for crop land clearance and for livestock by burning in the early rains to promote fresh grass regrowth.

However, over time, there has been an abuse of these traditions. Bush burning is used for hunting rodents and other small mammals by both boys and men. Considerable kudos is attached to the size of rat caught by a young boy. Farmers report that trucks of young men go out from Tamale into the rural areas to hunt by burning. Consequently this results in widespread bush-fires during the dry season threatening unharvested crops and destroying organic matter.

4.4.4.3 Organic soil inputs

4.4.4.3.1 Animal manure

The head of the household owns the family livestock and owns the right to, and the decisions concerning, manure distribution and use. Livestock figures are shown in Table 20. Livestock are herded during the day and spend the night, either in a kraal, enclosure, or tied to pegs.
Table 19. Livestock ownership among farmers interviewed in the Ghana savannah zone.

<table>
<thead>
<tr>
<th></th>
<th>% of households owning</th>
<th>Average herd/flock size*</th>
<th>Range*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle</td>
<td>38</td>
<td>11</td>
<td>4-25</td>
</tr>
<tr>
<td>Sheep/goats</td>
<td>78</td>
<td>13</td>
<td>2-25</td>
</tr>
<tr>
<td>Poultry</td>
<td>90</td>
<td>21</td>
<td>3-50</td>
</tr>
</tbody>
</table>

* Excluding two chief’s households with more than 50 of each type of livestock.

Traditionally, poultry manure was only applied to the vegetable plot and sheep/goat and cattle manure to the compound farm. Manure reaches the compound farm via a number of alternative routes.

Manure and household refuse is heaped and allowed to decompose for 2 to 3 years before the undecomposed fraction is burnt and the heap is levelled so that crops may be cultivated on it. This heap is often used as a toilet by children and therefore, for hygiene reasons, the site may be changed as often as every year. The heap is rotated around the compound farm so that all parts receive manure. Alternatively, manure is put with household refuse in a pit which has been dug for the extraction of building materials, as a form of land reclamation. Finally manure may be kept completely separate from the household waste and applied directly to the compound farm in the dry season. The management of manure is very poor with manure during the rainy season not being collected but lost to leaching during the heavy rains. The compound farm also receives manure in the dry season as cattle are grazed on it and/or pegged in rotation around the farm at night.

The only cases of farmers taking manure to the bush farm were recorded in Dungu (peri-urban) where there are no compound farms. Manure was taken by bicycle during the dry season and incorporated at land preparation, primarily for maize and sorghum. This was also observed in other villages not included in the survey sample. In general, as the size of the compound farm decreased, i.e. in the areas of highest land pressure, the application of manure to the main farm increased. In such cases, manure was applied to the household farm rather than individual plots.

Damanguli has not reached that stage. Only one farmer indicated the use of cow dung on the bush farm. However in informal discussions within the village, it was generally acknowledged that those farmers with sufficient manure beyond the requirements of their compound farm do take the manure to the bush farm. However it must be remembered that the percentage of farmers owning cattle is relatively low and the greatest demand for manure exists where, generally, cattle herd numbers are lower.

Women’s access to manure is limited and socially complex. Although men said that they would give a woman manure if requested, the women said they would rather get a male relative to request manure from either their own or another household on their behalf. This applies particularly to cow dung since it had a higher value associated with it and a wife may only have some once the husband has sufficient. Sheep/goat manure is more accessible since a lower value is attached to it and it is usually the women who sweep out the pens.
In both peri-urban and rural areas, farmers leave their cattle with the Fulani tribe. The Fulani either grow maize on old kraal sites or peg the animals in rotation around a plot of land during the dry season. One Fulani interviewed herded a total of 100 cattle which were pegged each night in rotation on 0.8 ha (2 acres) of land for the dry season. His maize was the best in the village. However, farmers can request the Fulani to graze cattle over specific portions of the bush farm which are due to be cropped.

4.4.4.3.2 Crop residues

Crop residues are generally left in the field to decompose and/or feed grazing animals. Maize, sorghum and millet stalks are collected as fuelwood in the peri-urban areas. Stalks are also used for construction and mat making. There is very little evidence of the collection of residues for dry season fodder, although some farmers reported that they did. Groundnut and bean residues are collected.

4.4.4.3.3 Human sewage

Human sewage is the main urban waste available to farmers around Tamale. Representatives of the Tamale Municipal Assemble (TMA) and the sewage truck disposal drivers were interviewed. Thirteen % of farmers use human sewage and all these farmers are located in Dungu village. Within the village itself farmers report that a majority use human sewage. The TMA is not officially aware or responsible for the dumping of effluent on farms. Officially the TMA acquires land on which trenches are dug. Effluent is poured into these trenches and, when full, sand is poured on top and natural vegetation allowed to grow over it. The land is then leased to farmers for agricultural purposes, although they are advised not to grow root crops for health reasons. Such land is considered to be fertile for the next 10 years.

The TMA stipulate that feeder roads to the farms should not be waterlogged and the land is cleared of stumps which might otherwise damage the tyres of the truck. In practice, the effluent is dumped at one spot and allowed to dry before the farmer redistributes it. Two types of sewage are available, from cesspit WCs and communal pit latrines. Farmers are reported by the drivers to prefer the latter since it has a lower water content.

Consequently the farmers’ fields provide an important disposal site for the TMA during the dry season. During the rainy season, since crops are in the fields and the tracks become easily waterlogged, they are forced to dump at unofficial sites near to the road. Even in these situations, farmer will allow the sewage to dry and then collect it for their gardens.

The farmers indicated that the demand for sewage increased 10-15 years ago as the fertilizer subsidy was removed. At present demand and supply are high. However transport is the limiting factor, with TMA only possessing one disposal truck until very recently. They now have a second. The amount paid to the truck drivers varies from c3000-5000 for fuel costs plus a tip for the driver. One of the farmers had paid c20,000 in 6 months, but had only had two deliveries. There were reports of up to six deliveries per dry season per farmer.

The sewage, as with the manure, tends to be applied to the maize and sorghum.
Although farmers prefer a tractor to incorporate the sewage, it is done with a hoe when necessary. At no point did any farmer express concerns that the handling and use of sewage on crops was unhealthy, dirty or culturally unacceptable.

4.4.4.4 Cropping Patterns

Fifty three % perceived that they were practising crop rotation although the understanding of crop rotation for soil fertility maintenance was generally low. Yam is used at the start of the cropping cycle owing to its high nutrient requirement. Also, a local taboo does not allow the cropping of yam twice within one rotation cycle. Some farmers planted maize and sorghum after a cotton crop to benefit from the residual fertilizer. In general farmers did not have a set strategy for rotation crops. The decision as to which crops to grow is made on a yearly basis and is dependent on the current fertility of the soil and recent applications of fertilizer and manure

4.4.4.5 Other

There was no evidence of liquid manure or green manure use

4.4.4.6 Constraints to organic soil fertility management

As a result of the past subsidies on fertilizer and the activity of the cotton companies there has been a strong traditional reliance on fertilizer in Northern Ghana for household food production. This ready availability of fertilizer, which can be obtained on credit, has acted as a considerable barrier to the uptake of organic techniques. However, this situation can now provide one of the greatest opportunity for organic uptake. The farmers can no longer afford fertilizer and are being forced to make conscious decisions concerning organic resource use in order to sustain household food supply. However, there are several constraints to this uptake:

1) The extremely low level of education amongst farmers (95% received none) means that techniques such as composting, and knowledge of plants and the benefits of cropping patterns, are not gained.

2) Actual manure available is relatively low in comparison to the amount needed, not only owing to the low number of livestock but more importantly to their management regime. Current animal housing and manure handling methods mean that considerable amounts are lost to leaching and evaporation.

3) What manure is available is prioritized for the household farm. This can restricts enterprising dependant individuals who wish to experiment and start using on their own plots. Manure, cow dug in particular, has considerable standing within the traditional culture and in some areas requesting it has to be done with respect. Therefore, although sufficient manure might be available and unused, complex social customs exist as to why it cannot readily be used by other farmers. This access to manure is even harder for women farmers.
4) Although extension services are aware of issues surrounding organic farming, and the service had had considerable funding from the German Government, adoption by framers has yet to occur.

4.4.5 Pest control

4.4.5.1 Pesticides

Thirty three % of farmers used pesticides of whom 62% used them on cotton; 31% on maize; 15% on maize; 15% on groundnuts. Sixty nine % of farmers using pesticides could not name the chemical since the chemical was often obtained directly from, and/or was sprayed by, the cotton company. The remainder named Karate.

Owing to the low number of farmers using pesticides (13) plus the fact that the spraying is often carried out by the cotton company, figures for farmer perceptions of effects on the sprayer, and the use of protective clothing are too low to allow comment. However, a significantly large proportion of farmers (75%) were of the opinion that pesticides did not effect the consumer. Eighteen % reported that no effect would take place if the correct harvest interval was left and only 7% gave a positive answer (‘chemicals meant for cotton should not be sprayed on food’). These figures can be attributed to the fact that pesticide use had been traditionally limited to cotton as opposed to food crops. There was no evidence of herbicide use.

4.4.5.2 Organic pest control

Eighty three % of farmers used some form of organic pest control. Thirty five % used ash predominantly on okra as well as on beans and groundnuts. Fifty three % were actually aware of its use but those who did not adopt this method failed to do so because of its ineffectiveness. Twenty five % used mechanical means such as chasing/shouting at birds and rodents, scarecrows and traps. Eighteen % used one or more of prayer, weeding, neem fruit, paraffin and tobacco solution. Rotation, intercropping, biological control or use of resistant varieties did not feature.

Natural pest control knowledge and use is mostly limited to traditional methods with virtually no evidence of introduced technologies. This is as a result of minimal promotion by either the extension service or NGO’s in the area. The extremely low level of education also leads to poor understanding of cropping patterns and plant insect life cycles for pest control.
APPENDIX 1: Report of consultation with UK based project leaders

Participants in consultative meeting:

John Bridge, CABI Bioscience
Mark Holderness, CABI Bioscience
Richard Plowright, CABI Bioscience
Janny Vos, CABI Bioscience
Phil Harris, Henry Doubleday Research Association
Ester Roycroft, Henry Doubleday Research Association
Martin Adam, NRI
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 fertiliser 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 investigated 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 is 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 consensus 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 scientific 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 of 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).

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 address 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.

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 its 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.


  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.


  H. UK ARI - NRI: socioeconomic research (RRAs).

  I. Bureau of Integrated 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)

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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 II: Report of international mission to Ghana

Integrating pest management and soil fertility management

Report of a mission to Ghana
17-28 January 2000

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January 2000
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Acronyms

AEA Agricultural Extension Agent
AESA Agro-ecosystem Analysis
AMA Accra Metropolitan Assembly
AVRDC Asian Vegetable Research and Development Centre
BIRD Bureau of Integrated Rural Development, KNUST, Kumasi
CPP Crop Protection Programme (DFID)
CRI Crops Research Institute, Kumasi
DBM Diamond Back Moth
DED German Technical Co-operation
DFID Department For International Development (UK)
FAO Food and Agriculture Organisation
FFS Farmer Field School
GOAN Ghana Organic Agriculture Network, Kumasi
GTZ German Development Co-operation
IBSRAM International Board for Soils Research and Management
ICM Integrated Crop Management
ICP Ghanaian-German Project for Integrated Crop Protection
ICPM Integrated Crop and Pest Management
IPM Integrated Pest Management
JFS Joint Funding Scheme (DFID)
KNUST Kwame Nkrumah University of Science and Technology, Kumasi
MoFA Ministry of Food and Agriculture
NGO Non-Governmental Organisation
NRI Natural Resources Institute
OM Organic Matter
PRA Participatory Rural Appraisal
PTD Participatory Technology Development
PTD&E Participatory Technology Development and Extension
SF Soil Fertility
SRI Soils Research Institute, Kumasi
TOT Training of Trainers
UNDP United Nations Development Programme
Terms of reference

1. Review research capacities and activities in existing and recent DFID-supported research programmes, MoFA and National IPM programmes, in vegetable cropping systems in Ghana, where the themes of pest management and soil fertility management interact and establish areas of complementarity.

2. Determine, through links to the ‘in-country PRA’, the knowledge gaps and requirements and scope for incorporation of soil improvement technologies within farmer IPM/ICM programmes in Ghana.

3. With stakeholders from across the research-extension-farmer continuum, prioritise themes identified by farmers for research attention and develop a framework for the establishment of participatory, systems-based approaches to drive the ICM research process.

4. Identify gaps in knowledge where DFID-supported research might usefully contribute to the integration of soil fertility and pest management.

5. Describe and evaluate the linkages and networks that facilitate the process of technology development from identification of need to adoption or uptake of technologies.

6. Review the mechanisms linking farmer experiential-learning programmes and research programmes in Ghana in the areas of soil fertility and crop health

Introduction and background

This mission was an activity within a DFID-CPP-funded Programme Development Project. This project seeks to identify strategies that can link strategic and adaptive research activities in soil fertility and pest management, yet be driven by the explicit demands and immediate involvement of different categories of farmers.

Specific project objectives are:

Review the areas of DFID funding relating to Ghana in which useful linkages might be established between soil fertility and crop protection issues.

Develop strategies for the integration of soil fertility management and soil pest management in research, promotion and dissemination in the vegetable crop systems of Ghana, addressing the processes by which farmer knowledge and farmers understanding of integrated crop management needs can drive a process of research that provides a meaningful context for studying the interaction of soil fertility and crop health.
Explore the scope for adopting similar approaches to other crops where parallel research and participatory learning partnerships exist.

**Earlier studies**

An earlier survey of farmers’ knowledge, perceptions and practice of a range of crop protection and soil fertility techniques in Ghana indicated generally low levels of knowledge (Harris *et al.*, 1997). The earlier survey interviewed peri-urban and rural farmers in three areas of Ghana. Villages and farmers were selected at random and the vast majority had not participated in IPM or SF projects or training, nor had they been exposed to promotion of these technologies by government or NGO extension activities.

In the forest zone of Ghana, 43% of farmers used fertiliser of whom 76% applied this fertiliser to vegetable crops, the remainder was used on oil palm, maize and yam. The percentage of farmers using fertiliser was significantly higher in peri-urban than in rural areas, reflecting the greater intensity and commercialisation of vegetable production closer to the market centres.

Seventy-one percent of farmers interviewed used pesticides, of whom 54% sprayed cocoa, 40% vegetable crops and only 12% used pesticides on other crops. Pesticide use is dominated by a small number of chemicals. Farmers’ knowledge, use and perceived benefits of natural pest control were all low. Thirty-eight percent of farmers interviewed were aware of the use of wood ash to control pests, but only 13% actually employed this technique. Four percent were aware of the use of plant extracts as alternative pesticides (neem leaves, pepper, local plants) but none were using them. Physical measures such as traps, fencing, hunting, dogs or scarecrows, were used by 22% of farmers against small mammals, birds and rodents which are common in the rural areas. Sixteen percent perceived weed control, inter-cropping and rotation to be contributing to pest and disease control.

A major constraint appeared to be the extremely limited knowledge of any non-chemical control strategies for diseases and insect pests. Traditional pest control was not part of collective community knowledge. The predominance of the use of pesticides over the last 20 years has meant that such traditional knowledge has been lost; additionally small mammals, rodents and birds were the major pests in the past rather than the insects associated with commercial vegetable production of today.

Despite concerns about the economic cost of their use, there was satisfaction with pesticides, these being perceived as effective, quick acting, and giving the product a marketable look.

In the savannah zone, 58% of farmers interviewed used fertiliser on the household farm, with maize being the main fertilised crop. However, only 29% of women with plots used chemical fertilisers and it was here that much of the vegetable production was concentrated. Eighty-three percent of farmers used some form of non-chemical pest control. Thirty-five percent used ash, predominantly on okra as well as on beans and groundnuts. Fifty-three percent were actually aware of its use but those who did not adopt this method failed to do so because of its ineffectiveness. Twenty-five percent used mechanical means such as chasing/shouting at birds and rodents,
Integrating pest management and soil fertility management

scarecrows and traps. Eighteen percent used one or more of weeding, neem fruit, paraffin and tobacco solution. Rotation, intercropping, biological control or use of resistant varieties did not feature in farmers’ responses in the survey.

Natural pest control knowledge and use was mostly limited to traditional methods with virtually no evidence of introduced technologies. This is a result of minimal promotion by either the extension service or NGO’s in this area. The extremely low level of education also leads to poor understanding of cropping patterns and plant insect life cycles for pest control.

A number of key constraints were apparent, some of which were already being addressed in research projects funded by DFID and others and in development and training projects by DFID, GTZ and others.

Recent and current projects

More recently there have been a number of research projects in Ghana that have, or potentially could have, addressed the interrelationship of pest damage and soil fertility. These have included 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 organised 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 (Gregory et al., 1998).

Also of major importance in developing the concept of the holistic management of a crop to produce healthy plants that are able to yield well and resist pest attack without reliance on pesticide inputs, has been the development of IPM Farmer-Field Schools, demonstration farms and NGO extension activities. The Farmer Field Schools utilise principles of group experiential learning to empower farmers to adopt ecology-based management systems. This approach is being implemented in Ghana by the FAO-UNDP funded National IPM Programme and through GOAN in a DFID-JFS.

Vegetable production systems in Ghana

Blake et al. (1997) classified the agricultural production systems in the peri-urban zone of Kumasi and identified four that included vegetable production.

- Sole crop vegetables (rainy season); sometimes an opportunistic cultivation as part of bush fallow rotation.
- Sole crop vegetables (irrigated)
• Specialised valley-bottom cropping; continuous cropping of cash crops close to urban markets and sources of compost.

• Backyard farms; continuous cropping, mixture of perennial and annual crops.

Harris et al. (1997) divided farms into categories suggested by farmers themselves and several of these farm types include vegetable crops. In the forest zone, farms were divided into the main farm, which is usually some distance from the homestead, and the home-garden. Home-gardens refer to small growing areas in close proximity to the homestead and are a common feature in this zone. Plantain and banana, with coconut in the wetter areas, are the most common crops in the home gardens, with additional vegetables, food and tree crops also planted.

On the main farm, three main soil types were identified by the farmers and influence the choice of crops. Marshy soils are flooded in the wet season and remain moist during the dry season. They are suitable for crops such as sugar-cane and rice, which have high water requirements, and for dry season vegetable production. If no marshy land is available, dry season vegetables are located as close as possible to a water source. Sandy, red soils with a low fertility were considered suitable for maize and cassava production. Black clay soils of higher fertility are used for all crops except maize and cassava.

In the savannah zone, the household farm consists of the compound farm, which is located next to the homestead and the bush farm, which is some distance away. The compound farm is usually cropped predominantly with maize. Crop choice is linked to the grazing regime of the animals. When the compound farm is being cropped, all small stock are either housed or tied to stakes in grazing areas not far from the house and brought vegetation. The bush farm is important for providing a diversity of short and long season crops. The main crops grown are cereals: maize, sorghum, millet and rice; legumes: groundnuts, beans and cowpeas; root crops: yam and cassava; and vegetables: tomatoes, pepper, okra and indigenous leaves (bra, ayoyo). In addition there are female dependants’ personal farms. The majority of women cultivate small vegetable gardens of pepper, okra, tomato and indigenous vegetable leaves such as bra and ayoyo on their husband’s or son’s farms as a contribution to the household food production. However, 64% of female dependants in the peri-urban villages had their own plots, although examples of this were rare or absent in the rural areas. The women grow groundnuts with other crops such as maize, beans or vegetables because the groundnuts can easily be sold for cash.

To the above vegetable production systems may be added major intensive irrigated vegetable production projects such as at Weija, producing vegetables for local consumption and for export.

Vegetable production statistics for Ghana

Table 1 shows considerable room for improvements in vegetable yields in Ghana which, in many cases are below the mean values for other developing countries in Africa.
Integrating pest management and soil fertility management

Table 1. Yields (tonnes / hectare) of certain vegetables in Ghana and selected regions of the world. (FAO statistics; weighted averages of the years 1988 – 1998).

<table>
<thead>
<tr>
<th>Vegetable</th>
<th>Ghana</th>
<th>Africa</th>
<th>Africa - Developing</th>
<th>Africa - Developed</th>
<th>Asia - Developed</th>
<th>World</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chillies / Peppers</td>
<td>3.6</td>
<td>7.9</td>
<td>7.9</td>
<td>***</td>
<td>38.5</td>
<td>11.4</td>
</tr>
<tr>
<td>Eggplant</td>
<td>3.7</td>
<td>18.6</td>
<td>18.6</td>
<td>***</td>
<td>32.7</td>
<td>15.2</td>
</tr>
<tr>
<td>Okra</td>
<td>5.5</td>
<td>2.9</td>
<td>2.9</td>
<td>***</td>
<td>***</td>
<td>5.3</td>
</tr>
<tr>
<td>Onions</td>
<td>9.9</td>
<td>13.2</td>
<td>12.6</td>
<td>19.5</td>
<td>44.6</td>
<td>16.4</td>
</tr>
<tr>
<td>Tomatoes</td>
<td>7.2</td>
<td>20.3</td>
<td>19.9</td>
<td>31.1</td>
<td>62.5</td>
<td>26.3</td>
</tr>
<tr>
<td>Vegetables</td>
<td>5.0</td>
<td>9.4</td>
<td>9.1</td>
<td>17.0</td>
<td>27.3</td>
<td>15.4</td>
</tr>
</tbody>
</table>

TOR 1. Capacities and activities in existing and recent DFID research programmes, MoFA and National IPM Programmes, and areas of complementarity.

During the mission the following projects were visited:

1. National IPM Programme
   Dzorwulu/ Plantpool Vegetable Producers Association (AMA) Farmer Field Schools
   Mataheko Village (Dangbe West) Farmer Field Schools

2. Composted Waste in Urban Agriculture - Dr Richard Awuah – CABI, KNUST, CRI, SRI

3. Biological Control of Root-Knot Nematodes - Dr Barbara Hemeng – KNUST, Reading, NRI
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4. GOAN Outreach, Indigenous Knowledge, FFS and Demonstration Farm activities – Emmanuel Antwi

5. Integrated Food Crop Systems Project – NRI, MoFA, VSO

6. Sedentary Farming Systems Project – Dr Wolf-Dieter Zschekel - GTZ

7. Ghanaian-German Project for Integrated Crop Protection - Dr. Petra Schill - GTZ

8. Kumasi Natural Resources Project – Dr Charles Quansah – KNUST, NRI

9. IBSRAM Soil Fertility Project - Dr Charles Quansah – KNUST, IBSRAM

Details of the individual projects and activities relevant to SF x IPM are given in Appendix 1.

The projects include experimentation at various levels ranging from researcher-led and managed strategic research to farmer experimentation with no formal collection of results or monitoring (Table 1).

Table 1. Research activities of projects visited.

<table>
<thead>
<tr>
<th>Project</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>On-station strategic research</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>On-farm strategic research</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adaptive participatory research</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FFS farmer experimentation</td>
<td>x</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PTD farmer experimentation</td>
<td>x</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PTD&amp;E technology stimulation</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

All projects had carried out some form of PRA, survey or consultation, either before or during the project, which identified a researchable constraint. However, in the case of the more strategic projects, the research agenda seemed to have come from the overseas research partner, which was equated with the donor agency. With the exception of Project 2, Composted Waste in Urban Agriculture, which had the specific objective of investigating the effect of a soil amendment on vegetable pests and diseases, there was very little consideration of the interactions in the other projects. There are several possible reasons for the lack of data on SF x IPM interactions from current projects.

1. Lack of holistic approach
With the more formal research projects, the main objective of the project was usually to enhance crop production and quality through improved soil fertility. Pest and disease incidence was noted and addressed as part of the agronomy package. Pests and diseases were sometimes identified and chemical controls applied but no formal monitoring of pest and disease levels in relation to soil treatments was undertaken.
There are research projects in progress or recently completed that take no account of the effect of soil amendments on pests and diseases.

There is no suggestion that this situation will change with new projects without some additional external push to integration. We were informed that a new DFID-NRSP project on alternatives to slash and burn is due to start in the Kumasi area. It would be interesting to see what potential there is for including SF x IPM interactions in this at the outset.

2. Complexity of experimental design to study interactions
It is very difficult to design experiments that provide high quality data on SF x IPM interactions. Where the objective of the project is to increase crop productivity by soil fertility interventions, it is normal to apply recommended or farmers' practice levels of pest and disease control. Conversely, where the trial is to investigate a pest control intervention, it is likely that recommended or farmers' practice soil fertilisation would be chosen. Many of the experimental designs are already stretched to include sufficient treatments and replications to provide information on fertiliser types, application rates etc. Extending these to provide simultaneous data on pests has a multiplying effect on treatment numbers in factorial designs. Only one project appeared to have attempted such an approach. This was an extension of the Composted Waste in Urban Agriculture, carried out as a KNUST-funded postgraduate research project under the supervision of Dr Richard Awuah. This experiment included a factorial design, which included treatments with and without inorganic fertilisers, compost, insecticides and fungicides. This was an on-station research project.

3. Requirement for multidisciplinary teams
By definition, investigating the interaction between soil fertility and crop protection requires a multidisciplinary research team. It appears that it can be difficult to build this into the project at the outset, either because of a lack of a holistic approach, or the practical and institutional difficulties of collaboration between colleagues and institutions. Thus, the detailed factorial experiment carried out by Dr Awuah, specifically to investigate soil fertility x crop protection interactions, monitored insect pests and diseases but did not consider nematodes. For reasons of research focus discussed in (1) above, many of the research teams quite understandably and deliberately did not include the full range of expertise that would be required for SF x IPM studies.

On a separate issue of multidisciplinarity, there was an impression that socio-economic studies were seen as separate components of the research, often as preliminary, or add-on sub-projects or consultancies, rather than an integral part of the research process.

4. General nature of results from PTD, FFS etc.
Detailed data on SF x IPM interactions may be difficult to collect from the less formal participatory research, PTD and FFS experimentation. Understanding and proving significant interactions may require more of a reductionist experimental approach and fairly ‘hard’ scientific investigation. On the other hand, participatory research tends to use more general indicators such as marketable yield, income generation, labour requirements that make it difficult to ascribe treatment differences to soil or pest...
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factors. PTD farmers experiments and FFS experimentation may have even less formal indicators such as ‘satisfaction with the technique’, ‘willingness to continue with it’, ‘number of farmers adopting’ etc. Clearly, much of the subject is still at the black box level and there is considerable strategic/reductionist research needed.

One approach to the subject, which does not seem to have been attempted, is the comparative study of matched pairs of farms, as an alternative to factorial experimental designs. This is an approach widely adopted elsewhere to investigate differences between organic and conventional farming, where it is impossible to replicate long-term organic and conventional plots in short-term, small-scale field trials. Where soil fertility interventions have been adopted on significant numbers of farms, there is a scope for paired comparison of these farms with non-adopting farms for pest and disease occurrence and crop tolerance. Examples of techniques that have been sufficiently widely adopted for this approach include the use of poultry manure on vegetables and the use of *Mucuna* as a cover crop in maize. However, it was also pointed out that this approach was appropriate for only a proportion of vegetable farmers as many practised shifting cultivation or ‘one-off’ commercial production.

The scientific expertise required to study the interaction is available in the universities and national research institutes. Given that participatory research demands a considerable time input by senior researchers, this usually requires researchers to be based locally. There are, thus, a relatively small number of experts available in each discipline. It is possible that this restricts competition and risks over-commissioning of certain institutions.

In addition to their strategic research function, the universities and research institutes are heavily involved in adaptive research with farmers groups, though the extent of this varies from project to project and can be constrained by researchers time and the logistics of on-farm research.

NGOs have also been involved in adaptive research, with the university providing analytical facilities. An example of this is the involvement of GOAN in the composting component of the Kumasi Natural Resources Management Project. GOAN was the only NGO mentioned as working in the Kumasi area, though that may reflect the fact that GOAN is a network of >90 NGOs and farmers groups rather than a single NGO. There were said to be more active NGOs in the north of the country.

While NGOs can play a significant role in adaptive research projects and are certainly enthusiastic, dedicated and good value for money, they currently lack staff with research training rather than with general agricultural backgrounds. Training of NGO staff in research methodology and/or secondment of university or research institute staff to NGOs would be ways of solving this problem.

The extension service does not formally carry out experimental work. However, it was considered essential to integrate MoFA staff into the research team at the outset. There are AEAs for each zone and it is within the remit of their jobs to collaborate in research. They can be used to collect more detailed field data than could be provided by the farmers themselves. The AEAs could be trained by research teams to collect data.
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The general research results carried out in FFSs etc. are not formally reported but feed into the FFS and Extension systems as described below under linkages.

TOR 2. Knowledge gaps and requirements and scope for incorporation of soil improvement technologies within farmer IPM/ICM programmes in Ghana

The team interviewed only groups of farmers who had participated or were participating in FFSs. Therefore, the level of knowledge and understanding that was apparent is typical of these groups only and not of Ghanaian farmers in general. However, the following areas were identified as general knowledge gaps even within these farmers groups.

1. Lack of on-farm record keeping and cost-benefit analysis.
2. The interactions between organic and inorganic crop nutrition, application rates, methods and timing.
4. Below ground pests and diseases.
5. Manure storage and management.
7. Green manure
8. Distinction between biotic and abiotic effects on plant growth. Recognition of symptoms of pest damage, diseases, environmental stress and deficiency symptoms.
9. Seed selection, preparation, storage, seed-borne disease

Further points were reported that were the views of project leaders and staff interviewed or said by them to be typical of farmers. This information requires supporting study.

1. There is a lack of appreciation of the value of organic fertilisers which are seen to be old fashioned; and a similar negative attitude to the use of animal manures and composting exists.
2. Links between soil fertility and pest and disease.
3. Composting techniques
4. Mulching
For a detailed survey of farmers’ practices and perceptions related to soil fertility and pest and disease control, see Harris et al. (1997). This earlier survey interviewed farmers in three agroecological zones of Ghana over a five-month period in 1996. Within each zone, one urban centre was chosen and for each of these, two peri-urban and two rural villages were identified. In each village, ten farmers were interviewed. None of the farmers had participated in organic soil fertility or IPM training and few had contact with NGOs promoting these approaches. The most significant difference between this 1996 study and later studies including this mission, has been the increase in the acceptability and use of poultry manure by vegetable and staple food crop farmers.

TOR 3 / Project 1. Prioritised themes identified by farmers for research attention.

The ranking is the perception of the interviewers, no formal ranking was done with farmers groups by either the international or the in-country team.

1. Marketing is a major constraint – low and variable prices, gluts.
2. Access to and cost of all soil fertility inputs.
3. Access to and cost of pest control inputs including spraying equipment – desire to reduce pesticides for both cost and health reasons.
4. High cost of credit.
5. Need to abandon crops or land. Declining yield. Build up of soil borne pests and diseases, especially nematodes and soil-borne fungal diseases of tomato. Most important pest and diseases are: detailed below.
6. Seed quality, choice and supply.
7. Water supply and cost for dry season vegetable production especially for urban farmers.
8. Lack of crop-specific recommendations for botanical pesticides.
11. Increase in secondary pests following cover crop introduction
Pests and Diseases

The Farmer Field Schools and the Projects visited both reported a range of pests and diseases but any attempt at attributing an overall economic importance to any of these records is not possible.

The FFSs approach by its nature and tradition gives an emphasis to readily observable, generally arthropod pests and beneficials. In visits and discussions there was also an emphasis on tomato growing. This crop is clearly of major economic importance within the vegetable growing systems considered and affected by a wide range of pests and diseases. However, in some cases the Projects visited had apparently concentrated on tomato less due to the crops importance but more due to a familiarity with the crop and its wide range of pests and diseases and for purposes of scientific convenience rather than established research demand.

Clearly the wide range of crops and agro-ecosystems involved requires that considerable short-cuts and assumptions as to the applicability of results to different crops and locations must be made. Only in this way can research activity be financially, administratively and scientifically manageable but the shortcomings still need to be recognised.

A further potential bias exists in the expertise associated with both the FFSs and the various Programmes and Projects visited. Many Projects had conducted initial pest and disease surveys, or included pest and disease assessments in their ongoing activities but such surveys and assessments have clearly, and perhaps inevitably, been influenced by the specialisms, competence and enthusiasm of any staff and researchers involved. Thus a further bias towards well staffed and recognised disciplines, both nationally and internationally, may have occurred. Again, even if this is considered unavoidable it should be recognised.

On cabbage, reported the most profitable crop in many visits, the most serious pest appeared to be the Diamond-back Moth, *Plutella xylostella*. There was considerable enthusiasm for the use of neem, farmers at Dzorwulu stating that they were able to resume cultivation of cabbage (stopped due to an inability to control DBM) with the use of neem.

Other major pests of cabbage reported from the FFSs were mirid bugs and aphids, traditionally controlled by Karate sprays, the IPM approach was encouraging crop monitoring and the encouragement of natural enemies.

No major diseases of cabbage were reported although the inadvisability of a humid below canopy layer was recognised with farmers either planting to encourage air flow, removing lower leaves, or avoiding mulching for this reason.

Tomatoes had a wide range of pest and diseases reported. *Heliothis* sp. is a major insect pest and the effectiveness of a feeding repellent such as neem on a fruit borer was raised. *Prodagrica* sp. was also reported as a pest. Mirid bugs and aphids were reported the major insect pests in the FFSs.
Leaf spots in general, *Septoria* in particular were mentioned on tomato. Soil diseases named included *Fusarium*, *Sclerotium* and bacterial wilt. In general however, below ground diseases were un-recognised and un-reported although both wilts and nematode diseases were known of and ‘good’ and ‘bad’ soils recognised. Many project leaders reported nematodes as major pests on vegetables. The most confident reporting of nematodes as a problem by farmers was on carrot, not surprisingly as in this case attack can be seen to directly affect yield and marketability. However, in many other cases indirect evidence e.g. problems being worse on sandy soil or less in the wet season, suggest the possible involvement of nematodes.

There was also some suggestion of crop rotation and its benefit against soil diseases, including nematodes. For example, it was reported that cabbage could do well alongside tomatoes that were failing. A cropping sequence following tomatoes with eggplant was twice reported. If nematodes (presumably root-knot, *Meloidogyne* spp.) were involved in any problems on such tomatoes the acceptability of this sequence may reflect a greater tolerance of egg plant, or could indicate another, more specific soil-borne problem.

Apart from the expressed need for research on the pests and diseases of chilli expressed by one Programme other crops received little consideration.

**TOR 3 / Project 2, 5, 6. Framework for establishment of participatory, systems-based approaches to drive the ICM process. Linkages and networks that facilitate the process of technology development from identification of need to adoption or uptake of technologies. Mechanisms linking farmer experiential-learning programmes and research programmes in Ghana in the areas of soil fertility and crop health.**

1. **Existing linkages, networks and uptake pathways**

There appear to be effective linkages between some of the major stakeholders involved in SF& IPM in Ghana. For example, the national IPM programme (now ICPM) works closely with the national extension system, from where it recruits its cadre of farmer trainers and trainers of trainers. The programme also has links with national research institutions such as CRI and universities, from where it recruits resource persons on various aspects of health crop production. The national ICPM programme has been given the mandate to institutionalise the Farmer Field School approach into the mainstream extension system, which is one of the major uptake pathways in the country. Other existing uptake pathways include NGOs (e.g. GOAN) and the various ‘farmer groups’ from which volunteer farmers are recruited to participate in field schools and on-farm research and demonstration programmes.

The link between other field-based projects and agricultural research institutions is less formal. There is a general feeling among some field-based projects that there is already a good selection of technological options in the areas of SF&IPM, which can
be pulled off the shelf and tested with farmers in various farming systems. However, what should be emphasised is that the institutional infrastructure is already in place to facilitate the entire research and development process from basic research, adaptive research and dissemination. What is needed is to simply strengthen some of the weak links.

An obvious link that needs to be strengthened is that between NGOs and research institutions. Based on our limited observation, it appears as if NGOs do not have sufficient capacities to undertake elaborate scientific validation of some technological options. NGO research capacities can be strengthened by seconding scientific staff (both biological and socio-economic) from national agricultural research institutions.

Primary and secondary schools are another potential platform that can be used to disseminate SF&IPM technologies. This potential has not been sufficiently utilised in Ghana. In this respect, Ghana can learn a great deal from the Kenyan experience, where schools now rank as one of the most important uptake pathways, along with the national extension service.

At the community level, there is a tendency to rely exclusively on ‘farmer groups’ identified by extension personnel. As we will argue below, these farmer groups do not always represent the broad spectrum of socio-economic groupings in the community. To this end, it is recommended that other community-based institutions and platforms such as churches, informal credit schemes, self-help groups, clan groups, and women’s groups etc should also be identified and utilised where possible.

2. Methods and approaches.

There are various approaches being used in Ghana to generate and disseminate SF&IPM technologies. These range from short-term training courses and workshops to more long-term interactive learning approaches such as Farmer Field Schools (FFS) and Participatory Technology Development (PTD). The FFS approach is derived from the East Asian rice IPM model, where groups of farmers learn and discover scientific tips and practical agronomic skills to cultivate and manage a given crop. Topics cover all-important areas of the production circle from land preparation to post-harvest. The first test crop which was used in Ghana was rice, followed by vegetables, plantains and cowpeas. Other crops such as cassava, cocoa and tobacco are also being considered.

Two GTZ projects in Sunyani District, the Sedentary Farming Systems Project and the Integrated Crop Protection (ICP) project use an approach called PTD. The PTD approach is equivalent to the Participatory Action Research (PAR) being used in FSS. The PTD approach is more community-based and ‘systems’ orientated because it focuses on a wider array of crop enterprises to suit different interest groups. The two projects also use a broader range of community groups as platforms for participatory learning and dissemination.
3. Two models of farmer involvement: Output vs Process.

The various SF&IPM projects operating in Ghana can be divided into two categories in terms of the extent to which they involve farmers in the technology development process.

The first category is output-oriented, where technology development is the preserve of the scientist who identifies the research problem, designs and manages the experiment and evaluates the research results with minimal participation of farmers. Research results are then handed over as outputs to dissemination agents such as Extension, FFS and NGOs. These output-oriented projects tend to view dissemination as a separate process from technology generation.

The second category of projects is more process-oriented and emphasises farmer involvement. These projects seek to involve farmers in problem identification, formulation of research goals and objectives, research design, monitoring and evaluation of the research results. Technology development is seen as a process and the aim is not to produce finished technological outputs but to generate general principles which can be adjusted by farmers to suit specific circumstances and needs.

Although existing process-oriented SF&IPM projects have achieved a great deal in the direction of promoting participatory learning, there are several opportunities for improvement and these are elaborated below.

3.1. Need to strengthen interactive and iterative learning.

During our visits to farmer field schools, farmers tended to overstate the superiority of the new techniques and ideals being promoted by FFS over traditional practices. This goes to show that whereas the notion of participatory learning is accepted at the institutional and methodological levels, the mind-set and attitudes of farmers, researchers and extensionists may still be framed within the context of the conventional Transfer of Technology (ToT) approach. There is, therefore, a need to ensure that the learning process is not unidirectional and does not reproduce teacher/pupil relationships, which the conventional ToT model is often accused of. The goal should be to move towards a more participatory relationship where farmers, scientists and extensionists are equal partners in the process of knowledge exchange and technology generation.

3.2. Incorporating ITK and Farmer innovation into the technology development process

A major requirement for strengthening interactive learning is to develop a systematic way for integrating farmer’s knowledge and innovations into the technology generation process. One strategy, which has been used by some projects, is to undertake one-off special studies on farmer knowledge and perceptions. This has been the only workable option for projects with short life spans and which cannot
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access longer-term social science inputs. However, since farmer knowledge and perceptions are dynamic and continually unfolding, the ideal situation is to develop a mechanism to elicit, record and analyse indigenous knowledge and farmer innovations on a continuous basis. It is also desirable to use this information, together with relevant scientific information, in elaborating the participatory learning and intervention strategies.

To illustrate the above, we use the case of the Mataheko Farmer Field School in Dangbe West district. We found that farmers were locally experimenting on the use of fresh and green neem fruits rather than using dried peeled seeds as recommended in the field school. Preparing neem pesticide from peeled and dried seed is more labour intensive and is only restricted to one particular season. From their initial observation, farmers feel that using fresh green neem fruits is equally effective but this is not backed by scientific evidence. There is a clear need in this case to obtain scientific evidence about the concentration of the active ingredients in the two types of neem preparations and to test their efficacy by wide scale on-farm testing. There are other examples of farmer innovations and experimentation, reported in this mission, which can contribute towards the planning of SF & IPM research. For example;

- Some farmers are trying different seedbed preparation methods (sunken and raised beds) to suit dry season and rainy season conditions.
- Some farmers have adjusted the 40 x40cm distance between cabbages recommended by Mataeko FSS to 60 x 60cm. They say this enables them to obtained bigger heads, which sell better.
- One farmer has changed the spatial arrangement of cabbage plants from that being recommended by FFS (ie from triangular to rectangular pattern). He maintains that his system ensures better ventilation and better crop performance.
- Although FFS recommend poultry manure over cattle manure on account that the latter encourage weeds, some farmers are observing more positive effects of cattle manure on yields and long-term soil fertility improvement.

All the above examples may have potential implications for soil fertility and soil pests/disease interactions in the farming system.

3.3. Achieving greater representation and better targeting of SF&IPM information.

A major difficulty being experienced by many of the projects visited is their inability to reach a proportionate number of women as compared to men. For projects focusing on vegetable production systems, this is often justified on account that women are less involved in vegetable production, and that they tend to be more involved in vegetable trading instead. The fact that women dominate vegetable trading cannot be disputed, but these constitute a different category of women. However, women in vegetable producing households are actively involved in vegetable growing and help their male family members in tasks such as cultivating, nursery establishment and
transplanting. At Mataheko, we found that manure application is predominantly done by women, who also do most of the harvesting and selling (see the labour division matrix obtained from Mataheko village given in Table 3).

The above finding has important implications for the design and implementation of a participatory learning programme. Targeting of SF&IPM technological information should take into account how agricultural production is socially organised and accomplished on the ground. Looking at how roles and responsibilities are negotiated and allocated between different members of the household can do this. If it is women who apply manure, then it is them who should be targeted with information pertaining to manure management (types and rates, application techniques, manure quality and nutrient release patterns, interaction with pests, manure storage methods etc).

3.4. How to reach women

The problem of male-bias is partly due to the fact that project staff use male dominated public meetings to choose farmer volunteers. Although project staff often seek representatives from existing ‘farmer groups’ in the locality, men also dominate most of these groups. Identifying female controlled spaces, which can then be used as platforms for participatory learning, can solve this problem. There are different types of customary and non-customary institutions and networks which bring women together in most African communities and these include reciprocal labour sharing groups, informal credit and fund raising groups, healing fraternities, pottery making groups, religious groupings etc. Against the above, it is recommended that the identification of spontaneously developed grassroots level community institutions must be an integral part of any participatory learning strategy which aims at involving different interest groups in the community.

Another way of dealing with the problem of male bias is to develop an understanding of the relative importance of different crop enterprises for men and women within any farming system. For example in some parts of Ghana, important crop enterprises for women include okra, plantains and yams. A GTZ funded project in Sunyani has been relatively successful in reaching female farmers because it has the flexibility of focussing on a different range of crops including those controlled by women. The issue of methodological flexibility will be revisited in section 3.6.

3.5. Link to poverty alleviation

Since ‘poverty alleviation’ is an explicit DFID institutional goal, there is need to ensure that participatory learning projects are targeting the more resource-poor sections of the community. In the context of Ghana, the choice of peri-urban vegetable growers is a good starting point because there is evidence that in some situations, this constitutes one of the poorer segments of the peri-urban community. For example, a well-being ranking exercise carried out in Mataheko village showed that 23 out of the 34 vegetable growing households (i.e. 67 %) belonged to the poorest well-being category, while only 11 (32%) and 4 (11%) belonged to the medium and rich categories respectively. It must be pointed out that since the vegetable growing enterprise is much more diverse and more complex than we
Integrating pest management and soil fertility management

currently understand, this scenario might differ from locality to locality. There is need to therefore situate vegetable growing in the context of the wider farming systems and the multiple livelihood strategies being pursued by different categories of people in each locality.

3.6. Building flexibility; the case of Farmer Field Schools.

The Farmer Field School approach is a very popular approach to encourage mutual learning between farmers, scientists and extensionists, and there seems to be great local demand for more schools. As already pointed out, the principles, approach and even some of the tools being used are based on the East Asian model of rice IPM. Our recommendation is that there is need to adapt the FFS approach to make it more relevant to the realities of smallholder African farming systems, which are much more complex and diverse than the East Asian situation. The following are some proposals:

- The current focus on single commodities in many FFS elsewhere makes it difficult to consider the farming systems in a more holistic manner. In order to address the diverse interests and priorities of different categories of people, there is need to look at the range of crop enterprises and livelihood strategies being pursued by different categories of people.

- In order to reach different categories of people, there is need to use a wider range of community institutions as platforms for participatory learning, rather than enrolling people into a formal group. Using existing community institutions will make the learning process less formal and more inclusive.

- As we have argued above, information dissemination must take into account the social division of labour and responsibilities in different crop enterprises. The current practice is to focus all the training on the same group of people, who are predominantly men, irrespective of gender division of agricultural roles.

3.7. Need to broaden the range of participatory learning tools.

The range of visual and experiential tools being used in participatory learning programmes should be expanded. In particular, there is need to help farmers comprehend below ground pests and diseases and soil biological processes. These areas still largely remain outside the local people’s boundaries of knowledge and experience.

TOR 4. Opportunities for DFID-supported research to contribute to the integration of pest and soil fertility management.

Understanding the vegetable production systems

There are many quite distinct vegetable production systems in Ghana and the situation appears to be more complex than that described by either Blake et al. (1997) or Harris et al. (1997). Even within Kumasi, Blake et al. (1997) recognised four
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vegetable production systems and there are more systems in other regions. The main systems are sub-divided according to tenure and gender of farmer. Land management varies dramatically between systems; some systems fallow some do not, some systems using irrigation some not, some short-term commercial enterprises some settled land. The potential for many of the techniques relevant to soil fertility will vary among the systems. A study to classify the different systems, describe their characteristics, and analyse their importance and relevance to DFID’s poverty focus is needed, in order to target soil fertility/pest control activities most effectively.

Related to this is the need, expressed unanimously by stakeholders from the research and extension organisations, 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.

There is a need to objectively assess the appropriateness and effectiveness of different social groupings as vehicles for SF x IPM promotion.

Soil fertility x pest control interactions

There is overwhelming evidence from development projects, research projects and FFSs that organic soil fertility options are acceptable and economically viable alternatives to chemical fertilisers in at least some vegetable production systems. Crude calculations suggest that poultry manure and Mucuna cover cropping are both cost-effective alternatives to chemical fertilisers, although poultry manure may be a viable option only close to major urban areas where it is available and is currently in surplus. Figures quoted were 50,000 cedis for 50kg of NPK 15:15:15, i.e. 6600 cedis/kgN compared with 60,000 cedis for 6 tonnes of poultry manure (2.5% N), ie 400 cedis/kgN. Economic analyses have been carried out by Akatse et al. (1999) and these indicate high net returns from organic and organic + inorganic soil fertility inputs Table 2.

Organic soil fertility options are being adopted to varying degrees including poultry manure, cow manure, cover cropping and farm-scale composting. There is still no production of municipal compost in Kumasi and limited availability and farm use of compost from Accra.

There is thus scope for research, based on these technologies, to investigate the interactions between organic soil amendment and crop protection. With the currently most acceptable techniques as a starting point, the objectives of such research should be to optimise methodology for pest control as well as soil fertility. Little is known about interactions with soil types, possible mixtures of organic amendments, organic-inorganic combinations, application rates, placement and timing, or of the possible enhancement of biocontrol value of organic inputs by management and amendment.
Table 2. Yield and net returns for nutrient management trials in Training of Trainers course (Mc = million cedis). Adapted from Akatse et al. (1999).

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Marketable yield (t/ha)</th>
<th>Total revenue (Mc/ha)</th>
<th>Total costs (Mc/ha)</th>
<th>Net returns (Mc/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cabbage</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control (no fertiliser)</td>
<td>18.03</td>
<td>4.24</td>
<td>2.56</td>
<td>1.69</td>
</tr>
<tr>
<td>NPK 15:15:15 @ 60 kgN/ha + AS @ 30 kgN/ha</td>
<td>30.30</td>
<td>7.13</td>
<td>3.18</td>
<td>3.95</td>
</tr>
<tr>
<td>Poultry manure @ 20 t/ha</td>
<td>30.50</td>
<td>7.18</td>
<td>2.78</td>
<td>4.40</td>
</tr>
<tr>
<td>Manure + NPK, both at above rates</td>
<td>36.09</td>
<td>8.49</td>
<td>3.28</td>
<td>5.21</td>
</tr>
<tr>
<td><strong>Tomato</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NPK 15:15:15 @ 40 kgN/ha</td>
<td>5.59</td>
<td>2.60</td>
<td>3.42</td>
<td>-0.82</td>
</tr>
<tr>
<td>Poultry manure @ 10 t/ha</td>
<td>7.85</td>
<td>3.65</td>
<td>3.11</td>
<td>0.54</td>
</tr>
<tr>
<td>Compost @ 15 t/ha + NPK 15:15:15 @ 20 kgN/ha</td>
<td>9.64</td>
<td>4.48</td>
<td>3.44</td>
<td>1.04</td>
</tr>
</tbody>
</table>

There is a need for a dual research approach, including both adaptive and strategic research. There is a sufficiently large pool of farmers adopting organic soil fertility practices for on-farm participatory research to be carried out in preference to the on-farm but researcher-led approach that has been typical so far. With reasonable numbers of farmers adopting the techniques there is also the scope for comparative survey type research. However, while the organic fertility techniques themselves are well reported, there is relatively little published information on interactions with pest control. Therefore, strategic, basic research to understand the biology, chemistry and physics of the interactions is urgently required to allow the development of appropriate techniques or baskets of options.

**Soil-borne pests and diseases**

There are likely to be significant interactions between soil fertility and foliar pests and diseases via crop nutritional status and vigour, and these interactions merit attention. However, on the basis of most likely interactions and on the priority given to these problems by all stakeholders, special emphasis should be given to soil-borne pests and diseases, including the under-researched subject of nematode control. The problems of soil-borne pests and diseases, often not differentiated, are so severe in some of the areas visited that they result in complete crop failures, farmers abandoning some crops completely, and also abandoning infested land.

Interventions are required that combine soil fertility building with soil-borne pest and disease control, but that offer alternatives to the traditional long-rotation bush fallow system. Many candidate interventions could be tested, and there would be advantages in a concerted programme to compare techniques for a wide spectrum of
soil-borne pests and diseases, rather than separate projects on individual organic techniques and pests. Among the techniques that deserve attention are:

1. Nematode biocontrol.
2. Rotation.
3. Effect of different organic soil amendments and combinations.
4. Role of cover crops – including possible role of cover crops as reservoirs of pest and diseases.
5. Organic-inorganic interactions.
7. Enhancement and maintenance of natural or introduced biocontrol agents.

Indigenous Knowledge

In general, knowledge of soil fertility and pest and disease issues has been reported to be low amongst farmers in all parts of Ghana. On the other hand, there are examples of local knowledge and practice including the use of indicator species to assess soil fertility, and appreciation of the value of poultry manure for nematode control. GOAN has recently started a one-year project on the promotion of indigenous knowledge about soil fertility and pest control. This project, which is funded by UK NGOs, will collect and catalogue indigenous knowledge on these subjects and make the information available through a documentation centre in Kumasi. A research programme to validate the indigenous knowledge uncovered, as well as novel techniques developed as a result of farmer experimentation, would be valuable and could be carried out collaboratively with GOAN.

Other SF x IPM topics

There are a number of other priority research topics identified by stakeholders that would be appropriate for DFID funded research, for which UK institutions have competitive advantage and which would relate directly to the interaction between soil fertility and pest control:

1. Vegetable nursery management including the use of sub-soil, soil from river beds, pasteurisation of nursery soil by burning residues, and solarisation for pest and disease avoidance, combined with appropriate soil fertility treatments to improve plant vigour.

2. Influence of soil fertility on post harvest storage and quality.


4. Selection of cover crops and varieties for antagonist and beneficial purpose, and for the promotion of mycorrhizae.
5. Compost and manure management. Improved storage and management of organic soil fertility inputs to conserve nutrients and optimise pest control properties.

6. Development of simple decision guides for farmers on how to use and manage manure.

7. Validation of farmers developments with neem. Neem is proving effective and popular as a botanical insecticide. Farmers are experimenting with neem and developing their own practices using neem leaves and unripe fruit. They are also experimenting with neem as a soil drench and may be in a position to apply neem seed cake as a dual fertiliser/pesticide for nursery beds. Efficacy of some of these preparations needs validating and proper recommendations developed in the context of soil fertility and pest control.

Other topics

There are two topics which are not directly linked to the interaction between soil fertility and pest control but which were identified as priority issues, as top priority in the case of marketing.

1. Marketing is a major constraint to improving livelihoods of vegetable producers. There is seasonal over production, variable prices and the market is often controlled by a cartel of traders. Some attempts are to be made by MoFA to set up wholesale/retail outlets for produce in cities outside the market. GOAN is planning direct sales of organic produce. Produce marketing arrangements in which CMB has the sole right to market cocoa from Ghana is hampering efforts to develop higher value organic export markets. There is scope for economic research of these issues and the related institutional issues so as to inform policy within Ghana.

2. A study of vegetable seed supply, choice, marketing, quality and testing would clarify the issues relating to seeds that have been identified as constraints and suggest possible interventions.

Conclusions and recommendations

1. Existing and recently completed projects include experimentation at various levels ranging from researcher-led and managed strategic research to farmer experimentation with no formal collection of results or monitoring.

2. All projects had carried out some form of PRA, survey or consultation, either before of during the project, which identified a researchable constraint. However, in some of the more strategic projects, the research agenda seemed to have come from the overseas research partner, which was equated with the donor agency.
3. With the exception of the project, Composted Waste in Urban Agriculture, there was very little consideration of the interactions in the other projects. There are several possible reasons for the lack of data on SF x IPM interactions from current projects.
   - Lack of holistic approach
   - Complexity of experimental design to study interactions
   - Requirement for multidisciplinary teams including socio-economic studies
   - General nature of results from PTD, FFS etc.

4. One approach to the subject, which does not seem to have been attempted, is the comparative study of matched pairs of farms, as an alternative to factorial experimental designs.

5. The scientific expertise required to study these interaction is available in the universities and national research institutes. There are a relatively small number of experts available in each discipline. It is possible that this restricts competition and risks over-commissioning of certain institutions.

6. NGOs have also been involved in adaptive research but currently lack staff with research. Training of NGO staff in research methodology and/or secondment of university or research institute staff to NGOs would be ways of solving this problem.

7. It was considered essential to integrate MoFA staff into any research teams at the outset. There are AEAs for each zone and it is within the remit of their jobs to collaborate in research.

8. The team interviewed only groups of farmers who had participated or were participating in FFSs. Therefore, the level of knowledge and understanding that was apparent is typical of these groups only and not of Ghanaian farmers in general. However, there were areas identified as knowledge gaps even within these farmers groups.

9. The ranking of farmers’ priorities placed marketing issues as the main constraint, with access to and cost of soil fertility and pest control inputs coming second and third, respectively.

10. The Farmer Field Schools and the Projects visited both reported a range of pests and diseases but any attempt at attributing an overall economic importance to any of these records is not possible.

11. There appears to be effective linkages between some of the major stakeholders involved in SF& IPM in Ghana.

12. The link between other field-based projects and agricultural research institutions is less formal. However, the institutional infrastructure is already in place to facilitate the entire research and development process from basic reasearch to adaptive research to dissemination. What is needed is to strengthen some of the weak links.
13. An obvious link that needs to be strengthened is that between NGOs and research institutions.

14. Schools are another potential platform that can be used to disseminate SF&IPM technologies.

15. At the community level, there is a tendency to rely exclusively on ‘farmer groups’ identified by extension personnel. It is recommended that other community-based institutions and platforms such as churches, informal credit schemes, self-help groups, clan groups, and women’s groups etc should also be identified and utilised where possible.

16. Although existing process-oriented SF&IPM 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 ITK and Farmer innovation into the technology development process
   • Achieving greater representation and better targeting of SF&IPM information
   • Improvements in reaching women
   • Improving links to poverty alleviation
   • Building flexibility
   • Broadening the range of participatory learning tools

17. Opportunities for DFID-supported research to contribute to the integration of pest and soil fertility management include:
   • Understanding the vegetable production systems
   • Objectively assessing the appropriateness and effectiveness of different social groupings as vehicles for SF x IPM promotion

18. There is overwhelming evidence from development projects, research projects and FFSs that organic soil fertility options are acceptable and economically viable alternatives to chemical fertilisers in at least some vegetable production systems.

19. There is thus scope for research, based on these technologies, to investigate the interactions between organic soil amendment and crop protection. With the currently most acceptable techniques as a starting point, the objectives of such research should be to optimise methodology for pest control as well as soil fertility.

20. Little is known about interactions with soil types, possible mixtures of organic amendments, organic-inorganic combinations, application rates, placement and timing, or of the possible enhancement of biocontrol value of organic inputs by management and amendment.

21. There is a need for a dual research approach, including both adaptive and strategic research. While the organic fertility techniques themselves are well reported, there is relatively little published information on interactions with pest control. Therefore, strategic, basic research to understand the biology, chemistry
and physics of the interactions is urgently required to allow the development of appropriate techniques or packages of techniques.

22. There are likely to be significant interactions between soil fertility and foliar pests and diseases via crop nutritional status and vigour, and these interactions merit attention. However, on the basis of most likely interactions and on the priority given to these problems by all stakeholders, special emphasis should be given to soil-borne pests and diseases, including the under-researched subject of nematode control.

23. Interventions are required that combine soil fertility building with soil-borne pest and disease control, but that offer alternatives to the traditional long-rotation bush fallow system include:
   - Nematode biocontrol.
   - Rotation.
   - 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.

24. A research programme to validate the indigenous knowledge uncovered by GOAN and others, as well as novel techniques developed as a result of farmer experimentation, would be valuable.

25. There are a number of other priority research topics identified by stakeholders that would be appropriate for DFID funded research, for which UK institutions have competitive advantage and which would relate directly to the interaction between soil fertility and pest control:
   - Vegetable nursery management
   - Influence of soil fertility on post harvest storage and quality.
   - Stimulation of Mycorrhizae by organic interventions
   - Selection of cover crops and varieties for antagonist and beneficial purposes
   - Compost and manure management.
   - Validation of farmers developments with neem.

26. There are two topics which are not directly linked to the interaction between soil fertility and pest control but which were identified as priority issues:
   - Marketing
   - Vegetable seed supply, choice, marketing, quality and testing
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References


Appendix 1 – Individual visit reports

Wednesday 19th January. Visit to Dzorwulu / Plantpool Vegetable Producers Association, Accra.

The project

This was chosen for a visit as it is a site for one of the FAO/UNDP funded Farmer Field Schools within the National IPM Programme.

Farmer field schools were started in 1995 and the Dzorwulu FFS has been operational for 12 months. UNDP has highlighted five poverty districts and the Accra Metropolitan Assembly (AMA) urban vegetable production is considered to be in this list.

The area is flat, moderately low lying land along a main drainage channel between a railway line and this channel. Some of the area lies adjacent to an electricity sub-station and some land is under high tension power lines.

The land is controlled by the AMA, but is used on an informal basis, without deeds, tenure rights or rent, by individuals who farm their own plots but co-operate on group and external issues and some in the FFS. The area has apparently been cropped continuously with vegetables for about 30 years.

There are 188 farmers of whom 30 (including four women) attended the FFS.

The growers receive advice from a government extension officer who visits the site approximately every two weeks. He provides information, but this was said mainly to be recommendations for mainstream products such as fertilisers and pesticides.

Those farmers who attended the FFS are training others who did not.

Soils

Soils vary from sandy loam to moderately heavy clays with a wide variety of types and considerable local variation. Some patches where very poor crop growth or crop failure occurred were said to be saline. There was evidence of surface salts on some beds and the edges of beds. Water from boreholes is said to be saline (although the water used for irrigation is from the domestic potable mains so should not be a contributing factor). Continuous use of poultry manure may contribute to high salts content. Cow manure was reported to be beneficial in the salt affected areas. These areas have been recognised for a long time and there was no suggestion that the problem was increasing. Soil testing has been carried out as part of the FFS, but no information was available.

Water

At one time the growers used water from a drainage channel at the edge of their land, but this is heavily polluted and buyers refused to buy vegetables irrigated with this water. Growers switched to irrigating with mains water, which is piped to three or
four standpipes on the site. A few of the growers have hosepipes; the others use watering cans. With privatisation of the water supply industry, water is now metered and its high cost is seen as a major problem that could make vegetable production uneconomic.

Crops

The Association specialises in the production of leaf vegetables, cabbage being the most valuable. Lettuce and onion are also major crops. Carrots, cucumber, bell pepper, amaranth, radish, parsley, okra and pak choi were also seen. Chilli pepper was said to be cultivated on the bunds for home consumption and for use in the neem leaf/chilli pepper spray preparations.

Carrots are said not to grow well because of nematode infestation and because of the nature of the soil. It is difficult for carrots produced by the project to compete in the market with carrots imported from Togo, although the locally produced carrots are said to have a better taste. Tomatoes are not grown as they cannot compete with specialist tomato growers elsewhere in the city (and presumably the country?).

There was dissatisfaction with the supply of seeds. There was said to be a monopoly seed supply and mainly Japanese varieties were available. Previously Suttons seeds had been available. There was thus a feeling that inappropriate varieties were being used in some cases, that there was variation in crops within named varieties, and that seed quality was sometimes poor.

Most of the crops are grown throughout the year. Crop rotation is practised. Successive cabbage crops are not grown on the same bed because of disease build-up. Onion, carrot or another crop, depending on likely market demand follows cabbage.

Crops are sold to buyers who trade them in the local markets. Buyers either buy crops as required or contract to buy a bed of crops when ready for harvest and then collect them as required. Growers were dissatisfied with the price obtained which was said to be about 50% of the retail price.

Pests and diseases

The most important pests are leaf eating insect pests of cabbage (diamond back moth, aphids, semi-looper etc.) and root knot nematodes of crops, especially carrot. Nematode infestation was said to be worse on sandy than on clay soil and worse in the dry season than in the wet season. Lettuce is attacked by leaf miner and this is not controlled by neem, so it is necessary to spray with a systemic insecticide, Actellic (pirimiphos-ethyl). Furadan (carbofuran) had been used at one time to control nematodes but use was discontinued as the chemical was said to ‘destroy the soil’. Nematodes are controlled by rotation only. Ants also reportedly attacked carrot.

A brown spot of lettuce was observed but was said only to affect older leaves at the end of growth. No action, other than rotation was taken to control diseases.
A major innovation in the group has been the introduction of neem seed extract as a pesticide for control of insect pests of cabbage. This is used as a replacement for Karate (cyhalothrin). Farmers had previously been introduced to neem as a pesticide but had not adopted it as they lacked information on doses etc. The FFS has taught them to prepare and use the neem seed extract. They report very favourable results and are prepared to substitute neem for karate completely. A constraint to the use of neem this year has been the supply of seeds. These are only seasonally available and had been collected as required without the collection and storage of a supply for the rest of the year. It is planned to store and use sufficient after the next seed harvest. The seeds are abundant and collected by children from streets and compounds.

The introduction of neem as a pesticide was said to have allowed farmers to return to cultivating cabbage; after they had stopped because of a build up of pest resistance to the common insecticides.

The lack of neem has led some farmers to use karate again; one has bought a commercial neem preparation (neemol from India; 0.15% azadirachtin). The farmers have also been informed that they can use neem leaf extract for the same purpose as neem seed extract as long as it is mixed with chilli pepper. The leaves are pounded, left overnight or fermented for between several days and two weeks before use.

**Soil fertility**

A variety of soil fertility inputs are used including poultry manure and cow manure. Poultry manure is readily available in sufficient quantity from commercial poultry producers. It is available free for collection from some areas and then costs 1000 cedis per 50 kg bag to transport, or available delivered for about the same price. Cow dung is available fresh nearby from a government cattle station, at 3000 cedis per 50 kg. The quality of the poultry manure varies depending on the age and the size of the wood chips used as bedding. Both manures are stored for some time to condition them before use. Management of the manure involves stockpiling in the open with watering if required. Crop residues are added to the cow manure. Losses from leaching and volatilisation are likely to be very high, especially with the cattle manure.

The FFS taught farmers to apply the poultry manure and incorporate it two weeks before transplanting seedlings to avoid scorching. This is said to give better crop growth than the previous practice of applying poultry manure two weeks after transplanting.

Chemical fertilisers are sometimes used (NPK 15:15:15, ammonium sulphate), mainly on the better land. They are not used on sandy soil and are used in combination with manure on the heavier clays. There is thus quite a sophisticated strategy for soil amendment use.

Some compost is made from crop residues or other available materials but the quantities must be minimal.
Link between soil fertility and crop protection

Although it was said to be included in the curriculum of the FFS, no farmer specifically linked pest and disease incidence to soil fertility.

Experimental plots

A small trial comparing municipal compost and poultry manure was being carried out on behalf of a postgraduate student of the Swedish Agricultural University. Poultry manure gave the best early results but the compost is giving better residual effects in a succeeding crop. The crops received a normal spray regime using neem so no data on the effect of compost on diseases is recorded.

Farmers' perceived constraints

1. Lack of tenure – the risk that authorities can carry out public works etc. on the land at will. In one case the group had to lobby hard to prevent crops being damaged by public work on a drain.

2. Low profit margins because of variable market demand and (perceived) low prices paid by traders.

3. Expensive metered water.

4. Crop growth reduction or crop loss reportedly due to salinity in the soil.

5. Soil type unsuitable for certain vegetables.

6. Poor choice and quality of vegetable varieties.

7. Nematodes of carrot and other crops.

Researchable issues

Efficacy of neem leaf extracts, formulation and doses of neem leaf/ pepper preparations, storage of neem/ pepper extracts

The seed supply chain, market, selection, testing and recommendation of crop varieties

Improved manure management methods

Investigate the cause of the ‘salinity’ problem and methods for ameliorating it, including soil amendments and precision applications.

Marketing chain potential for co-operative marketing, farm gate sales, added value etc.

Methods to control nematodes on carrot.
Thursday January 20th. Visit to Mataheko (Dangbe West) Farmer Field School.

The project

A meeting was held with Mr James Tanihu (a leading farmer) and farmers who had attended the FAO-UNDP Farmer Field School. The village was a relatively new settlement on stool lands to the east of Accra. The land was made available at a nominal rent (one farmer paid 20,000 cedis, less than £4, per year for use of 150 acres). The areas probably qualifies as peri-urban with excellent road communication with Accra. There was evidence of new settlement for residential purposes along the main road and this may in future encroach on the farmland. The area is in the coastal savannah agro-ecological zone with neem and grassland as the dominant natural vegetation.

The lead farmer had a tractor and trailer, although this was the only one in the village and was used by others for ploughing and to transport manure to the fields. Out of 150 acres the lead farmer used 50-60 for vegetable production. He also had 120 cows, small livestock and a snail farm and a newly started mushroom farm. There was sufficient land for a two year fallow.

The government extension officer visited the village approximately three times each month.

The FFS ran from May to October 1999. Of the 30 participants in the FFS, eight were women. As a result of the FFS several of the farmers were teaching the techniques learnt to between two to four of the other farmers who had not attended the FFS.

An exercise to determine the division of labour between genders was carried out as was a wealth ranking exercise (Table 4).

Table 3. Division of labour between men and women showing men’s opinions and (in parentheses) women’s opinions. A maximum of five units were divided between the genders for each task in the vegetable production cycle.

<table>
<thead>
<tr>
<th>Task</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land preparation</td>
<td>5 (5)</td>
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</tr>
<tr>
<td>Ploughing</td>
<td>3 (3)</td>
<td>2 (2)</td>
</tr>
<tr>
<td>Nursery management</td>
<td>3 (3)</td>
<td>2 (2)</td>
</tr>
<tr>
<td>Transplanting</td>
<td>3 (3)</td>
<td>2 (2)</td>
</tr>
<tr>
<td>Spraying</td>
<td>4 (4)</td>
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</tr>
<tr>
<td>Fertiliser application</td>
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<td>3 (4)</td>
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<tr>
<td>Weeding</td>
<td>4 (4)</td>
<td>1 (1)</td>
</tr>
<tr>
<td>Harvesting</td>
<td>1 (1)</td>
<td>4 (4)</td>
</tr>
<tr>
<td>Selling</td>
<td>1 (1)</td>
<td>4 (4)</td>
</tr>
</tbody>
</table>
Wealth ranking exercise: Mataheko Village

Local criteria of wellbeing:

Rich households:

Have tractor
Have hundred herds of cattle or over
Have zinc and block house
Grow a wide range of crops
15-20 acres of land or more
Three-four wives and many children
Food whole year round
Children attending school
Income of 5-6 million cedis per season

Medium households:

Have motorbike or bicycle
30-50 head of cattle
Zinc house without blocks
9-10 acres of land
One or two wives
Food all year round
Children attending schools
Income of 2-3 million cedis per season

Poor households:

Thatch and mud house
Three head of cattle or none
One wife
Dry season food shortage
Diet not very varied, confined to main staples such as Banku and vegetables
Income 300,000 to 1million cedis per season.

Table 4. Number of households in the three wealth categories: Mataheko village.

<table>
<thead>
<tr>
<th>Rich</th>
<th>Medium</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>11</td>
<td>23</td>
</tr>
</tbody>
</table>

Soils

Soils in the area were uniform and appeared to be a sandy loam.

Water

Water was a constraint and had to be paid for. A quarter of the farmers only grew rain-fed crops; the rest used watering in the dry season.
**Crops and livestock**

A wide range of field crops and vegetables is grown including, maize, cassava, okra, cabbage, spring onion, Chinese cabbage, tomato. Cabbage is the most profitable crop with price per head varying from 700 to 2000 cedis depending on the season with the highest price obtained in the dry season.

Mushrooms were produced on sawdust in the dry season, both by individual farmers and as a group enterprise. The techniques for mushroom cultivation had been learnt from the government extension officer.

From the FFS, farmers had learned and now practice appropriate crop rotation. They had already been rotating the crops but now appreciate the benefit both for crop protection and for nutrient supply to crops with differing nutrient requirements. They had been taught the optimum spacing for crops but had modified the spacing for cabbage from 45x45 to 60x60 cm as they obtained bigger heads that were preferred in the market. Farmers had been taught to optimise use of space on the beds with a triangular planting design, but at least one farmer had reverted to square planting, as he believed that it improved air circulation through the crop.

They had learned the technique of staking indeterminate tomato varieties, but had not yet tried this. They also learned to prune tomatoes to improve fruit size.

All farmers had adopted the ideas of monitoring crop growth and performance.

Some of the farmers had large herds of cattle that were extensively grazed and kept in kraals at night. Small ruminants, rabbits and snails were also kept.

**Pests and diseases**

Diamond back moth, *Plutella* was mentioned as a major pest of cabbage. Crickets had damaged cabbage plants after transplanting and gaps had been replanted.

A crop of tomatoes, grown after maize was completely abandoned because of wilt. There was evidence of both root knot nematode and wilt disease but it was not possible to identify the primary cause. Farmers could name and recognise insect pests and beneficials.

Neem kernel preparation was sprayed weekly on cabbage to control insect pests and was considered to be very effective. Farmers had experimented successfully with neem leaf preparations and also reported success using preparations from pounded whole immature fruit.

In the FFS, farmers had learned to prune old leaves of cabbage to allow free air circulation around the base of plants and to remove any disease and aphid inoculum present on the older leaves.

Farmers had previously use Karate as an insecticide and Kocide (?) as a fungicide to control *Septoria* on tomato. They had used Furadan as a nematicide (now banned) but stopped because of concern about its toxicity.
Soil fertility

Poultry manure is purchased for 12,000 cedis per trailer load, but this is uncommon. Kraal manure is virtually the only fertiliser used. This is available from several large kraals. It is available free of charge and is used on all crops, not just vegetables. The surface layer of the manure in the kraal is removed and the older material dug out and transported to the field where it is stacked until used. At present, the nutrient concentration from extensively grazed cattle means that crop nutrient supply is not a constraint. There is presently no demand for improved manure management techniques.

Mulching had been recommended in the FFS for water conservation but was one of the less popular interventions because “it is not needed if you have enough water”. Also because there was a lack of access to mulching material, and because when there is sufficient moisture in the soil mulching was felt to encourage stem rots.

Link between soil fertility and crop protection

Farmers understood crop rotation to be of joint value to crop nutrition and crop protection. No specific link was drawn between soil fertility and pest and disease incidence or control.

Experimental plots

As a result of the FFS, farmers were conducting their own trial comparing cow dung and poultry manure as fertilisers for dry season cabbage. The crops were transplanted at different times and were mulched with rice straw obtained free of charge from a government rice project. The mulch was to conserve water. The farmers reported that early growth was better with the cow manure.

Farmers’ perceived constraints

1. Cost and availability of water
2. Unexplained crop failure of tomato

Researchable issues

Efficacy of immature neem fruit preparations, year-round neem treatments.

Value of organic amendments, especially poultry manure, for control of nematodes, considered in relation to rotation and fallow.
Friday 21st of January. Meeting to discuss ‘Composted waste in peri-urban agriculture’ and related projects with Dr Richard Awuah, Department of Agriculture, KN University of Science and Technology, Kumasi

This multidisciplinary research project was funded by DFID CPP and involved CABI, CRI, SRI and KNUST. The project investigated the effect of municipal compost on the incidence of pests and diseases in cabbage and tomato at two village sites, Swedru and Daku. The project also investigated the effects of this municipal compost on soil fertility. It was originally intended to study soil-borne pests and diseases, but they were found to be absent from the sites selected so the project concentrated on foliar pests and diseases. The trials were researcher managed on farmers’ fields.

The compost did not significantly reduce pest incidence but improved growth and yield, and improved soil fertility. The project used no pesticides so that pest control effects of the compost would be apparent. Yields were increased with 20t/ha compost, the lowest rate used, and were not significantly higher with rates up to 100 t/ha. In an ancillary pot experiment, high compost application rates were phytotoxic, but lower rates controlled nematodes.

The multidisciplinary nature of the project was valuable, but there were logistical and management difficulties in co-ordinating a project with input from several institutions.

The project was supposed to be a first phase of a larger research project and included no dissemination of promotion activities. The results were presented to one farmers’ workshop. A related study ‘Farmers’ perceptions of pests and diseases and the use of composts’ was carried out by H Warburton (NRI) and P Sarfo-Mensah (BIRD, KNUST).

Dr Awuah considered that the main incentive to the use of soil amendments for crop protection was to reduce the use of chemical pesticides because of health risks and also because of insect resistance. The use of organic soil amendments should also contribute to sustainability of land use in intensive vegetable production systems.

Dr Awuah has a MPhil student undertaking a follow-on experiment with compost from the original supply from Accra. This is designed to study the interaction of soil fertility and pest and disease control. The trial is on university land. A factorial experiment in a randomised complete block design will include treatments +/- NPK, compost (20 t/ha), Topsin (fungicide), Karate (insecticide). The student has completed one season’s trial with okra. Soil analysis before and after the trial has been completed. Agronomic data has been collected. No economic analysis has been carried out but can be. No data has been collected on nematode infestation. The major pest has been Podagrica and the major disease, Septoria leafspot. Data is being analysed. It would be desirable to repeat the trials to obtain results for a second cropping season and to monitor residual effects. It is not clear whether funding and another student will be available to continue the research.

Other information: Other research has indicated the value of mulching on Septoria leaf spot of tomato. Mulch reduces soil splashing, the source of inoculum. However, farmers are not adopting this technique.
Friday 21st January. Meeting to discuss ‘Biological control of root-knot nematodes’ and related projects with Dr Barbara Hemeng, Department of Agriculture, KN University of Science and Technology, Kumasi

This project was linked to the Integrated Food Crops System Project at Sunyani. Good control of nematodes on tomato have been obtained using Verticillium and/or Pasteuria as biological control agents with a mixture being the best. Pot and field trials have been carried out using biological control agents from the UK.

Other information: Also discussed was the value of fallows in reducing nematode populations and the possibility of using improved fallows, designed to optimise soil fertility and nematode control benefits. Reports on the value of the incorporation of Sesbania or Mucuna green manures for nematode control were discussed.

There is evidence that mulching with grass and Chromolaema can increase populations of natural nematode populations.

It is widely believed that poultry manure is a good control for nematodes. Pig manure and especially pigeon manure have also been reported to be highly effective. An earlier project had established the benefit of poultry manure in controlling nematodes on cabbage.

Farmers in the area are aware of nematodes as a pest and recognise symptoms.

Field Trip to Offinso Farmer Field School (FFS). Saturday 22nd January 2000.

Approximately 35 FFS members were present (essentially the whole membership), of which 8 were women, for our visit, taking place in the 7th week of the second AESA (Agro-Ecosystems Analysis) FFS, meetings. These are held on Thursdays (see notes on the meeting with Mr Emmanuel Antwi, General Secretary, GOAN, Sunday 23rd).

After some introductions, presentations were made of the FFS ‘AESA’ findings of tomato and cabbage crops grown under ‘Farmer Practice’ and ‘IPM’ with questions being asked during and between presentations. (See below for a summary of these presentations). After these presentations and questions NSP and PH left the group to visit the demonstration farm leaving PS to conduct some simple PRA exercises with the group.

During the initial introductions the majority of the group members introduced themselves as ‘tomato farmers’, with others presenting themselves as ‘pepper’ ‘okra’ and ‘cabbage’ farmers. Surprisingly no farmers presented themselves as more than one-crop farmers although clearly this must have been the case. Tomato and cabbage were considered the most lucrative crops.
Questioning of the group was conducted in a mixture of English and Akan and questions were passed on and replies received invariably via one of the Trainers. The influence this could have had on the replies received cannot be ascertained.

Initial questioning revolved around the growing of tomatoes. There was a recognition of “good soil” and “bad soil”, and although it was claimed that all farmers had “the same” soil it was not established whether this was “good” or “bad” soil.

When asked why it was the soil that was viewed to be “not good” as opposed to attributing problems to pests it was stated that when due to pests the plant would wilt with insects on it. However, the FFS had shown (taught?) that when due to “the soil” the plant had no roots when uprooted, and that sandy soil was worse for tomatoes. “Bad soil” could however, be good for cabbage or eggplant, and when planted together it had been observed that tomatoes could die whereas cabbages could thrive.

It was felt that sandy soil got “too hot” for tomato and when irrigated the water “boiled” the plant. In addition water drained away from sandy soil. It was also felt that sandy soil was not suitable for a fibrous plant with a soft stem like tomato whereas cabbages and eggplants had stronger stems so could tolerate “hot” better.

The FFS had promoted the use of sub-soil and compost in nurseries, in contrast to the Farmers Practice of using topsoil. Benefits were viewed as due to the high costs of “chemicals” in Farmer Practice. A farmer commented that a bag of fertiliser costs 50,000 cedis whereas a day’s labour (i.e. the opportunity cost of spending a day making compost) was only 6,000 cedis. A further advantage was felt that compost could be made in the Dry Season when on-farm activity was low.

IPM was showing (teaching?) disease to be present in the topsoil and plants to be very healthy with compost. Compost was also felt (farmers had been told?) to control weeds. Compost was still apparently only a FFS activity, being made at the Demonstration Farm; in addition there was some use of poultry manure by the farmers. Its cost was dependant on the distance it was necessary to transport it, at between 30,000 – 60,000 cedis for a 7-ton truck load. Such quantities were purchased by groups of farmers (such groups existing prior to the setting up of the FFS).

The use of neem, although known, was not common due to a lack of neem trees. It was planned to obtain seed from other villages and plant them locally.

In discussing control of insects one (male) farmer commented that after a FFS he had decided to closely observe the underside of a (tomato?) leaf and had seen ants eating aphids, whereas another mentioned the health effects of using chemicals but that these did not occur with neem.

A female farmer asked why there were still lots of pests after using chemicals. Among a range of replies and responses this provoked where that:

- Chemicals killed natural enemies
• Pest were flying / highly mobile (and could quickly re-invade from elsewhere) whereas natural enemies could only walk
• With no knowledge of what was a pest, treatment continued (and costs were incurred) until pests disappeared
• Resistance could develop.

Among aspects of “indigenous knowledge” described where the making of small nursery beds in the dry season and large beds in the wet season, which could lead to costs (labour) savings and that in the dry season leaves and other plant material could contribute a mulch.

Table 5. FFS field school presentation of AESA for tomato growing using “traditional” farmer practices.

<table>
<thead>
<tr>
<th>Tomatoes</th>
<th>Farmer Practice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variety ‘Power’</td>
<td></td>
</tr>
<tr>
<td>Date transplanted</td>
<td>6/1/2000</td>
</tr>
<tr>
<td>Growth stage</td>
<td>35 days after planting</td>
</tr>
<tr>
<td></td>
<td>Average number of leaves - 8</td>
</tr>
<tr>
<td></td>
<td>Average Height – 5”</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Insect Pests - 35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Enemies</td>
<td>20</td>
</tr>
<tr>
<td>Ants</td>
<td>11</td>
</tr>
<tr>
<td>Spiders – 7</td>
<td>Grasshoppers - 2</td>
</tr>
<tr>
<td>Frogs - 2</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Observation</th>
<th>Reason</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pests more than natural enemies</td>
<td>Lack of spraying</td>
<td>Needs spraying with Karate or Dithane</td>
</tr>
<tr>
<td>Dead plants</td>
<td>Soil not good for tomatoes</td>
<td>Change tomatoes to different land place.</td>
</tr>
</tbody>
</table>

Table 6. FFS field school presentation of AESA for tomato growing using IPM.

<table>
<thead>
<tr>
<th>Tomatoes</th>
<th>IPM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variety ‘Pectomech’</td>
<td></td>
</tr>
<tr>
<td>Sown</td>
<td>16 / 12 / 1999</td>
</tr>
<tr>
<td>Date transplanted</td>
<td>6/1/2000</td>
</tr>
<tr>
<td>Growth stage established</td>
<td>35 days after planting</td>
</tr>
<tr>
<td>Soil condition dry</td>
<td>Average number of leaves – 5</td>
</tr>
<tr>
<td></td>
<td>Average Height – 4”</td>
</tr>
<tr>
<td>Insect Pests - 73</td>
<td>Natural Enemies - 46</td>
</tr>
<tr>
<td>Mirids – 72</td>
<td>Spiders – 5</td>
</tr>
<tr>
<td>Frog - 1</td>
<td>Ants - 41</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Observation</th>
<th>Reason</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dead plants</td>
<td>Land not good for tomatoes</td>
<td>Replace tomato with garden egg</td>
</tr>
<tr>
<td>Fertiliser (NPK) destroys tomatoes</td>
<td>Distance too close</td>
<td>Next time should place fertiliser in planting hole</td>
</tr>
</tbody>
</table>
Table 7. FFS field school presentation of AESA for cabbage growing using Farmer Practice.

<table>
<thead>
<tr>
<th>Cabbages</th>
<th>Farmer Practice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variety ‘Oxylus’</td>
<td></td>
</tr>
<tr>
<td>Sown 16 / 12 / 1999</td>
<td>Agricultural Information</td>
</tr>
<tr>
<td>Date transplanted 13/1/2000</td>
<td>Average number of leaves – 5</td>
</tr>
<tr>
<td>Growth stage established - 35 days after planting</td>
<td>Average Height – 2”</td>
</tr>
<tr>
<td>Soil condition dry</td>
<td>Leaf diameter – 4”</td>
</tr>
<tr>
<td>Soil condition</td>
<td>Canopy diameter – 10”</td>
</tr>
</tbody>
</table>

Insect Pests - 42 | Natural Enemies - 12
Looper – 1 | Frogs – 5
Grasshopper - 1 | Spiders – 2
Aphids – 40 (grouped in colonies) | Ants - 5

<table>
<thead>
<tr>
<th>Observation</th>
<th>Reason</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>More pests</td>
<td>No spray</td>
<td>Spray with karate</td>
</tr>
<tr>
<td>Dry soil</td>
<td>Lack of water</td>
<td>Need water</td>
</tr>
</tbody>
</table>

Table 8. FFS field school presentation of AESA for cabbage growing using IPM.

<table>
<thead>
<tr>
<th>Cabbages</th>
<th>IPM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variety ‘Oxylus’</td>
<td></td>
</tr>
<tr>
<td>Sown 16 / 12 / 1999</td>
<td>Agricultural Information</td>
</tr>
<tr>
<td>Date transplanted 12/1/2000</td>
<td>Average number of leaves – 4</td>
</tr>
<tr>
<td>Growth stage established - 35 days after planting</td>
<td>Average Height – 3”</td>
</tr>
<tr>
<td>Soil condition dry</td>
<td>Leaf diameter – 4.5”</td>
</tr>
<tr>
<td>Soil condition</td>
<td>Canopy diameter – 3 - 8”</td>
</tr>
</tbody>
</table>

Insect Pests - 46 | Natural Enemies - 15
Grasshopper – 3 | Spiders – 5
Bugs - 3 | Frogs – 8
Aphids – 40 | Ants - 2

<table>
<thead>
<tr>
<th>Observation</th>
<th>Reason</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>No dead plant</td>
<td>Good soil</td>
<td></td>
</tr>
<tr>
<td>Pests more than natural enemies</td>
<td>No spraying</td>
<td>Needs to be sprayed</td>
</tr>
<tr>
<td>Dry soil</td>
<td>Lack of water</td>
<td>Watering</td>
</tr>
<tr>
<td>Less natural enemies</td>
<td>Due to poison</td>
<td>Do not spray with poison</td>
</tr>
</tbody>
</table>
Integrating pest management and soil fertility management

Table 9. Farmer perceptions of various soil fertility improvement options: Offinso GOAN IPM Farmer Field School.

<table>
<thead>
<tr>
<th></th>
<th>Compost</th>
<th>Poultry manure</th>
<th>Sheep droppings</th>
<th>Cow dung</th>
<th>Inorganic fertiliser</th>
<th>Mulching</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Low cost</strong></td>
<td>*****</td>
<td>***</td>
<td>*</td>
<td>**</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td><strong>Low labour</strong></td>
<td>**</td>
<td>*</td>
<td>**</td>
<td>**</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td><strong>Low Hazard</strong></td>
<td>****</td>
<td>**</td>
<td>*</td>
<td>**</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td><strong>Easy to apply</strong></td>
<td>****</td>
<td>**</td>
<td>**</td>
<td>**</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td><strong>High yield</strong></td>
<td>**</td>
<td>**</td>
<td>****</td>
<td>**</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td><strong>Good quality produce</strong></td>
<td>****</td>
<td>***</td>
<td>**</td>
<td>*</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td><strong>Good soil amendment</strong></td>
<td>****</td>
<td>***</td>
<td>**</td>
<td>**</td>
<td>**</td>
<td>****</td>
</tr>
<tr>
<td><strong>Easily Available</strong></td>
<td>*****</td>
<td>**</td>
<td>**</td>
<td>**</td>
<td>**</td>
<td>****</td>
</tr>
<tr>
<td><strong>Easy Transport</strong></td>
<td>*****</td>
<td>**</td>
<td>**</td>
<td>**</td>
<td>**</td>
<td>****</td>
</tr>
<tr>
<td><strong>High residual effect</strong></td>
<td>*****</td>
<td>**</td>
<td>**</td>
<td>**</td>
<td>**</td>
<td>****</td>
</tr>
</tbody>
</table>

Table 10. Pairwise matrix ranking of the farmer criteria

<table>
<thead>
<tr>
<th></th>
<th>Low cost</th>
<th>Low labour</th>
<th>Low hazard</th>
<th>Easy to apply</th>
<th>High yield</th>
<th>Good quality</th>
<th>Good Soil Amendment</th>
<th>Easily available</th>
<th>Easy transport</th>
<th>High residual effect</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Low cost</strong></td>
<td>X</td>
<td>LC</td>
<td>L H</td>
<td>L C</td>
<td>H Y</td>
<td>G Q</td>
<td>S A</td>
<td>E A</td>
<td>L C</td>
<td>L C</td>
</tr>
<tr>
<td><strong>Low labour</strong></td>
<td>X</td>
<td>L H</td>
<td>E A</td>
<td>H Y</td>
<td>G Q</td>
<td>S A</td>
<td>E A</td>
<td>E A</td>
<td>E T</td>
<td>R E</td>
</tr>
<tr>
<td><strong>Low Hazard</strong></td>
<td>X</td>
<td>L H</td>
<td>L H</td>
<td>L H</td>
<td>L H</td>
<td>L H</td>
<td>L H</td>
<td>L H</td>
<td>L H</td>
<td>L H</td>
</tr>
<tr>
<td><strong>Easy to apply</strong></td>
<td>X</td>
<td>H Y</td>
<td>G Q</td>
<td>S A</td>
<td>E A</td>
<td>E T</td>
<td>R E</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>High Yield</strong></td>
<td>X</td>
<td>G Q</td>
<td>S A</td>
<td>H Y</td>
<td>H Y</td>
<td>R E</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Good Quality</strong></td>
<td>X</td>
<td>G Q</td>
<td>G Q</td>
<td>G Q</td>
<td>G Q</td>
<td>G Q</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Good soil amendment</strong></td>
<td>X</td>
<td>S A</td>
<td>S A</td>
<td>S A</td>
<td>S A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Easily Available</strong></td>
<td>X</td>
<td>E A</td>
<td>E A</td>
<td>E A</td>
<td>E A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Easy Transport</strong></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>High residual effect</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Farmer Criteria in order of importance:

L H = Low hazard  9
GQ = Good quality produce  8
SA = Good soil amendment  7
RE = High residual effect  5
LC = Low cost  4
EA = Easily available  4
Integrating pest management and soil fertility management

<table>
<thead>
<tr>
<th>HY</th>
<th>ET</th>
<th>LL</th>
<th>EAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>High yield</td>
<td>Easy to transport</td>
<td>Low labour</td>
<td>Easy application</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

The above table shows that this farming community regards pesticide hazard to humans as the most important consideration when choosing between technological options. Quality of produce is the second most important criteria. This is understandable because vegetables are grown mainly for sale in the local and urban markets. Surprisingly, labour did not feature as a very important consideration.

Sunday 23rd January 2000. Meeting with Mr. Emmanuel Antwi, General Secretary Ghana Organic Agriculture Network (GOAN).

Mr. Antwi gave a well practised presentation of the GOAN with opportunities for questions. Starting in 1995 the GOAN concentrates on organic agriculture (i.e. low pesticide / fertiliser usage) and agriculture and now involves work with a total of 96 NGOs and farmers groups.

GOAN started activities using the expertise of the original members (including two officers trained in IPM via the National IPM Programme) with no recognised need for Training of Trainers etc.

There was then a realisation that the FFS approach was better than the 3-day Training Course approach, Training Courses offering no opportunity for follow-up whereas FFSs lead to farmers requiring less later training and follow-up.

With close links with the MoFA, AEAs were also included in TOT training to re-orientate farmers practices towards IPM and away from pesticide usage.

Farmer Field Schools are season long (i.e. 16 – 20 weeks) and require the participation of the farmer for one day per week. In forming a FFS local authorities or existing groups (e.g. farmer or church organisations) are contacted and members may volunteer or be proposed. Over-subscription may be solved by 'natural' dropping-out or by the group asking to choose. The day of the FFS is generally chosen on a recognised “taboo” (no farm work) day.

There are no exclusively women Farmer Groups but a minimum of 40% female participation is a stated goal.

The purpose of GOAN training was to promote self-sufficiency and income generation among small and medium scale farmers in rural and peri-urban areas and not for ‘organic’ production (in the western sense). For the purpose of the discussion present activities were categorised in two main areas.
1. Soil fertility management

Various activities were being promoted including discouraging uncontrolled burning of fallow lands, or at a minimum its controlled burning. The use of cover crops (especially *Mucuna*) is being promoted as is the use of manures (principally poultry and others in areas where they are available) and composting.

2. Plant protection

Use of pesticides was considered low in traditional agriculture due to their high cost although more common in cash crop / commercial agriculture, especially when supplied “indiscriminately” by company (?) suppliers. Mr. Antwi commented that pest problems arose from sedentary farming and the use of pesticides reducing the numbers of beneficials.

3. Indigenous knowledge

GOAN has just embarked on a one-year one-person project to obtain and collate aspects of local indigenous knowledge of soils, pest control and post harvest issues.

It was known that farmers recognised “good soils” and bad soils based on various indicators (Table 11).

Table 11. Indicators of soil fertility.

<table>
<thead>
<tr>
<th>GOOD SOILS</th>
<th>BAD SOILS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presence of earthworm casts</td>
<td>Grasses and weeds start appearing =</td>
</tr>
<tr>
<td>Certain indicator plants</td>
<td>fertility falling</td>
</tr>
<tr>
<td>Less undergrowth</td>
<td>Falling yields</td>
</tr>
</tbody>
</table>

Farmers chose their land according to season moving to valley bottoms in the dry season. The FFS had promoted the use of sub-soil in nursery beds (apparently an idea from FFSs in Indonesia) and it was noted that farmers traditionally sowed and grew seedlings for transplanting in land around termite mounds.

A general shortage of organic matter was felt to be a constraint. Other issues included seed quality, most farmers planting retained seed (tomato, eggplant, chilli and okra) with only cabbage and onion using bought seed.

Finally market issues were considered a major difficulty facing farmers, in particular price instability resulting both from seasonal gluts and the activities of “market mammies” controlling prices.

GOAN appears to be a thriving NGO umbrella organisation attracting a lot of support. (They are described very complimentarily in the U.K. Project Leaders report on Project R6799). We were shown the construction site of the new HQ and told of future plans, which include expanding and developing their network both nationally and regionally. Clearly GOAN will be sought after collaborators of any outside

Although messages had not arrived and intended contact persons were not available, under the enthusiastic chairmanship of Dr. Kofi Agbeli (a vet by training and the recently installed Regional Director for the MoFA) a full and productive meeting was held with more junior participants in the Project.

The full structure of the IFCSP was not elucidated, but in addition to the ‘Soil and Water Component’ a report was shown of a ‘Participatory Farm Management Project (DFID – University of Reading). It is believed that the UST – University of Reading ‘Biological Control of Root-Knot Nematodes’ project may also be a part of the IFCSP.

The discussion fell broadly under the headings of ‘Pest Management’, ‘Agronomy’ and ‘Post-Harvest’.

Major vegetables grown in the area were considered to be tomato and garden egg plus chillies and okra with tomato being the most lucrative. In contrast to other areas visited cabbage was described as a minor crop but no full explanation of why this should be so was obtained.

**Pest management**

An initial survey of pests and diseases was conducted. The international expert involved was Brian Critchley, Entomologist, NRI and Barbara Hemming (Nematologist at KNUST) had some involvement at the beginning (this was not elaborated upon) but apparently no other soil pathogen / disease expertise was included. Major soil associated diseases were felt to be *Fusarium*, *Sclerotium*, and bacterial wilt. There was no specific mention of nematodes (see above). In addition to suggestions for future IPM strategies the major output of this phase was the NRI produced ‘Pest and Diseases’ handbook assembled by Brian Critchley.

Varietal / Seed quality (with nearly 80\% of farmers retaining their own seed) was considered a major problem and a Varietal Improvement Programme (i.e. varietal selection) was established with CRI and KNUST. How successful this has been was not established although it was commented that most AVRDC selections proved unsuccessful. There is apparently some cross-border trade in seed with neighbouring Togo and a Tono Irrigation Project in Bolgatanga is bringing in seed.

Disease problems were viewed as related to soil type / land used. Sandy loams occurred on the upper slopes with clay loams in the valley bottoms. In these valley bottoms (where dry season production is focussed and project activities had been concentrated) foliar diseases were considered more important than soil borne diseases.
Integrating pest management and soil fertility management

Although farmers could recognise “good soil” it was stated that farmers drew little connection between the soil and pest problems. Farmer’s tendency to spray (with Karate) at the sign of any insect was mentioned. There was some experimental use of neem but few neem trees were grown in the area.

**Agronomy**

Principal agronomic aspects addressed were those of soil moisture and nutrients / organic matter. Various soils had been tested and following this a range of green and animal manures, including the use of old “forgotten” technologies were tested. (The Regional Director recalled that in his childhood cattle were encouraged to spend some time in land intended for maize).

Such testing was both on-farm (5m$^2$ plots) and on-station and included pest monitoring.

It was felt that the potential for uptake of any technologies was greater in high-labour / high-value systems where costs associated with proposed factors such as the extra land preparation needed for green manures were considered economic.

- **Green Manures**

  *Mucuna* was mentioned as a promising green manure technology for wet season production and for dry season production with access to water. The comparative costs were considered very attractive, NPK (15-15-15) fertiliser being sold for 40,000 cedis a bag whereas *Mucuna* seed cost the equivalent of 12,000 a hectare and could promote yields of two successive crops.

  Work on *Mucuna* was being expanded to the development of seed production and storage technologies. Other green manures mentioned were *Crotolaria* and *Sesbania*. It was mentioned how *Sesbania* (*bispinosa*) was grown and cut after two months on vegetable beds.

- **Composting**

  Work on composting was just starting; this seemed to be as part of a World Bank project. In addition a World Bank ‘Land and Water Management’ project had been running for 3 years and was about to embark on a second phase 2.

  It was commented that composting was once taught in schools but the technology never went on-farm. Some use of black soil was mentioned.

**Research gaps**

Regarding crops the need for work on pests and diseases of chillies was specifically mentioned.

Nursery management problems needed attention. At present nursery beds used built up field soil. There was some promotion of the use of sub-soil but soil had low OM
and additions of OM were also needed. Leaflets on nursery management were being produced.

Guidelines for farmers selection of seed e.g. from (saleable) healthy fruits rather than from otherwise unusable / un-saleable diseased or unhealthy fruits needed to be developed and promoted.

Leaflets on both the preparation and use of animal and green manures were being prepared and such information was to be fed through the Agricultural Extension Service.

Finally some attention was being paid to the examination of indigenous knowledge and practices – the linking / leaning together of adjacent tomato plants rather than staking being mentioned.

**Post-harvest / marketing**

A wide range of issues associated with post-harvest handling, processing and marketing were mentioned.

A baseline survey had been conducted by John Sherrington, an NRI Statistician (?). As part of this (or the survey by Ms. Chan?) differences were noted between men and women farmers, with women farmers being more aware / concerned with factors such as quality and taste. It was felt that OM could improve the post-harvest quality of fruit as could increases in K.

Post-harvest processing essentially consisted of drying of chillies (and some okra) with improved dryers developed in collaboration with NRI. This aspect was also part of the MoFA / GTZ ‘Sedentary Farming Systems Project’. Improvements consisted essentially of developing a plastic cover for the traditionally used drying platform and there were positive signs of adoption by farmers. (The contact at the GTZ Sedentary Farming Project later commented on the poor durability of plastics for these purposes).

Marketing and Socio-Economic issues were discussed. There had been a study of the marketing chain for tomatoes (80% of which were supplied to Kumasi and Accra). Farm-gate prices per box (which farmers felt had been getting bigger thus leading to lower prices per kilo being paid them) of tomatoes varied from 15,000 – 40,000 cedis. Market prices were considered to be around 50,000 (presumably the lack of range in the market price due to the activities of market mammies?). Accra was recognised as a “closed” market whereas Kumasi was considered more open.

Poor roads and short “shelf life” of fruit were also problems. Although up to 50% of tomatoes reaching the market might be damaged it was felt all was sold in some quality category (including for very damaged fruit, directly for making sauces).

Final comments emphasised the highly site specific specialisation in particular vegetable crops, and that vegetable production was just one of a range of rural livelihood activities. The importance to the sector of young men who farmed for a few years to build up capital to start in other ventures in later life was also mentioned.
Meeting to discuss ‘Sedentary Farming Systems Project’ with Dr. Wolf-Dieter Zschekel, Animal Production Specialist, GTZ, Sunyani

The project

Working with MoFA and DED (the German Development Service), the project started in 1996 and aims to raise productivity of small-scale farmers in the Brong Ahafo Region by introducing appropriate sedentary farming systems. The project thus includes work on crop, livestock and post harvest topics. The project works in three districts of the region, one in each of the forest, transition and savannah zones. Emphasis is on the whole farming system of farmers practising bush fallow rotation, so much of the work has been on staple food crops such as maize. The short-term immigrant, tenant dry season vegetable growers are not included.

A PTD approach is followed and priorities for agricultural development were determined by PRA in 1996. Initially, the project worked with ‘pilot farmers’ chosen by AEAs but has changed to a community approach as the former methods aroused jealousies. This means the project has to deal with community issues, although in practice the PTD community groups soon shrink to small ‘interest’ groups.

Farmers and field staff make cross visits to observe successful technologies in different districts. The project provides start-up assistance for the farmers by giving tools, wheelbarrows etc.

Technologies

Only immigrants from the north had previously used animal manures. The project introduced the spot application of poultry manure. This is successful with plantain but transport and availability limit uptake of poultry manure by maize farmers. The technique is also successful with pineapple and results in larger and earlier fruit with a good market advantage.

Cover cropping with Mucuna, Cajanus and Canavalia has been tried. Around 80-100 farmers are using Mucuna for fallow with maize and record 50-70% increases in yield.

Alley cropping has been tried but with little uptake, probably because it is labour intensive. Mixed hedgerows have been demonstrated including Gliricidia, Cassia, Flemingia. Leucaena had been tried elsewhere and was difficult to manage and has not been introduced to this project.

Work is in progress on livestock health, feed quality and supply, and animal holding conditions. Zero grazing with stall feeding of grass from contour bunds did not prove popular. An attempt to develop dairy production was unsuccessful.

Post-harvest interventions include improved storage facilities, solar drying and marketing issues.
Meeting to discuss ‘Ghanaian-German Project for Integrated Crop Protection’ with Dr. Petra Schill, Expert in Integrated Crop Protection, GTZ, Sunyani

The project

The ICP Project is a joint GTZ-MoFA project. Its original aim was to adopt a Participatory Technology Development approach to the development of technologies for IPM with target crops. The focus has changed somewhat and the project has now adopted an approach described as Participatory Technology Development & Extension, reflecting a greater emphasis on extension and presentation of appropriate technologies to farmers and less emphasis on technology development and research. There is a feeling that there are enough technologies available for the individual crops, limited opportunity for introducing others, and that the constraint has been lack of effective extension.

The process involves establishment of/ contact with farmers’ groups. Technology Fairs are held with farmers. The Fairs identify problems and discuss possible interventions, including those that the farmers might suggest. Farmers then decide which of the technologies to try. There is a process of feedback and training. The ICP Project has arranged for Master Trainers to be trained and these are District Agricultural Development Officers. These in turn train Agricultural Extension Agents, who are the front line extensionists working with the farmers.

The difference between this approach and the FFS approach of the National IPM Programme is that PTD&E is carried out on the individual farmer’s land using his/her resources. Further, the FFS approach is commodity specific whereas the PTD&E approach works within the existing mixed farming system and claims to lead to adaptation and extension of new technologies for other crops on the farm.

The project considers it essential to adopt an integrated approach that includes marketing aspects.

Crops/ Crop Systems

The project works through MoFA in four districts of Brong Ahofo Region and is planned to last for 12 years. The initial focus has been on okra, cowpea, plantain and tomato, which the target farmers grow in various rotations and combinations. Certain crops are gender specific; thus, okra, garden egg and plantain are mainly women’s crops while tomato is a man’s crop.

The project does not work with the specialised valley-bottom commercial dry season vegetable growers as these are usually young men who farm rented land in the area for short period of time and move on when pests and diseases become excessive or when soil fertility declines. In this system there is little concern for soil fertility and it is difficult to establish farmers’ groups with which to develop a PTD&E relationship.

Irrigated projects cultivate land intensively and continuously, and so must solve problems of pest and disease build up and soil fertility decline. Rainfed vegetable
production may also involve more stable use of land and offers the opportunity for falls and rotation.

Backyard farms, which exist in all areas, manage to avoid the build up of soil-borne pests and diseases by high organic matter input and by mixed cropping and rotation.

**Pest and diseases**

Nematodes are a major problem. Farmers are aware of the symptoms of nematode infestation. *Fusarium* disease is also a major problem in intensive vegetable production.

**Technologies**

There is virtually no history of the use of animal manure in the area and none of compost. Historically, soil fertility was maintained solely by bush fallow. Animal production was by free grazing and there was no history of collection or management of manure. Poultry manure, where available, has been introduced with spectacular results and is widely adopted by project and non-project farmers in the area. Where plantain farmers have no access to poultry manure they may be willing to experiment with alternatives.

Only a few farmers use chemical fertilisers on vegetable crops. Fungicides are used including dithane, Kocide and, increasingly, the systemic benlate. Insecticides include pyrethroids, karate and decis.

*Tagetes* (*minuta?*) a species of marigold is naturalised locally in gardens and on waste ground. Some attempts have been made to use this for nematode control but farmers have not been keen to adopt the technique.

Rotation or abandoning land appear to be the only practical solutions at present for the build up of soil-borne pests and diseases, though appropriate soil-based treatments might extend the duration of cropping. Rotation includes shifting from tomato to garden egg as the latter are more resistant to *Fusarium*. There are experiments in progress in Ghana involving grafting tomato onto garden egg rootstocks, but this technique is not known to the farmers.

The project promotes the use of neem as an insecticide – produced at a local level. Especially for women’s groups in the PTD&E programme. Initially, neem leaf preparation was used. GTZ are looking at the possibility of a national neem pesticide production plant. Locally, a small neem press is being considered as a co-operative venture, which would provide neem insecticide for local use and a small amount of surplus for income generation. Local people are aware of insecticidal properties of *Jatropha* (*curcas?*) which is planted locally as a living fence species.

**Linkages**

In addition to the strong links to the development partner MoFA, the project has some links to the DFID Integrated Food Crop Systems Project and the neighbouring GTZ Sedentary Farming Systems Project. They considered that the IFCSP hampered by a
short-term approach and that it tended to pay extra money and incentives to attract key staff and to obtain early results.
Appendix 2

**Thursday January 27th. Meeting with Project Leaders and interested scientists, Crops Research Institute, Kumasi.**

This well attended and lively meeting attempted to assess impressions and opinions and draw conclusions with national counterparts.

In addition to the International Team the following were present:

- Prof. Kwame Afreh-Nuamah, National IPM Co-ordinator.
- Dr. O-A Danquah, Crops Research Institute and CABI Liaison Officer.

The Kwame Nkrumah University of Science and Technology, Kumasi was represented by:

- Dr. Barbara Hemming
- Dr. Richard Awuah
- Dr. Peter Boateng
- Dr. Charles Quansah

The Integrated Food Crops Systems Project, Sunyani, Brong Ahafo was represented by Mr. Kofi Biney and the Crops Research Institute by Mr. James Timbilla (head of the in-country PRA team).

A wide range of research needs were raised.

- The need for studies in appropriate technologies of seed treatment to limit the impact and spread of seed-borne diseases.
- A range of work into the preparation and use of organic manures (types, methods of curing, application rates etc.).
- The impact of neem and other potential botanicals on fungal, bacterial and viral diseases.
- The potential for farmer participatory breeding and selection of improved varieties (especially for low fertility soils, drought and high temperature tolerance).
- The study of crop rotations and their interactions with pests and diseases, fertilisers and improved fallows.
- The potential use of biological control agents and their interactions with soil fertility.
- Nursery management, including studies of current practices and potential for improved management technologies.
• The potential for innovative methodologies (such as paired comparisons between farms using different technologies) to assess the impact of various technologies.

• The influence of mulches and green manures as reservoirs or alternate hosts for potential pests and diseases.

• Regarding uptake and adoption of improved technologies, a range of institutional issue were discussed. These included land tenure (or lack of) and its influence on the potential uptake of long-term soil improvement / disease control technologies. It was clearly recognised that technologies need to be appropriate, and integral to this was a need for a clear identification of the target group who would tentatively benefit from a particular technology.

• Linkages between different components of the Ghanaian NARS were considered good and the holistic nature of the assessment required in the research activities proposed could be achieved by using and developing these linkages.

• Given the potential institutional complexity of some of the proposed topics it was considered important that as projects were identified, developed and implemented the appropriate levels of the MoFA (including sub-ministerial, regional and district) be kept informed.
## Appendix 3 – Itinerary

<table>
<thead>
<tr>
<th>Date</th>
<th>Activity</th>
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<tbody>
<tr>
<td>Monday 10 January 2000</td>
<td>Travel to Accra</td>
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<td></td>
<td>Overnight Accra</td>
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<tr>
<td>Tuesday 11 January 2000</td>
<td>1. Meeting to discuss project and logistics.</td>
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<td></td>
<td>With Helen Wedgewood</td>
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<td></td>
<td>Rural Livelihoods Coordinator</td>
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<td></td>
<td>DFID Rural Livelihoods Office</td>
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<td>P.O. Box 296</td>
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<td>Accra</td>
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<td>Ghana</td>
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<td>Fax: +233 21 227384</td>
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<tr>
<td></td>
<td>Email: <a href="mailto:helenwedgewood@dfid.rlo.com.gh">helenwedgewood@dfid.rlo.com.gh</a></td>
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<tr>
<td></td>
<td>2. Meeting to discuss logistics with Alex Paintsil</td>
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<td>Development Officer</td>
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<td></td>
<td>3. Bank</td>
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<td>4. Car hire</td>
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<td>5. Project planning meeting with the International Team:</td>
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<tr>
<td></td>
<td>Nigel Price</td>
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<td>Patrick Sikana</td>
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<td></td>
<td>Overnight Accra</td>
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<tr>
<td>Wednesday 12 January</td>
<td>1. Visit to Dzorwulu/ Plantpool Vegetable Producers Association, one of</td>
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<td>the sites for National IPM Programme Farmer Field Schools</td>
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<td></td>
<td>2. Visit to Teshie municipal composting plant.</td>
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<td></td>
<td>Overnight Accra</td>
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<tr>
<td>Thursday 13 January</td>
<td>1. Visit to farms at Mataheko (Dangbe West), site of Farmer Field School</td>
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<td></td>
<td>Travel to Kumasi</td>
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<td></td>
<td>Overnight Kumasi</td>
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<tr>
<td>Friday 14 January 2000</td>
<td>1. Meeting to discuss ‘Composted waste in urban agriculture’ and</td>
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<td>related projects with</td>
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<td></td>
<td>Dr Richard Awuah</td>
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<td>Department of Agriculture</td>
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<td>KN University of Science and Technology</td>
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<td>Kumasi</td>
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<td></td>
<td>2. Meeting to discuss ‘Biological control of root-knot nematodes’ and</td>
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Integrating pest management and soil fertility management

<table>
<thead>
<tr>
<th>Date</th>
<th>Activities</th>
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</table>
| Saturday 22 January 2000 | 1. Visit to GOAN Demonstration Farm and Farmer Field School at Offinso  
Overnight Kumasi                                                                 |
| Sunday 23 January     | 1. Meeting with Emmanuel Antwi  
General Secretary  
GOAN  
Overnight Kumasi            |
| Monday 24 January     | 1. Meeting with MoFA staff connected to the 'Integrated Food Crop  
Systems Project' and  
Dr Kofi Agbeli  
Regional Director of Agriculture  
Sunyani  
Brong Ahafo  
2. Meeting to discuss ‘Sedentary Farming Systems Project’ with  
Dr Wolf-Dieter Zschekel  
GTZ  
P.O. Box 473  
Sunyani  
Ghana  
Tel: +233 61 27376  
Fax: +233 61 27376  
Email: gtzsun@ncs.com.gh  
3. Meeting to discuss ‘Ghanaian-German Project for Integrated Crop  
Protection’ with  
Dr. Petra Schill  
GTZ  
P.O. Box 473  
Sunyani  
Ghana  
Tel: +233 61 27276  
Fax: +233 61 27376  
Email: icpsun@ghana.com  
Overnight Kumasi |
| Tuesday 25 January    | 1. Meeting to discuss the ‘Kumasi Natural Resources Management  
Project’ and the ‘IBSRAM Soil Fertility Project’ with  
Dr Charles Quansah  
Department of Soil Science  
Faculty of Agriculture  
KNUST  
Kumasi |
### Integrating pest management and soil fertility management

<table>
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<tr>
<th>Date</th>
<th>Activity</th>
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| **Wednesday 26 January** | 1. Meeting with in-country team  
Crops Research Institute  
Kumasi  
Overnight Kumasi |
| **Thursday 27 January** | 1. Meeting with Project Leaders and Representatives  
Crops Research Institute  
Kumasi:  
Present:  
Prof. Kwame Afreh-Nuamah, National IPM Co-ordinator  
IPM Secretariat  
PPRSD  
MoFA  
Pokuase  
Ghana  
Te: 767668/767669  
Dr. O-A Danquah, Crops Research Institute and CABI Liaison Officer  
P.O. Box 3785  
Kumasi  
Ghana  
Fax: +233 51 60142  
Email: criggdp@ghana.com  
Dr. Barbara Hemming  
Dr. Richard Awuah  
Dr. Peter Boateng  
Dr. Charles Quansah  
Mr James Timbilla  
Mr K. Biney, MoFA, Sunyani  
Travel to Accra  
Overnight Accra |
| **Friday 28 January** | 1. Report writing  
2. Meeting with Helen Wedgwood  
DFID Field Office  
End of mission |
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

J. A. Timbilla¹, K. G. Ofusu-Budu² & V. Asante³

¹Biological Control Unit, Plant Protection Division, Crops Research Institute, P. O Box 3785, Kumasi, Ghana.

²Agricultural Research Station Kade, Faculty of Agriculture, University of Ghana, Legon, Accra, Ghana.

³Agricultural Economics Department, University of Ghana, Legon, Accra, Ghana.
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

Executive summary
Introduction and background
Terms of reference
Methodology
Results
Conclusions and recommendations
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, Dzonwulu and Mataheko. Each site operate under different land use systems. Farmers at Weija produce their crops under irrigation. Those at Dzonwulu 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 Dzonwulu 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 Dzonwulu, 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 intercropped. 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)**

<table>
<thead>
<tr>
<th>Insect pests</th>
<th>Diseases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>25%</td>
<td>75%</td>
</tr>
<tr>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>37.5%</td>
<td>63.5%</td>
</tr>
</tbody>
</table>

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)**

<table>
<thead>
<tr>
<th>Name of pesticide</th>
<th>Rates</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Karate</td>
<td>40ml/knapsack</td>
<td>As and when necessary</td>
</tr>
<tr>
<td>Actellic</td>
<td>Not specified</td>
<td></td>
</tr>
<tr>
<td>Neem seed solution</td>
<td>2 Milo tins/knapsack</td>
<td>Twice a week</td>
</tr>
</tbody>
</table>
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)

<table>
<thead>
<tr>
<th>Insect pests</th>
<th>Diseases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caterpillars (borers), aphids, Mirids,</td>
<td>Curling of leaves, Septoria spp., fungal and</td>
</tr>
<tr>
<td>grasshoppers, Thrips, leaf miners, Plutella</td>
<td></td>
</tr>
<tr>
<td>xylostella, Hellula undalis and Ceratitis caputata.</td>
<td>viral (suspect)</td>
</tr>
</tbody>
</table>

The caterpillars were indicated to attack tomato. In Ghana Helicoverpa armigera is the main lepidopteran borer of tomato. The thrips were said to associate 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

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

With respect to diseases table 4b summarizes the pesticides applied for their control.
Table 4b. Pesticides applied to control diseases above ground

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

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 constraint 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)

<table>
<thead>
<tr>
<th>Insect pests</th>
<th>Diseases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caterpillars (armyworms and borers), aphids, whiteflies, grasshoppers, <em>Podagrica</em> spp., leaf miners, <em>Plutella xylostella</em>, <em>Hellula undalis</em>, <em>Nisotra</em> spp. and grasshoppers</td>
<td>Fungal diseases (<em>Fusarium</em>, <em>Alternaria</em>, <em>Septoria</em>, damping off), curling of leaves, flower abortion,</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>Name of pesticide</th>
<th>Rates</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Karate</td>
<td>40mls/knapsack</td>
<td>Fortnightly</td>
</tr>
<tr>
<td>Dipel 2X (biopesticide)</td>
<td>15g/knapsack</td>
<td>Weekly</td>
</tr>
<tr>
<td>Cymbush</td>
<td>25mls/knapsack</td>
<td>Weekly</td>
</tr>
</tbody>
</table>

Here, the farmers complained about armyworms (*Spodoptera* spp.) in addition to the borer (*H. armigera*). The farmers also complained about *Podagrica* spp. and *Nisota* 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)

<table>
<thead>
<tr>
<th>Name of pesticide</th>
<th>Rates</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Furadan</td>
<td>Not specified</td>
<td>once</td>
</tr>
<tr>
<td>Dithane M-45</td>
<td>,,</td>
<td>monthly on others but weekly on tomato</td>
</tr>
<tr>
<td>Kocide</td>
<td>½ pkt/knapsack</td>
<td></td>
</tr>
</tbody>
</table>

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)

<table>
<thead>
<tr>
<th>Insect pests</th>
<th>Diseases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>60%</td>
<td>40%</td>
</tr>
<tr>
<td>20%</td>
<td>80%</td>
</tr>
</tbody>
</table>

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)

<table>
<thead>
<tr>
<th>Name of pesticide</th>
<th>Rates</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polythrine</td>
<td>30 ml/knapsack (young plants)</td>
<td>Weekly for tomato and two weekly for okra and eggplant</td>
</tr>
<tr>
<td>Karate</td>
<td>50 ml/knapsack (old plants)</td>
<td></td>
</tr>
<tr>
<td>Dursban</td>
<td>40 ml/15 l</td>
<td></td>
</tr>
</tbody>
</table>

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)

<table>
<thead>
<tr>
<th>Insect pests</th>
<th>Diseases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lepidopteran fruit borers, aphids, whiteflies, grasshoppers, Podagrica spp.</td>
<td>Fungal diseases (<em>Fusarium</em>, <em>Alternaria</em>, <em>Septoria</em>, curling of leaves, blackening of stems, flower abortion,</td>
</tr>
</tbody>
</table>

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)

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

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)

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

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 *Imperata 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.
Appendix IV: Proceedings of collaborative workshop on IPM * SFM

Integrated Pest & Soil Fertility Management: A collaborative workshop to shape future initiatives

hosted by the
Tropical Soil Biology and Fertility Programme (TSBF)
and
CABI African Regional Centre (CABI-ARC)
in collaboration with
CABI Bioscience and the Natural Resources Institute (NRI)

15-18 February 2000
Nairobi, Kenya

Proceedings edited by
Vos, J.G.M.\(^1\), Pound, B.\(^2\), and Butterworth, J.\(^2\)

\(^1\) CABI-Bioscience, Ascot, UK
\(^2\) Natural Resources Institute, Chatham Maritime, UK

April 2000

CABI Bioscience/ Natural Resources Institute (NRI)
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The authors would also like to acknowledge the contributions of all participants at the workshop.
BACKGROUND

Two on-going studies on ‘Integrated Pest & Soil Fertility Management’ are currently being supported by the UK Department for International Development (DFID) under the Crop Protection Programme managed by NRI International. Both are short programme development studies aiming to identify opportunities to develop integrated crop management strategies. A study led by the Natural Resources Institute in collaboration with the Tropical Soil Biology and Fertility Programme (TSBF) and the African Highlands Initiative (AHI) is focused on issues in banana, maize, and cassava-based cropping systems. In particular, this study is concentrating on effects of soil fertility on crop health, and consequently the ability of crops to tolerate or resist pest attack. In Ghana, a study led by CABI-Bioscience in collaboration with TSBF and local institutions is focused on issues in vegetable cropping systems. This study is concentrating on existing soil fertility and/or pest management research and implementation projects, and needs for further integration of soil fertility and pest management as identified within those projects.

The interactions between soil fertility and crop protection have also been identified by the TSBF and the AHI as an important and exciting area for research in support of development. This workshop has been called to bring together these initiatives.

WORKSHOP AIM

To bring together a multi-disciplinary group of specialists and stakeholders to assess demand and identify priority areas for future research, promotion and dissemination activities concerned with interactions between soil fertility and pest management (insect pests, diseases and weeds) giving particular attention to the needs of farmers and research areas that are likely to have an impact on the alleviation of poverty.

EXPECTED OUTPUTS

The expected outcome of the workshop is that opportunities, gaps and researchable constraints for integrated pest and soil fertility management will be identified, categorised and prioritised against specific criteria. These will provide essential inputs to be reported to the DFID Crop Protection Programme in a framework for a future research agenda on integrated pest and soil fertility management.

WORKSHOP PROCESS

The joint workshop followed participatory processes, taking care to involve all participants. Participation was promoted by rotating chairpersons, facilitators and rapporteurs throughout. The workshop included group work sessions where small groups explored issues in detail, with subsequent reporting, discussion, refinement and validation of group findings in plenary sessions. The process will continue to involve all participants after the workshop through open circulation of the report and subsequent documents arising from the studies and workshop. This communication will enable all participants to make further contributions, suggestions and modifications to both studies.
OUTCOME OF THE WORKSHOP

The stakeholders represented at the workshop determined that integrated pest and soil fertility management offers considerable potential for collaborative research and development, and that this is likely to achieve sustainable impacts in improving the livelihoods of resource-poor farming families in sub-Saharan Africa. In particular, the integrated approach can respond to the needs of farmers cultivating soils of poor or declining fertility by reducing losses to pests, and by improving the range of integrated crop production options available to farmers with limited access to external inputs.

The workshop identified four potential research themes for a future research agenda in integrated pest and soil fertility management. While not mutually exclusive, these themes represent areas within which specific projects might be developed. The themes agreed by the workshop are:

1. **Effects of organic amendments on soil pests (incl weeds) and beneficials**
2. **Effect of cultural practices on the inter-relationships between soil fertility, pests and beneficials**
3. **Inter-relation of soil fertility management, plant condition and pest damage**
4. **Effect of agro-chemicals on soil organisms and soil fertility**

It was recognised that some potential research projects or interventions are likely to cut across themes. Examples of cross-cutting themes include the development of methodologies for research on integrated pest and soil fertility management, such as the development of suitable farmer participatory research and dissemination approaches in this area.

The outputs of the workshop are being used to develop, by the end of April-2000, an action plan containing recommendations for research, promotion and dissemination activities as part of the future strategy of the DFID Crop Protection Programme. The researchers and other stakeholders that participated in the workshop are determined to work together to support this important effort, and other initiatives in the field of integrated pest and soil fertility management.

ACKNOWLEDGEMENTS

The organisers of the workshop want to thank DFID for funding the workshop. TSBF is acknowledged for their interest and enormous efforts to help run this workshop, under difficult and sad conditions. CABI-ARC is thanked for their unfailing administrative support, ICRAF for allowing us to use their excellent facilities. In addition, all workshop participants are gratefully acknowledged for their participation and efforts to run this workshop productively.
ANNEX 1. Workshop programme (14 – 18 February 2000)

Monday 14 Participants travel to Nairobi

Tuesday 15 Morning session: Setting the scene: Chairperson Kwasi Ampofo

8.30 Registration
9.00 Welcome and workshop opening address
9.10 Introduction of participants
9.30 Background to the two DFID studies
10.00 Introduction to the two studies led by NRI and CABI
10.30 Introduction to TSBF activities

TEA

11.30 Discussion – developing a common language and concepts

LUNCH

Afternoon session: Food crop systems in Eastern Africa: Chairperson Barry Pound

13.45 Outcome of a review of SFM*IPM relating to banana, maize and cassava-based cropping systems in Africa (NRI, AHI, TSBF)
14.45 Explanation of group tasks following the NRI-led review

TEA

15.15 Group work
16.15 Group presentations
17.00 Synthesis of presentations

Wednesday 16 Morning session: Vegetable systems in Ghana: Chairperson Martin Kimani

9.00 Outcome of integrating pest and soil fertility management in Ghana (CABI, HDRA, TSBF)
10.00 Discussion
10.15 Explanation of group tasks following the CABI-led study

TEA

11.00 Group work

LUNCH

Early afternoon session: Presentations: Chairperson Mateete Bekunda

13.45 Group presentations
14.45 Synthesis of presentations

TEA

15.30 Recap of both studies and purpose of workshop
Late afternoon session: Identification of problems. Chairperson Robin Buruchara

15.45 Identification of problems, information gaps and constraints
16.45 Classification of problems into categories

Thursday 17 Morning session: Translating researchable constraints into research ideas. Chairperson: Mary Okwakol

9.00 Summary of identified categories of problems
9.15 Translation of categories of problems into research themes

TEA

11.30 Group work to analyse identified research themes

LUNCH

Afternoon session: Finalisation of research themes and closure.

13.45 Group presentations and discussion

TEA

16.00 Allocation of workshop examples of SF*IPM interactions to research themes
17.00 Summary of the workshop
17.30 Workshop closing remarks

Friday 18 Participants depart
GOOD MORNING LADIES AND GENTLEMEN,

On behalf of TSBF, NRI and CABI, it is my pleasure to welcome you all to this workshop here today, and for the next three days on: ‘INTEGRATED PEST & SOIL FERTILITY MANAGEMENT: A COLLABORATIVE WORKSHOP TO SHAPE FUTURE INITIATIVES’. This is a regional workshop funded by DFID of the British Government through its Crop Protection Programme, which is managed by NR International.

Before we begin with the formal proceedings of this workshop, I would just like to take a few minutes to explain why some of our colleagues, who should have been here, are sadly not with us today. As many of you are aware, this workshop should have been a much happier occasion had it not been for the fateful flight KQ 431 which left Abidjan, Cote d’Ivoire bound for Nairobi on Sunday 30 January. By now you should all be aware that at least 169 passengers on board that flight perished when the plane inexplicably crashed shortly after take-off from Abidjan Airport. Sadly for us all here today, there were a number of good friends and colleagues aboard that flight, and in particular I would like to name, Dr Patrick Sikana of TSBF and Dr Paul Spiejer of IITA, Uganda who were scheduled to participate in this meeting here with us today. The loss of these two friends and colleagues has been a great shock to many of us gathered here today, and I think that it is important that we spare a few minutes to remember our dearly departed colleagues.

Many of our colleagues from TSBF are at this moment in Zambia, having attended Patrick’s funeral, which took place in Zambia over the weekend. Professor Mike Swift, Director of TSBF, together with some of his staff are currently in Zambia, and therefore I’m sure you will all accept the apologies of Mike and the rest of the TSBF staff for not joining us here today. Despite this tragedy, Mike has expressed his wish that this meeting should continue, even in his absence, and he has also made it clear to me that he will try and join us following his return from Zambia on Wednesday! Although under the circumstances, I’m sure all of you will be understanding if indeed Mike is unable to join us.

Despite our depleted numbers, and the extremely sad and difficult circumstances in which we find ourselves here today, I sincerely hope that we can work together in order to make this a successful workshop!

Amongst the participants here today, we have a distinguished line-up of both Integrated Pest Management (or IPM for short) and Soil Fertility Management (or SFM for short) experts from around the region and beyond! I’m particularly happy to welcome representatives from NR International, Dr Jill Lenne and Dr Andy Ward, as well as Dr Anthea Cook of the Natural Resources Institute who is currently here in Kenya in her role as technical advisor to NR International.

I would also like to thank members of the organising committee for making this meeting possible, in particular Dr Kwesi Ampofo from CIAT, Tanzania, Drs Tony Russell-Smith, John Butterworth and Barry Pound from NRI, Dr Phil Harris from HDRA, UK and Dr Janny Vos and Martin Kimani from CABI. I should also mention that without the unfailing administrative support of Alice Ndungu from TSBF as well as Serah Mutisya and Mary Odhiambo from CABI – Africa Regional Centre, I doubt this meeting could have taken place. And last, but not least, I would like to thank the Director General of ICRAF, Dr Pedro Sanchez for kindly allowing us to host this meeting here at ICRAF’s headquarters.

So, I hope I’ve acknowledged everyone who has worked so hard to make this meeting possible today. Without further ado. I’d like to formally open this ‘cross-cutting’ workshop on
‘Integrated pest and soil fertility management’. In many respects, this is a quantum leap for both the IPMers and the SFMers here today in terms of broadening their approach to tackling researchable crop production constraints. It is vital that the emphasis is on the actual integration of pest and soil fertility management rather than simply an exchange of information by the two camps. The agricultural research and development community is moving, inexorably towards a systems based approach in terms of addressing constraints, and I hope that this workshop can make a significant contribution to this ultimate goal. Finally, I would like to encourage everyone present here today to contribute to this workshop – after all, the output of any one workshop can only be as good as the people who participate in, and contribute to the outputs. So, I’d like to encourage EVERYONE here today not to keep their mouths shut but to really participate in this innovative and challenging workshop, irrespective of where they come from or who they work for. In order for this to be a genuine stakeholders workshop, every voice must be heard!!! And, on that note, for the next 3 days, I’d like to wish you all a successful and constructive workshop, and I sincerely look forward to seeing the outcomes of this initiative.

Thank you

Sarah Simons
ANNEX 3. Background to the two DFID studies: Barry Pound, NRI

The Department for International Development of the UK Government (DFID) provides assistance to developing countries and the newly industrialised countries of Eastern Europe in the sectors of Health, Education, Engineering and Natural Resources through bilateral and multilateral aid. The three main policy aims of DFID are:

- Elimination of poverty
- Good governance
- Protection of the environment

The Natural Resources component of DFID includes twelve research Programmes under the Renewable Natural Resources Knowledge Strategy (RNRKS). These Research Programmes cover Forestry, Fisheries, Livestock, Systems and Crops.

The Crops Programmes include the Plant Sciences Research Programme, the Crop Post-Harvest Research Programme and the **Crop Protection Programme**.

The aim of the Crop Protection Programme (CPP) is to: *Develop, through research, improved crop protection strategies which are environmentally acceptable and appropriate for small farmers in developing countries*”. The three guiding principles for the Programme are that it should:

- Be responsive to farmer’s needs
- Provide sustainable outputs
- Involve partnerships with national and local institutions

In September 1999, the CPP commissioned two short studies (by CABI and NRI) to provide information and recommendations on the potential and possible directions for projects that take forward the interface between Soil Fertility Management and Pest Management.

An important component of these two complementary studies is this workshop, which helps to identify demand for SFM*IPM work and draws on the experience and expertise of participants from sub-Saharan Africa and elsewhere.

The workshop aim is: *to bring together a multi-disciplinary group of specialists and stakeholders to assess demand and identify priority areas for future research, promotion and dissemination activities concerned with interactions between soil fertility and pest management (insect pests, diseases and weeds) giving particular attention to the needs of farmers and research areas that are likely to have an impact on the alleviation of poverty.*

The expected outcome of the workshop is that: *opportunities, gaps and researchable constraints for integrated pest and soil fertility management will be identified, categorised and prioritised against specific criteria. These will provide essential inputs to be reported to the DFID Crop Protection Programme in a framework for a future research agenda on integrated pest and soil fertility management.*
ANNEX 4. Introduction to the NRI-led study

Integrated pest and soil fertility management: John Butterworth, NRI

Team
TSBF - Mike Swift
AHI - Kwasi Ampofo + AHI-IPM working group
NRI - Barry Pound, Tony Russell-Smith, John Butterworth, + project advisory panel representing a further range of disciplines.

Funding
The project is funded by the Department for International Development (DFID) Crop Protection Programme (CPP) managed by NRIInternational.

Focus of study
The study is focused on:
♦ The effects of soil fertility/soil health (and management) on crop health and losses to pests (insect pests, diseases and weeds)
♦ Sub-Saharan Africa, especially East and Central Africa
♦ Banana, maize and cassava-based cropping systems (but including other crops e.g. legumes in these systems)
♦ Improving strategies for resource poor-farmers

Activities
The main activities are:
♦ Literature search and review
♦ Workshop (in Nairobi 15-18 February 2000)
♦ Consultation
♦ Synthesis

Outputs
The outputs of the study, to be completed by the end of April 2000, are:
♦ Annotated bibliography (draft version already circulated)
♦ Action plan - containing recommendations for the CPP strategy (to be produced jointly with CABI-led study)
♦ The above outputs will be disseminated in a final technical report
♦ Draft of working paper - to quickly disseminate the findings of the studies (produced jointly with CABI-led study) in a brief, accessible paper. To be finalised for publication in a suitable newsletter/journal.
ANNEX 5. Introduction to the CABI-led study

Integrating pest and soil fertility management: Dr Janny Vos, CABI

Project leader:
CABI Bioscience (Janny Vos, Richard Plowright)

Collaborators:
HDRA (Phil Harris)
TSBF (Patrick Sikana)
Ghanaian collaborators (James Timbilla, James Akatse, K. Ofusu-Budu, Victor Asante)

Background:
During the last 15 years there has been an increasing interest in developing more sustainable approaches to agriculture and agricultural pest management, especially in the use of integrated pest management (IPM).
IPM is a knowledge-intensive and farmer-based management approach that encourages natural control of pest populations by anticipating problems and preventing pests from reaching economically damaging levels.
In the integrated soil fertility management (ISFM) approach, the soil is seen as a living system of organisms interacting with organic and inorganic matter.
Both IPM and ISFM have the same fundamental objective, which is to grow healthy crops in a sustainable manner.
There is a growing recognition that each approach needs to have a more holistic agro-ecological perspective.
Many IPM projects have developed a greater understanding for the need to attend to soil health, other beneficial effects of integrated farming systems, in order to develop sustainable solutions to some of the most difficult pest and disease problems.
There has also been a growing acceptance that for any of these approaches to succeed, farmers have to be seen as part of the learning and adaptation process.

Focus on on-going / completed vegetable IPM / SFM projects in Ghana:
National IPM project;
Composted wastes in peri-urban agriculture;
Integrated food crop systems project;
Kumasi natural resources project;
Ghana organic agricultural network;
Biological control of root-knot nematodes

Project objectives:
1. Review the areas of DFID and other funding relating to Ghana in which useful linkages might be established between soil fertility and crop protection issues.
2. Develop strategies for the integration of soil fertility management and soil pest management in research, promotion and dissemination in the vegetable crop systems of Ghana.
3. Explore the scope for adopting similar approaches in East Africa where parallel research and participatory learning partnerships exist.

Project activities:
1. Meeting with UK project leaders
2. Survey in Ghana on farmers perceptions and ideas
3. Meetings and discussions in Ghana with Ghanaian project leaders
4. Workshop to identify key IPM * SFM issues and constraints
Project outputs:
1. Documentation of the relevance and potential impact of an integrated approach to soil fertility and pest management in Ghana
2. Development of strategies for the integration of soil fertility management and soil pest management in research, promotion and dissemination in the vegetable crop systems of Ghana
3. Production of a framework prioritising potential areas for DFID support to projects integrating soil fertility and pest management
4. Extrapolation of the framework to other crop systems particularly in East Africa
ANNEX 6. Introduction to TSBF activities: Dr Mateete Bekunda, TSBF-AHI

Dr Bekunda provided an overview of TSBF activities relevant to the workshop.
ANNEX 7. Developing a common language and concepts

Discussions were held in plenary to develop a common understanding of key terms that were in common use throughout the workshop. These were:

- Pests
- Integrated pest management
- Soil fertility
- Integrated soil fertility management
- Integrated crop management
- Soil health
- Plant/crop health

The characteristics of each term, as suggested by participants, are included below:

1. Pests
Pests are to include insect and mite pests, diseases, weeds and any other noxious organisms that attack crops (thus ‘pests’ in the broadest sense of the word)

2. Integrated Pest Management (IPM)
It was thought that IPM is characterised by the following elements:
- use of different appropriate options in combination (biological, chemical, cultural)
- reduces chemical pesticides and fertiliser use
- reduces costly inputs
- reduces environmental toxicity aspects
- enables plants to resist (tolerate) rather than control pests.
- takes account of economic and social constrains
- integrates cultural, biological, chemical and physical pest management methods
- includes genetic host plant resistance
- ecological sustainability are at the centre of IPM philosophy
- contributes to ecological agriculture

3. Soil Fertility
The discussion on soil fertility included the following ideas:
- soil characteristics that contribute to system productivity
- ability of soils to provide plant nutrients which contribute to system production
- capacity of the soil to support optimum (including environment) quantity/quality yield of a crop if all other constraints are mitigated (optimum – objectives of management, fertility is a quality term)
- capacity of soils to sustain productivity
- soil fertility is static, management is dynamic
- water status, and physical and biological composition should be included
- time is important in optimum e.g. yields may crash in year X
- what about indigenous concepts? e.g. a local term for a fertile soil is a ‘fat’ soil

4. Integrated Soil Fertility Management (ISFM)
The discussion brought out the following phrases associated with ISFM:
- integration of inputs (cultural, physical, chemical, biological e.g. worms, symbionts): organic and inorganic
- same characteristics as IPM
- integrates strategies - physical, chemical, biological – which sustainably harness and conserve the capacity of soils to support plant growth (include erosion control)

5. Integrated Crop Management
- about practices and processes; strategies to manage the soil
- includes soil erosion control and other cultural practices e.g. crop rotations and varietal choice
- IPM, SFM and ICM are all approaches that are targeted at locally available material, and are effective strategies for small and resource poor
- requires multidisciplinary institutions
- requires interaction with farmers (e.g. farmer field schools)

ICM = ISFM + IPM. True or False?
- Partially true. ICM is broader than just IPM + ISFM, includes choice of variety and social and economic aspects

IPM, ISFM and ICM are conceptual philosophies, rather than approaches that deliver recipes. To use them there needs to be a good understanding by farmers of concepts such as nutrient cycling and pest life cycles. This brings implications for the ways research and extension interacts with farmers.

6. Soil health

- implies freedom from pests and good soil fertility
- management of pests / beneficials ratios to safe levels (ecological approach; good balance between good and bad organisms)
- health is a state of being
- absence of toxic elements
- ability to withstand stresses, strains and shocks; resilience of systems
- what are the indicators of soil health?
- is it possible to quantify soil health?

7. Plant / Crop Health

- balance between pest presence (e.g. leaf spots) and beneficials; not completely disease free
- human angle; no residual chemicals that are harmful to consumers.
- vigour of plant, absence of abiotic stress
ANNEX 8. Outcome of a review of SFM*IPM relating to banana, maize and cassava-based cropping systems in Africa (NRI, AHI, TSBF): Dr John Butterworth, NRI

This presentation of some of the preliminary findings from the on-going NRI/AHI/TSBF short study (see Annex 4 for background) focused on specific areas to provide background material for the workshop, and was primarily drawn from a review of literature on integrated pest and soil fertility management.

Types of interactions between soil fertility management and pests

1. Direct effects modifying the soil chemical, physical and biological habitat, for example
   ♦ Damage to germination and health of *Striga* seedlings by urea/ammonium ions in soil (chemical)
   ♦ Modifying moisture contents near the soil surface to suppress banana weevil which cannot survive in dry soil conditions (physical)
   ♦ Rotation of crops to avoid build up of soil-borne pests (biological)

2. Indirect effects by modifying biological control agents, for example
   ♦ Effects of organic amendments on competition and antagonistic effects on soil borne pests
   ♦ Modifying the habitat of natural predators e.g. predators of banana weevils which in W. Kenya have been observed to lay eggs in moist soil below banana mulch.

3. Indirect effects by modifying crop characteristics (e.g. vigour, biochemistry etc.). Such effects may arise through modification of the soil chemical, physical or biological habitat, for example:
   ♦ Control of *Striga* through improving soil fertility, and absorption and utilisation of nutrients by the host plant. Mechanisms may include interference with the exudation of Striga germination stimulants from the host, modification of the root:shoot ratio, and improved tolerance to the effects of the parasite.

Further examples are included in the annotated bibliography (circulated in draft form to participants) and the types of interactions are summarised in Figure 1 that shows in a simplified way the linkages between pest and soil fertility management.
An example which was presented and discussed was taken from an experiment on farmers management of bean stem maggot (BSM) in Kisii, Kenya. Various cultural practices were tested for the effects on BSM infestation and plant performance.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>BSM infestation / dead plant</th>
<th>% Plant mortality due to BSM</th>
<th>Yield / plot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical seed dressing</td>
<td>2.6 a</td>
<td>7.9 ab</td>
<td>573.9 ab</td>
</tr>
<tr>
<td>1/2 DAP + 1/2 FYM</td>
<td>2.2 a</td>
<td>4.6 bc</td>
<td>840.0 a</td>
</tr>
<tr>
<td>Earthing up</td>
<td>2.0 a</td>
<td>12.7 a</td>
<td>341.6 b</td>
</tr>
<tr>
<td>Mulch</td>
<td>2.3 a</td>
<td>7.8 ab</td>
<td>323.6 b</td>
</tr>
<tr>
<td>Control</td>
<td>4.0 a</td>
<td>11.8 a</td>
<td>490.5 b</td>
</tr>
<tr>
<td>LSD (0.05)</td>
<td>2.1</td>
<td>5.6</td>
<td>272.8</td>
</tr>
</tbody>
</table>

(after Ogecha, J. 1999)

In conclusion, improved soil fertility through addition of DAP and FYM was found to significantly increase yields, although BSM infestation was not significantly affected. The implication is that the plants were able to tolerate infestation which reduced plant mortality due to BSM and produced higher yields.

The study has focused on the indirect linkages between soil fertility management and pest management through the effects on crop health, one area which is particularly under-

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researched and which offers potential for improved interventions and adaptations to support resource-poor farmers. The complexity of these interactions are illustrated in Figure 2 which illustrates some of the important soil fertility and pest management practices of farmers (note these may often be dual purpose) and the interactions with soil health, crop health and pests.
Figure 2. Crop health mediated interactions between soil fertility management and pest management
Possible plant resistance mechanisms of interactions between crop health and pests include:

1) **preference/non-preference** to denote plant characteristics of and insect responses to the use of a particular plant or variety e.g. for oviposition (egg-laying), food, shelter or combinations of these;
2) **antibiosis** where plants exhibit resistance through exerting adverse influences on insect growth and survival; and
3) **tolerance** where a plant is able to support an insect population without loss of vigour or yield.

Preliminary conclusions drawn from the study are:

1) Interactions between soil fertility and pests, and between the management of soils and pests is generally a complex and under-researched area. This applies particularly in the case of smallholder farming systems in SSA, although there is a body of research evolving in response to perceived pest problems in some areas (including the East African Highlands) arising from declining soil fertility associated with increasing intensification of agriculture. Such intensification can reduce the temporal buffering effects of fallowing and rotations and the physico/chemical buffering of organic matter, and increase the seriousness of negative pest/fertility interactions.
2) Many crop protection studies neglect soil fertility issues, for example, by neglecting to record baseline soil fertility. This may clearly be an important reason for differing conclusions drawn on the role of fertilisers (inorganic and organic) as factors in losses to pests.
3) Few studies attempt to disentangle the direct effects of soil fertility and its management from the indirect effects on biological control or crop health resulting from agronomic practices.
4) The mechanisms responsible for the plant-mediated effects arising from increased soil fertility are little understood and under-researched.
5) There are comparatively few studies that take into account farmers constraints and existing management practices in relation to interactions between soil fertility and pests.
6) Interactions can be positive or negative. i.e. increasing soil fertility does not necessarily lead to reduced pest incidence/damage.
7) The quality, quantity and timing of soil improvements are all important in determining the extent and the direction of interaction.
8) The soil’s physical and biological environment are just as important as its chemical composition in determining the availability of nutrients, water and anchorage to crops.

To form a basis for the subsequent discussions, the question of ‘what types of ICM research (not forgetting promotion and dissemination activities) are demanded?’ was asked. Possible types of research were considered from basic research at the upstream end to adaptive research at the downstream end (see Figure 3). In the discussion it was recognised that farmer participation is important across this entire spectrum of research activities including basic research issues.
Figure 3. Adapted from Greenland *et al.* (1994)

**Discussion:**

**Question:** How exhaustive is the bibliography?

Response: The SF*IPM* bibliography is certainly not exhaustive. We are yet to incorporate much grey literature from projects. Appeal to all participants to send any literature or references to John Butterworth at NRI.

**Question:** Where does farmer participatory research fit in?

Comments from the floor in response: If farmers are involved in the early stages of research, then appropriate technologies with higher levels of acceptability and adoptability will result.

Comment about farmer participatory research from Kwasi Ampofo: We did some basic research on the study of the biology and ecology of *Ootheca* spp. with farmers. They monitored oviposition and larval development through adult diapause and emergence, as well as distribution in depth of soil. At the end of the study we did not have to convince farmers of management strategies. They came up with management ideas and went ahead and practised them. This shortened the technology generation process.

Comment from Barry Pound: Participatory research has moved on since the figure presented (Greenland, 1994), with farmers increasingly involved even at the basic level of research. However we need to be careful in the extrapolation of research results from location-specific trials with farmers to a wider audience.

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ANNEX 9. Workshop group tasks following the NRI-led review

The workshop participants were divided into four groups, as follows:

  - Group 1: Cereal-based cropping systems
  - Group 2: Root and tuber-based cropping systems
  - Group 3: Legumes in cropping systems
  - Group 4: Tree crops (particularly bananas/plantains)

Each group was asked to consider the following guide questions:

1. Within the cropping systems allocated to your group, what interactions have you observed or heard about between Soil Fertility and Pest Management?

2. What mechanisms do you think are responsible for the interaction?

3. Where any of these 4 these cropping systems are combined, have you observed soil fertility management practices that have implications for pest management?

4. What type of interventions do you suggest:
   - Strategic or basic research?
   - Adaptive research?
   - Any other type of intervention?

The outcome of this exercise was a series of cropping-system-based experiential and anecdotal information on interactions between IPM*SFM, mostly from sub-Saharan Africa. These were used as some of the examples of interactions that correspond to each of the research themes that were identified on the last day of the workshop (see Annex 14).
ANNEX 10. Outcome of integrating pest and soil fertility management in Ghana (CABI, HDRA, TSBF): Dr Janny Vos, CABI; Mr James Timbilla, CRI; Prof Phil Harris, HDRA; Dr Patrick Sikana (TSBF)

This presentation was built upon the results of each of the activities to-date in the CABI-led study (see Annex 5 for background). The results focused on the needs for further integration of IPM and SFM as identified by the target group of each activity (UK based project leaders for activity 1; Ghanaian farmers who have been exposed to IPM / SFM projects in Ghana for activity 2; Ghanaian project management and beneficiaries for activity 3).

1. Consultation with UK project leaders

The consultation was done with project leaders of the following projects in Ghana:

1. National IPM Programme Farmer Field Schools – FAO/UNDP
2. Composted Waste in Urban Agriculture – DFID
3. Biological Control of Root-Knot Nematodes - DFID
4. GOAN – DFID + others
5. Integrated Food Crop Systems Project – DFID
6. Kumasi Natural Resources Project – DFID

Constraints which impact on IPM*SFM research:

a. Lack of holistic approach (discipline oriented research)
b. Availability of soil amendments and other inputs
c. Few locally validated techniques
d. Few extension and research staff with broad knowledge and experience in participatory techniques
e. Poor farmer knowledge / awareness of: Pest and disease problems, impact of soil fertility on crop health, effects of soil organic matter, effect of soil moisture on pests, beneficial organisms in soils and the impact of soil fertility management

Synthesis of researchable constraints:

a. Unavailability of soil beneficials as biopesticides
b. Professional identification of soil-borne pests and beneficials
c. Effects of soil fertility on weed suppression / enhancement
d. Land tenure in Ghana (non CPP researchable)

Research needs as identified by UK based project leaders:

a. Mode of action of soil amendments (e.g. chicken manure) and it’s impact on soil fertility as well as pests and beneficials
b. Functional biodiversity in soils (relation physical, chemical and biological characteristics of tropical soils)
c. Development of participatory methods to enhance farmers’ knowledge of IPM*SFM
d. Adaptation of local crop management practices based on better knowledge of the functional biodiversity in tropical soils
e. Nematode biocontrol agents production (on-farm & commercial), validation and use in farmers’ fields
f. Impact of organic matter on beneficials and biocontrol agents in the soil (e.g. nematode biocontrol)
g. Management of bacterial wilt in a systems’ context
h. Interaction of mulching and weed management
2. Survey in Ghana on farmers perceptions and ideas

During the national survey the following projects involved in vegetable production were visited:

1. National IPM Programme Farmer Field Schools – FAO/ UNDP
2. Composted Waste in Urban Agriculture – DFID
3. Integrated Food Crop Systems Project – DFID

Observations:

a. Farmers soil fertility knowledge is low in areas with shifting cultivation, but better in areas where continuous cultivation takes place
b. Few farmers control pests in soils (below ground pests)
c. Few farmers know about natural enemies of pests in soils
d. Few farmers know that with increased soil organic matter content, certain crop diseases could be managed
e. Some farmers mix pesticides with a fertiliser solution before application or use plant hormones to manage certain diseases
f. In general the farmers awareness on interactions between soil fertility and pest management is limited to knowing that crops grown on poor soils are more susceptible to diseases
g. In general the farmers expressed both low soil fertility and pests (incl diseases) to be major constraints to crop production

Research needs as identified by farmers in the surveyed projects:

a. Water harvesting / conservation
b. Effective management of soil-borne diseases
c. Soil salinity management
d. Search for nematode resistant varieties (especially tomato)
e. Development of techniques for soil fertility testing in order to grow a healthy crop
f. Use of local materials to prepare compost
g. Termite management in vegetable systems in relation to mulching
h. Pest management in relation to green manure
i. Nursery management
3. Integrating pest management and soil fertility management

During the international mission the following projects involved in vegetable production were visited:

1. National IPM Programme Farmer Field Schools – FAO/ UNDP
2. Composted Waste in Urban Agriculture – DFID
3. Biological Control of Root-Knot Nematodes – DFID
4. GOAN Outreach, ITK, FFS and Demonstration activities – DFID + others
5. Integrated Food Crop Systems Project – DFID
6. Kumasi Natural Resources Project – DFID
7. Ghanaian-German Project for Integrated Crop Protection – GTZ (extra)
8. Sedentary Farming Systems Project – GTZ (extra)
9. Soil Fertility Project – IBSRAM (extra)

Discussions were held with various people including a Region Director of Agriculture, Project Leaders, Project Staff, Participating farmers.

General

The ranking of farmers’ priorities placed marketing issues as the main constraint, with access to and cost of soil fertility and pest control inputs coming second and third, respectively.

There was good evidence of efficacy and acceptance and economic viability of IPM and organic soil fertility inputs individually. Hence a good basis for interactions. Two major changes in the past six years the use of poultry manure and interest in neem.

RESEARCH ISSUES

Lack of holistic approach
With the exception of the project, Composted Waste in Urban Agriculture, there was very little consideration of IPM*SFM interactions in the other projects.

With the more formal research projects, the main objective of the project was usually to enhance crop production and quality through improved soil fertility. Pest and disease incidence was noted and addressed as part of the agronomy package.

Complexity of experimental design to study interactions
It is very difficult to design experiments that provide high quality data on SF x PM interactions. It is easy to design an experiment to determine whether compost improved cabbage yield. It is very difficult to design an experiment that determines whether cabbage yield is increased because of increased crop growth, reduction of pest damage, effects on soil physical properties or some combination; or whether compost is suppressing pest populations or providing plant tolerance. No project had really achieved that. Another problem is timescale. Many of these aspects cannot be studied by set up an experiment on virgin land on day 1 of the research funding.

One approach is to make use of long-term experiments – but these usually have a soil fertility/crop yield objectives and tend to provide intensive pest management to minimise losses. They may well not be amenable to experiments on pest control. A further approach to the subject, which does not seem to have been attempted, is the comparative study of matched pairs of farms. This requires a different scientific approach, which may need to be more ecological than agricultural.

Different types of research collect different types of data
Understanding and proving significant interactions may require more of a reductionist experimental approach and fairly ‘hard’ scientific investigation. On-station or researcher managed on-farm

More extensive, more adaptive, more distant research projects tended to collect data less relevant to understanding the interactions. Typical quotes from Ghana were.
“We couldn’t measure soil borne pests”.
“We could only assess disease on the harvested fruit”.
“We could only include two treatments, the farmer practice and the intervention”.

Such research tends to use more general indicators such as marketable yield, income generation.
PTD farmers experiments and PM&E may have even less formal indicators such as ‘satisfaction with the technique’, ‘willingness to continue with it’, ‘number of farmers adopting’ etc.

These results will tell us that compost is good for cabbages – but not why. And do we need to know? It is a policy and research management decision as to how much research is empirical - try it out and see and not worry why – and how much is directed at trying to understand the mechanisms in order to direct future research.

Requirement for multidisciplinary teams including socio-economic studies
Research on IPM*SFN requires a multidisciplinary research team. It may be difficult to build this into the project at the outset because of a lack of a holistic approach and also because of the practical and institutional difficulties of collaboration between colleagues and institutions.

Socio-economic studies were seen as separate components of the research, often as preliminary, or add-on sub-projects or consultancies, rather than an integral part of the research process.

Complexity of vegetable production systems
There are many quite distinct vegetable production systems in Ghana. The main systems are sub-divided according to tenure and gender of farmer. Land management varies dramatically between systems; some systems fallow some do not, some systems using irrigation some not, some short-term commercial enterprises some sedentary enterprises. The potential for many of the techniques relevant to soil fertility will vary among the systems. This has implications for research – it is important to understand the systems so that identified constraints lead to appropriate research.

RESEARCH NEEDS: ADAPTIVE RESEARCH

Optimising soil fertility inputs for pest control as well as soil fertility.
While the organic fertility techniques themselves are well reported, there is relatively little published information on interactions with pest control. Information is needed on:

- Soil types
- Mixtures of organic amendments
- Organic-inorganic combinations
- Application rates
- Placement and timing
- Possible enhancement of biocontrol value of organic inputs by management and amendment.
Optimising soil physical properties for pest control as well as soil fertility
Didn’t come up in discussion with project leaders.

Links between soil fertility and weed control
Was scarcely mentioned

Development of a range of options
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)

RESEARCH NEEDS: STRATEGIC RESEARCH

Biology, chemistry and physics of the direct interactions of soil fertility amendments and pests and diseases

Interactions between crop nutrient status and pest and disease resistance

Foliar pests and diseases
There are likely to be significant interactions between soil fertility and foliar pests and diseases via crop nutritional status and vigour, and these interactions merit attention.

Soil-borne pests and diseases
However, on the basis of most likely interactions and on the priority given to these problems by all stakeholders, special emphasis should be given to soil-borne pests and diseases, including the under-researched subject of nematode control. These are poorly understood by farmers, difficult to diagnose, devastating, few chemical options or resistant varieties.

Areas highlighted included

- Enhancement and maintenance of natural or introduced biocontrol agents
- Effects of different organic soil amendments and combinations in controlling soil-borne diseases and nematodes
- Organic-inorganic interactions
- Rotation
- Cover crops for antagonist and beneficial purposes – including possible negative role of cover crops as reservoirs of pest and diseases
- Improved, short-term fallows

Research to validate the indigenous knowledge
In general, knowledge of soil fertility and pest and disease issues has been reported to be low amongst farmers in all parts of Ghana. On the other hand, there are examples of local knowledge and practice including the use of indicator species to assess soil fertility, and appreciation of the value of poultry manure for nematode control. Experimentation based on ITK uncovered by GOAN and others, as well as novel techniques developed as a result of farmer experimentation, would be valuable.

PARTNERSHIPS

The institutional infrastructure
Does exist in Ghana to facilitate the entire research and development process for IPM*SFM – both in identifying the research agenda and disseminating and promoting outputs. Good links between MoFA, NGOs, Researcher Institutes and Universities, Development projects. What is needed is to strengthen some of the weaker links.
The scientific expertise
Required to study these interactions is available in the universities and national research institutes. There are a relatively small number of experts available in each discipline. It is possible that this restricts competition and risks over-commissioning of certain institutions.

NGOs
Have also been involved in adaptive research but currently lack staff with research.

Government extension
Opportunity for AEAs to be more involved in participatory research

TRAINING AND KNOWLEDGE

Although existing projects have achieved a great deal in the promotion of participatory learning, there are several opportunities for improvement including:

**Strengthening interactive and iterative learning**
Ensure that the learning process is not unidirectional. The goal should be to move towards a more participatory relationship where farmers, scientists and extensionists are equal partners in the process of knowledge exchange and technology generation.

*Incorporating ITK and farmer innovation into the technology development process*
*Farmer knowledge and perceptions of IPM*SFM are dynamic and continually unfolding. It should be built into the participatory learning strategies as well as informing research.*

To illustrate the above, we can use the case of the Mataheko Farmer Field School in Dangbe West district. We found that farmers were locally experimenting on the use of fresh and green neem fruits rather than using dried peeled seeds as recommended in the field school.

*Achieving greater representation and better targeting of SF&PM information*
Information dissemination must take into account the social division of labour and responsibilities in different crop enterprises and activities across the IPM*SFM border.

A major difficulty being experienced by many of the projects visited is their inability to reach adequate number so women. Women are often the main farmers for some crops. In one mainly male FFS it was nevertheless almost exclusively the women who were responsible for soil fertility inputs.

At the community level, there is a tendency to rely exclusively on ‘farmer groups’ identified by extension personnel. These farmer groups do not always represent the broad spectrum of socio-economic groupings in the community. To this end, it is recommended that other community-based institutions and platforms such as churches, informal credit schemes, self-help groups, clan groups, and women’s groups etc should also be identified and utilised where possible.

*Improving links to poverty elimination*
Are we targeting IPM*SFM research at this DFID objective? Rich commercial vegetable producers. In the context of Ghana, the choice of peri-urban vegetable growers is a good starting point because there is evidence that in some situations, this constitutes one of the poorer segments of the peri-urban community. For example, a well-being ranking exercise carried out in Mataheko village showed that 23 out of the 34 vegetable growing households (i.e. 67 %) belonged to the poorest well-being category, while only 11 (32%) and 4 (11%) belonged to the medium and rich categories respectively.
This scenario might differ from locality to locality. There is need to place vegetable growing in the context of the wider farming systems and the multiple livelihood strategies being pursued by different categories of people in each locality. Some vegetable growers had off-farm employment and diverse enterprises in snail farming, cattle ranching etc.

**Building flexibility**
The current focus on single commodities in many FFS elsewhere makes it difficult to consider the farming systems in a more holistic manner. IPM*SFM interactions more at the farm system level – than the single crop.

**Broadening the range of participatory learning tools**
The range of visual and experiential tools being used in participatory learning programmes should be expanded. In particular, there is need to help farmers comprehend below ground pests and diseases and soil biological processes. These areas still largely remain outside the local people’s boundaries of knowledge and experience.

**Schools and other community level institutions as dissemination targets**
In addition, Schools and other community level institutions can be dissemination targets as well as farmers groups. In this respect, Ghana can learn a great deal from the Kenyan experience, where schools now rank as one of the most important uptake pathways, along with the national extension service.

**Discussion:**

Question: How did farmers get to know about the growth hormones mentioned in James’ presentation?

Response: Information on growth hormones is available to farmers through advertisements and farmer education and by chemical companies. Farmers are keeping up to speed with advancement in agricultural technology.

Comment: Shifting rice cultivators in Cote d’Ivoire have extensive knowledge of soil fertility issues.

Response: Soil fertility knowledge (in Ghana) is low in areas where farmers practise shifting cultivation comparative to intensively-managed, peri-urban areas, where farmers are depending on small areas of land for their continued livelihoods.
ANNEX 11. Workshop group tasks following the CABI-led study

The workshop participants were divided into four groups, as follows:

Group 1:
Comparison of Ghanaian study with crop systems in Eastern Africa
Guide questions:
- In how far can the outcomes of the Ghanaian study to date represent the situation in Eastern Africa with regard to vegetable systems (please also identify gaps in information to answer this question)?
- Which of the identified constraints (which impact IPM*SFM) are specific to vegetable systems and which are common to a wide range of cropping systems across Africa?

Group 2:
Complexity of IPM*SFM research
Guide questions:
- How will research (at various levels) tackle the complexities of IPM*SFM in farming systems and the inherent challenges in experimental design?
- What are the requirements of multi-disciplinarities? Is there a need for additional training?

Group 3:
Farmers involvement in IPM*SFM projects
Guide questions:
- How should farmers be involved in IPM*SFM project development and implementation?
- Which uptake pathways should be included in IPM*SFM projects?
- How should impact assessment be done of IPM*SFM projects?
- What should the time-frame be for IPM*SFM projects?

Group 4:
Partnerships
Guide questions:
- What are the most effective partnerships to approach IPM*SFM?
- How can linkages between partners be strengthened?
- Which are potential partners in Africa to contribute to IPM*SFM and which are their strengths?

Results from working groups:

GROUP 1: COMPARISON OF GHANA AND EAST AFRICA

VEGETABLE SYSTEMS IN EAST AFRICA
- Tomato
- Cabbage
- Snap-beans
- Kale

1. Comparison Ghanaian survey outcome (vegetable systems)
   A) No shifting cultivation in E.A.
   B) Knowledge of soil fertility is generally high
   C) Pesticides and fertilisers applied separately. No use of hormones – comment from floor: in Ghana some farmers mix pesticides and fertilisers, others do not.
D) In some EA countries, production for export may influence knowledge of SF + IPM – comment from floor: in Ghana vegetable production for export is done as well, so this must not be seen as a difference

E) Other outcomes applicable in EA

2. Additional research needs in East Africa (compared to national survey outcome)
   A) In EA acidity in reclaimed wetlands
   B) Policy on inputs (costs/packaging/distribution/marketing)
   C) Interventions that are not labour intensive
   D) All other research needs identified are applicable in EA

3. IPM/SFM international mission to Ghana
   A) Research issues mentioned are applicable in EA
   B) Research needs mentioned are applicable in EA
   C) Strategic research needs mentioned are applicable in EA
   D) Gaps: 1. Methodologies to study interactions; 2. Epidemiology

4. Constraints mentioned in study in Ghana
   1. Constraints suggested by UK-based project leaders applicable in EA
   2. Vegetable production in EA is more market oriented; therefore tendency to use higher inputs (fertilisers etc), and better management
   3. Vegetables tend to be grown near homesteads/valley bottoms because of greater need for water and nutrients
   4. In livestock/vegetable systems, livestock are a source of manures. In livestock/cereal systems, there is nutrient depletion through cereals resulting in poor soils

GROUP 2: COMPLEXITY OF IPM*SFM RESEARCH

COMPLEXITIES
1. Soil ecosystem difficult to study
2. Lack of basic information
3. Gap in knowledge about beneficial organisms
4. Mechanisms for interactions between SFM and IPM poorly understood
5. Difficulty with isolating treatment factors
6. Pest dynamics in the soil poorly understood

INTERACTIONS
Do we need to understand all the interactions? No, only key interactions. E.g. Factors needed to generalise results; e.g. Factors where farmer lack of knowledge impedes progress

CHALLENGES FOR EXPERIMENTAL DESIGNS
1. Reductionist experiments:
   a) knowing factors involved
   b) controlling factors involved
2. Comparison experiments
   a) knowing history of land use to establish valid comparisons
3. Correlation experiments
   a) Correlation does not equal causation

REQUIREMENTS FOR MULTIDISCIPLINARY RESEARCH
1. Basic: physical scientists plus farmers
2. Strategic: physical scientists, socio-economists and farmers
3. Applied: physical scientists, socio-economists and farmers plus anthropologist
4. Adaptive: extensionists, socio-economists and farmers

CONDITIONS
1. Conditions under which these groups can interact
2. Appreciation of individual and collective roles in a project
3. Effective management structure
4. Effective and focused leadership
5. Team building activities
6. Involvement of all stakeholders
7. Keeping objectives in focus
8. Regular reviews of progress/refining objectives

TRAINING
1. Filling of skill/expertise gaps
2. Re-orientation towards multi-discipline working and participatory approaches

GROUP 3: FARMERS INVOLVEMENT IN IPM*SFM PROJECTS

1. How to involve farmers in IPM*SFM projects

Project Cycle:
   a) identification
   b) formulation and planning
   c) implementation
   d) impact assessment/evaluation

Farmer’s involvement at each stage of the cycle depends on the type of research: basic to adaptive

Research should:
   a) be demand driven (farmer) plus researcher knowledge
   b) capture farmers suggestions and criteria
   c) represent different farmer groups (gender, economic status etc)
   d) be geared towards what farmers can cope with (availability of materials)
   e) provide valuable data (statistical analysis where appropriate)

2. Uptake pathways in IPM*SFM projects

   a) farmer to farmer information transfer (requires communicators to understand basic principles underlying technologies being transferred)
   b) farmer field schools
   c) information networks
   d) demonstration plots and field days
   e) exchange visits between farmers/farmer groups
   f) audio-visual/printed media/posters/farmers newsletters
   g) use of drama and music
   h) awareness raising among policy makers
   i) incorporation into secondary/tertiary curricula
   j) farming competitions at group level

3. Impact assessment

Parameters: income, food security, awareness and appreciation/knowledge, adoption, empowerment (farmers’ ability to face new challenges).
Assessment methods: Surveys (formal and through PRA tools)

4. Time frame

- Determined by: type of research. i.e. basic - short term; adaptive – longer term
- Half year for inception phase
- Project proposal should consider possibility extension of implementation period beyond three years
- Networking with local institutions will enable continuation
- Could build on already-existing long-term trials

GROUP 4: PARTNERSHIPS

Two broad areas where partnerships are likely to be very different:

1. Downstream research (implementation and promotion) partnerships
   a) farmers, farmer groups, CBOs
   b) churches, schools, local councils
   c) government institutions
   d) NGOs
   e) Extensionists, commercial agents
   f) Scientists, methodological specialists (agronomists, pathologists etc.)
   g) Donors
   h) Regional networks
   i) Information/media specialists
   j) Private sector (factories/shops etc.)

Gender, age, economic status etc. should be taken into account

2. Most effective partnerships
   a) farmer/extensionist
   b) extensionist/researcher
   c) farmer/farmer
   d) farmer/researcher

3. Upstream research (implementation and promotion) partnerships

  In order of effectiveness:
  IARCS – NARS
  Researchers with downstream projects (farmers, project leaders)
  IARCS – IARCS

4. Most effective means to approach IPM*SFM
   a) Stakeholder analysis
   b) Understanding each other’s policies and priorities
   c) Openness
   d) Communication exchange
   e) Collaborative pilot projects
   f) Join new networks
   g) Genuine partnership from the start
   h) Time and money

POTENTIAL PARTNERS
TSBF                                   KARI
AHI                                     NARO
SACDEP                                 CIMMYT
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<tr>
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ANNNEX 12. Identification of problems, information gaps and constraints

CABI and NRI partners wrote the most important constraints and issues for IPM*SFM which resulted from the respective studies onto separate cards. In plenary session categories of issues were then agreed, to which the cards were then assigned by common consensus.

Knowledge/ awareness/ training in IPM*SFM/Uptake pathways including scaling up

IPM*SFM training not always for all socio-economic groups in community

Scientist-scientist exchange

Poor representation of women in IPM*SFM training

IPM*SFM information dissemination not looking at social division of labour

Lack of consideration of IPM*SFM issues in school and college curricula

Farmers need to be empowered to build livelihoods and act as environmental custodians

Educational tools for farmers to understand soil pests and biological processes

Little experience in participatory techniques

NGO staff lacking research training

Lack of multi-disciplinary approach

Diagnosis of present status of IPM*SFM/Scientific research that addresses knowledge gaps in IPM*SFM

Interaction between IPM*SFM maybe multi-trophic

Lack of knowledge of interaction between crop nutrient status and pest resistance

Lack of understanding availability of soil beneficials

Lack of knowledge of effect of soil fertility inputs on soil-borne pests

Indigenous knowledge is not well understood – needs to be complemented with basic research

Lack of understanding of role of water availability

Lack of knowledge soil physical properties affect on pest control

Little awareness/ knowledge of soil pests and beneficials

Complexity of vegetable production systems

Lack of validation of ITK and novel techniques

Lack of consideration of ITK and farmer innovation in technology development process
Lack of knowledge of interaction of soil fertility and beneficials
Interactions are positive and negative – dependent on many other factors
Inability to control devastating soil-borne pests

**Policy**
Research should be targeting poorest groups
Policies do not support integration of IPM*SFM
Donors are fickle. Panaceas come and go
Time frame
Process-based inter-disciplinary implementation projects are needed
Access to and cost of soil fertility and pest control inputs
Institutional policy and procedures needed

**Methodology development to approach IPM*SFM**
Approach could tend to focus on technical variables and fixes
Appropriate methodologies / indicators are required for PTD research
To understand/ separate mechanism, may need push systems to extremes
Lack of holistic approach
Difficulty in collecting basic data from adaptive research
Basic strategic research may not be replicable
Complexity of experimental design to study IPM*SFM
Inflexibility of focus on single commodities
Adaptive research is difficult to scale up
Existing participatory methods need to be modified

**Partnerships/ Institutional issues**
Requirement for multidisciplinary team
Farmers have a holistic perspective, researchers often don’t
Few experts in each discipline/ over-commissioning
Transaction costs are massive

There is a need to strengthen collaboration on IPM*SFIM

Cross-cutting:

Beneficiaries

Gender

Documentation

Impact assessment
ANNEX 13. Translation of constraints and issues into research themes

Through a process of facilitated discussion, four research themes were distilled from the identified issues (Annex 12). These themes were:

1. Effects of organic amendments on soil pests (incl. weeds) and beneficials
2. Effect of cultural practices on the inter-relation between soil fertility, pests and beneficials
3. Inter-relation of soil fertility management, plant condition and pest damage
4. Effect of agro-chemicals on soil organisms and soil fertility

The participants then divided into groups, each one taking a theme. Each theme was scored (out of five) for the importance of research, training, policy, methodology, partnerships and cross-cutting issues (beneficiaries, gender, documentation, impact assessment) to the theme, and this scoring was justified by a text narrative.

The resulting matrices were presented in plenary, discussed and refined. The final versions are included in this Annex.
### Group A: Effects of organic amendments on soil pests and beneficials

<table>
<thead>
<tr>
<th>Research</th>
<th>Training</th>
<th>Policy</th>
<th>Methodology</th>
<th>Partnerships</th>
<th>Crosscutting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Xxxxx</td>
<td>xxx</td>
<td>X</td>
<td>xxxx</td>
<td>xxxx</td>
<td>-</td>
</tr>
<tr>
<td>1. Some work done on pests (e.g. bean rot)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>2. Limited work on beneficials (Rhizobium, mycorrhiza)</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>3. Very limited work on pest/beneficials interaction (mechanisms)</td>
<td></td>
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</tr>
</tbody>
</table>

- 1. Capacity building of scientists
- 2. Dissemination and capacity building (farmers, extensionists – PTD)
- 3. Awareness / knowledge

- 1. Government can work behind institutions
- 2. Effective and appropriate technologies need to be developed and quantified

- 1. Recommendations should aim at options
- 2. Efficient methods to determine effects of organic amendments on pests, beneficials and interactions
- 3. Support for research facilities
- 4. Multidisciplinary approaches
- 5. Participatory approaches (inc. FFS)

- 1. Identify and involve relevant stakeholders
- 2. Multi-disciplinary/participatory team approaches

- 1. Beneficiaries: All stakeholders at various levels. e.g. scientists, farmers, extensionists and policy makers
- 2. Gender: technology should provide options
- 3. Documentation: Applicable for all categories
- 4. Impact assessment: should be applied at all stages and categories
Group B: Effect of cultural practices on the inter-relationships between soil fertility and pests and beneficials

Examples of cultural practices:
Choice of variety, Crop rotation, Water management (irrigation, drainage, mulching, ridging, weeding etc.), Mulching (in case it is not applied as a soil amendment), Pruning, thinning and rogueing, Mixed farming practices, Intercropping (incl. trap cropping e.g. nematodes/Striga), Crop residue removal/management, Tillage (ploughing, harrowing etc.), Solarisation, Burning, Fallowing, Agroforestry

N.B.: Not including fertilisation or application of agro-chemicals

Effect of cultural practices on the inter-relation between soil fertility, pests and beneficials

<table>
<thead>
<tr>
<th>Research</th>
<th>Training</th>
<th>Policy</th>
<th>Methodology</th>
<th>Partnerships</th>
<th>Crosscutting</th>
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<td>-</td>
</tr>
<tr>
<td>1. To be done with farmers, on farmers fields where possible</td>
<td>1. Development of appropriate curricula</td>
<td>Examples: burning of rice straw; bush burning; ban on intercropping in coffee</td>
<td>1. Novel techniques needed to look at inter-relationships, including design of studies and methods for economic evaluation</td>
<td>1. Multi-disciplines</td>
<td>1. Beneficiaries: Resource-poor farmers as prime beneficiaries. Other beneficiaries are extension (NGOs, CBOs and GOs); researchers and research managers; policy makers</td>
</tr>
<tr>
<td>2. ITK compilation and validation</td>
<td>2. Develop methodologies for training e.g. trainers, farmers etc.</td>
<td>2. Wide spectrum of research requires inputs from NGOs, GOs, CBOs, IARCs etc.</td>
<td></td>
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</tr>
<tr>
<td>3. Investigate inter-relationships (where, when how)</td>
<td>3. Methodologies for researchers (scientists, extensionists and farmers)</td>
<td>3. Documentation: Needed for all beneficiaries (different forms)</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>4. Impact assessment: Regularly (monitoring); farmers must be involved; environmental, social, economic, political impact need assessment</td>
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</tbody>
</table>
Group C: Inter-relation of SFM, plant condition* and pest damage

*includes vigour, nutrient balance, secondary products and morphology

<table>
<thead>
<tr>
<th>Research</th>
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</table>
Group D: Effect of agrochemicals on soil organisms and soil fertility

<table>
<thead>
<tr>
<th>Processes +ve</th>
<th>Fertilisers</th>
<th>Herbicides</th>
<th>Fungicides</th>
<th>Insecticides</th>
<th>Nematicides</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decomposition and mineralisation</td>
<td>Decomposition and mineralisation</td>
<td>Decomposition and mineralisation</td>
<td>Decomposition and mineralisation</td>
<td>N fixation</td>
<td>Nematicides</td>
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<tr>
<td>Phosphorus capture</td>
<td>Nutrient balance</td>
<td>Phosphorus capture</td>
<td>Nutrient balance</td>
<td>Predation</td>
<td>Predation</td>
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<tr>
<td>Nutrient balance</td>
<td>Physical characteristics</td>
<td>Nutrient balance</td>
<td>Physical characteristics</td>
<td>Decomposition</td>
<td>Decomposition</td>
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<tr>
<td>Soil pH</td>
<td>Physical characteristics</td>
<td>Soil pH</td>
<td>Physical characteristics</td>
<td>Predation</td>
<td>Predation</td>
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<td>Phosphorus capture</td>
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</tbody>
</table>

Some effects documented
Interactions very poorly researched
Research and development imperatives include:
1. Identify cropping systems with actual/potential agrochemical problems
2. Quantify positive and negative effects of agrochemical use on soil processes
3. Develop low-cost alternatives to agrochemicals which maximise positive and minimise negative effects on SF and pest management

Interdisciplinarity / participatory methods
Researchers, extensionists, farmers
Registration
Supply
Safety
Interactions
Research methods
Participation
Stakeholders
Multidisciplinary partnerships
Institutions
Beneficiaries
Gender relevance requires careful consideration
Documentation - Little currently available for regions/crops
Impact – productivity, food security, living standard, health, environment, empowerment

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ANNEX 14. Allocation of workshop examples of SF*IPM interactions to research themes

The final joint task of the participants was to assign examples of IPM*SF interactions collected on day one of the workshop (Annex 9) and identified through the outcome of the CABI-led study in Ghana on day two of the workshop (Annex 10) to one or other of the research themes. This provided a useful check on the meaning of the research themes. The examples should however not be taken as comprehensive – as they reflect a sub-sample of the experience of the participants in addition to the outcome of a vegetable study in Ghana – and cannot be seen as an exhaustive survey of actual or potential interactions over a range of cropping systems. Some of the examples that were given in day one of the workshop are based on hearsay or anecdotal evidence, rather than quantitative information, and many of the mechanisms of interaction are poorly understood.

The result of the exercise was as follows:

Effects of organic amendments on soil pests (incl. weeds) and beneficials
- Green manure x Striga control (Crotalaria, Desmodium) on maize, sorghum
- Pest reduction x soil fertility by use of cow urine and herbs around banana plants
- Liquid manure and mulch control black rot of cabbage
- Increase in weed seeds / soil pests through use of cow dung as fertiliser on various crops
- Weed management x soil fertility through composting of weeds of cassava
- Impact of compost on nematode biological control in vegetables
- Control of nematodes using chicken, pigeon, pig manure on tomato
- Nematode control x soil fertility through Crotalaria green manure on tomato and other crops
- Compost for nursery beds to avoid pests and improve soil fertility for vegetable seedlings
- Weed suppression x soil fertility using grass mulch can produce Mg syndrome on coffee
- Mulching in relation to termite management in various crops
- Weed suppression x soil fertility through use of cover crops

Effect of cultural practices on the inter-relation between soil fertility, pests and beneficials
- Stem borer control by straw burning reduces soil fertility in rice
- Nematode control x soil fertility through crop rotation for Irish potato
- Caterpillar control x soil fertility using wood ash on sweet potato
- Tuber moth control x soil fertility by ridging / moulding up for Irish and sweet potato
- Weed and pest reduction x soil fertility through weeding and thinning on Irish and sweet potato
- Weed management x soil fertility through bush burning on casava, cocoyam
- Weed management x soil fertility through use of cover crops in cereals (maize especially)
- Nematodes reduced through rotations x soil fertility when tomatoes and beans are rotated
- Weed problem x soil fertility due to use of Prosopis as green manure
- Reduction of diseases due to transport of mulches, e.g. cabbage / banana
- Weed suppression x soil fertility through use of cover crops (but some pests in cover crops) of cassava
- Reduction of weevils x soil fertility through removal of mulch around banana plants
- Sub-soil for vegetable nursery beds to avoid diseases
- Pest reduction (incl. weeds) x soil fertility through fallowing on all crops

**Inter-relation of soil fertility management, plant condition and pest damage**

- Low fertility -> fruit disorders on citrus / calcium deficiency on tomato
- Reduction of bacterial wilt through improving soil structure / drainage of solanaceous crops
- High Nitrogen uptake x aphid problems on citrus
- Low fertility x scale insect problem on citrus
- Pest severity increases with low soil fertility, e.g. root rots or nematodes or bean stem maggot
- *Phytophthora* problem x soil fertility when using fast degrading green manures on Irish potato
- Disease resistance x soil fertility through use of residual fertility from relay crops, e.g. cassava and cereals
- Lower termite problems at high fertility in maize (also trees?)
- High fertility (N) x *Striga* control in maize, sorghum
- Green manure x *Striga* control

**Effect of agro-chemicals on soil organisms and soil fertility**

- Disease resistance x soil fertility through use & residual fertility from relay crops
ANNEX 15. Closing remarks: Professor Mike Swift, TSBF

Professor Swift analysed the aim and expected outputs of the workshop in order to determine if it had achieved its objectives. It was concluded that the participation was indeed multidisciplinary, and that the various components of the two studies (including the workshop) have assessed demand and opportunities and constraints to research and development concerned with interactions between soil fertility and pest management. Throughout the workshop, the emphasis has been on the needs of small farmers and their limited access to resources.

The workshop has been particularly successful in identifying prioritised research themes against specific criteria, and it is expected that these will provide essential inputs to a framework for a future research agenda on integrated pest and soil fertility management to be included in the final reports of the NRI and CABI studies to be submitted to the DFID Crop Protection Programme.

A particularly pleasing outcome of the workshop has been the forging of new partnerships - between individuals, between institutions, and across the disciplines of pest management and soil science. This should provide the basis for future cooperation in research in this emerging area.

Professor Swift declared the workshop to be at a close and wished all participants a safe journey home.
ANNEX 17. Next steps

The outputs of the workshop and associated studies will be:

♦ A literature review and final technical report from the NRI/AHI/TSBF study focusing on maize, banana and cassava-based cropping systems.
♦ A final technical report from the CABI-led study incorporating the Ghana Case Study that focused on vegetable cropping systems.
♦ An action plan for future IPM*SFM research based upon the two studies and workshop, which will be presented to the Crop Protection Programme.
♦ A short paper to be published to quickly disseminate the findings of the two studies and the workshop to a wide audience.

Other activities will include communication of documents and issues arising from the workshop to all participants through e-mail, and the development of project proposals in integrated pest and soil fertility management.

Immediate follow-up actions in East Africa

Dr Mike Swift, the TSBF Programme Director briefly described some possible follow-up actions that could be immediately taken in East Africa.

The TSBF Programme has received a small amount of funds from the Rockefeller Foundation for exploratory studies in soil biology. These studies are to be implemented thought the TSBF African Network for Soil Biology and Fertility (AfNet) in seven countries (Kenya, Uganda, Zimbabwe, South Africa, Nigeria, Cameroon and Cote d’Ivoire). The exploration, largely focussed on the first objective and the first thrust, will consist of project planning workshops and a small extent of field method trials as a follow-up to proposals developed at a workshop in Nairobi in March 1999, which a number of participants from this meeting attended. The initiative proposed at that workshop has seven objectives (Box 1) and four main thrusts (Box 2).

Dr Swift proposes to suggest to the Steering Committee that the theme of IPM*SFM should be the main priority of this exploration in East Africa (ie Kenya and Uganda). The outcomes of this workshop, and in particular the four identified research themes, could act as a guideline in planning the exploratory research. The Steering Committee will be meeting in early April to consider these plans. The other institutions represented at this workshop will be kept informed of developments.

A second step of development would be to propose a joint meeting of the Soils and IPM Working Groups of the AHI to develop a joint plan of action.
Box 1

TSBF Soil Biology Initiative: Objectives.

1. To develop methods for the integrated management of the soil biological community that improve soil fertility, protect plant health and increase crop productivity.

2. To develop predictive understanding of the relationships between cropping system design and management and the functioning of the soil community.

3. To enhance the communication of knowledge between farmers and scientists as a means of facilitating the application of biological approaches to the management of soil fertility and plant health.

4. To develop and implement adoptable soil biological technologies and soil management practices that increase and sustain agricultural productivity and profitability.

5. To develop and validate indicators for soil biotic functions that contribute to ecosystem sustainability.

6. To establish, for the future benefit of African countries, databases on soil biodiversity.

7. To increase the human and institutional capacity in Africa for research in soil biology.
Box 2. The Four Research Thrusts.

1. Integrated Biological Management of the Soil:
The major benefits from research on soil biology are likely to be realised from the manipulation of the soil community as a whole through the indirect means of cropping system design and organic matter management. This is largely unexplored territory in African agriculture but merits a major investment. A wide range of cropping system designs are being advocated to alleviate constraints to agricultural production in Africa which have been recognised and diagnosed in the process of participatory on-farm research. Soil fertility depletion and soil-borne pests and diseases frequently score highly in such exercises.

Systems such as improved fallows and other agroforestry practices, intercropping and rotations with the incorporation of legumes, leguminous cover crops, reduced tillage and integrated nutrient and pest management practices are being tested to combat these constraints. It is implicit in the design of these systems that they rely on the efficient functioning of the soil biological community to sustain increased levels of production. This assumption has rarely been tested however. The integrated approach to soil management advocated here requires a research focus on the interactions between the key groups of soil biota and their combined impact on ecosystem functions.

The integration of soil fertility and pest management research and technology development is a major innovation in agricultural research. The main target of the integrated approach is the greater economic efficiency of enhanced nutrient cycling and soil and pest management coupled with the increased sustainability that such biologically based approaches will bring. An additional output will be the development and testing of biological indicators of soil quality and ecosystem sustainability.

2. Improving Soil Biological Technologies:
There are a number of successful ‘on-the-shelf’ applications of soil biological technologies, such as inoculation with N2-fixing bacteria or mycorrhizal fungi, biological control of soil-borne pests and diseases, and the use of earthworms for composting and soil structural modification. Many of these are under-utilised in, or inappropriate for, smallscale agriculture in Africa. A number of actions are proposed to examine the feasibility of application and development of relevant and improved variations of such technologies.

The adoptability of these practices is dependent on their ‘fit’ with the needs and opportunities of farmers, which is enhanced when there is shared knowledge and understanding between farmer and scientist. The development of approaches to enhance communication between scientist and farmer will be a key component of the research activities of all the thrusts in the Initiative.

3. Exploring and Conserving for Future Benefits:
The soil biota of tropical regions is largely undescribed but undoubtedly accounts for a very significant component of global terrestrial biodiversity. Such evidence as is available shows that, whilst the soil biota appear to have a substantial degree of resilience to stress and disturbance, this may in large part be accounted for by so-called redundancy in functional roles. Change in land-use and practice may however result in significant loss of species and consequent impact on functions.

In addition to the immediate practical applications that will be realised from improved management of the soil biota, there are also possibilities for other future benefits. One example of this is the utilisation of the vast diversity in the soil microbial gene pool for products in such sectors as the pharmaceutical, agrochemical, plant breeding, pest control and food additive industries. Bio-prospecting for such products is already being conducted and exploited in many developed countries and rapidly extended to tropical soils.

There is a strong case for the conduct of studies of soil biodiversity in its own right and for both agricultural and non-agricultural benefits, within the constraints of Intellectual Property Rights and the Convention on Biological Diversity.

4. Building Capacity:
The capacity for research in soil biology is patchily distributed in Africa, in terms of geography, expertise and facilities. For full realisation of the benefits of current research, and training of the next generation of scientists, a significant investment in capacity building must be made. This will include training in modern techniques of soil biology, a programme for graduate development and the enhancement and development of facilities in at least a small number of centers. Capacities in Africa will be developed by means of linkages with advanced centers elsewhere in the tropics (see Appendix 1) as well as in countries of the North.

A specific question of intellectual property rights arises from the potential for realising industrial benefits from the genetic exploitation of soil organisms (see above). The only way in which countries in Africa will to be able to obtain their share of such markets and protect their own rights is if they possess the skills and methods for molecular-genetic characterisation of soil micro-organisms in order to conduct their own explorations. It is thus essential that the capacity for application of these techniques be available in at least a number of African research centres.
The agreed responsibilities for actions arising from the workshop are shown in the table below (note that there are actions for all workshop participants):

<table>
<thead>
<tr>
<th>Action</th>
<th>Responsibility</th>
<th>Agreed deadline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arrangements made for best mechanism for continued electronic dialogue between workshop participants</td>
<td>Janny Vos and Kwasi Ampofo</td>
<td>As soon as possible after workshop</td>
</tr>
<tr>
<td>Suggestions for additions to the draft annotated bibliography and literature review circulated at the workshop to be sent to John Butterworth</td>
<td>All workshop participants</td>
<td>As soon as possible after workshop</td>
</tr>
<tr>
<td>Workshop report to be drafted, and send to Janny Vos</td>
<td>Barry Pound/ John Butterworth</td>
<td>19 February 2000</td>
</tr>
<tr>
<td>Workshop report to be finalised and circulated to all participants</td>
<td>Janny Vos</td>
<td>25 February 2000</td>
</tr>
<tr>
<td>Outline for action plan to be drafted and circulated to organisers*</td>
<td>Janny Vos</td>
<td>3 March 2000</td>
</tr>
<tr>
<td>Comments on action plan outline circulated between organisers* and responsibility for drafting sections agreed</td>
<td>Organisers*</td>
<td>10 March 2000</td>
</tr>
<tr>
<td>Draft action plan completed and circulated to all workshop participants</td>
<td>All organisers* , coordinated by Janny Vos</td>
<td>17 March 2000</td>
</tr>
<tr>
<td>Comments on draft action plan sent to Janny Vos</td>
<td>All participants</td>
<td>24 March 2000</td>
</tr>
<tr>
<td>Action plan finalised incorporating comments received, and circulated to all participants</td>
<td>Janny Vos</td>
<td>31 March 2000</td>
</tr>
<tr>
<td>Final technical reports for both studies completed, submitted to CPP and circulated to all participants</td>
<td>John Butterworth (NRI/AHI/TSBF study) Janny Vos (CABI-led study)</td>
<td>30 April 2000</td>
</tr>
<tr>
<td>Draft short paper produced and circulated to all participants for comments</td>
<td>John Butterworth leading, refined by Janny Vos</td>
<td>30 April 2000</td>
</tr>
<tr>
<td>Comments on draft short paper sent to John Butterworth</td>
<td>All workshop participants</td>
<td>15 May 2000</td>
</tr>
<tr>
<td>Comments incorporated and short paper submitted for publication</td>
<td>John Butterworth</td>
<td>15 June 2000</td>
</tr>
</tbody>
</table>

*Organisers - Mike Swift, Kwasi Ampofu, Janny Vos, John Butterworth
ANNEX 18. List of participants

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APPENDIX V: STRATEGY PAPER

INTEGRATED PEST AND SOIL FERTILITY MANAGEMENT: A STRATEGY FOR FUTURE RESEARCH

This publication is a joint output from two related research projects funded by the United Kingdom Department for International Development (DFID) for the benefit of developing countries. The views expressed are not necessarily those of DFID. The projects were carried out under contract with NRInternational (R7490 and R7503) Crop Protection Programme.

1. BACKGROUND

Farmers manage crops in a holistic manner and address both nutrient management and pest management within their decision-making processes and farming operations. By so doing, they establish specific environments that influence the plants and the micro-environmental niches in which pathogens and pests interact with antagonistic and competitor organisms. In many situations, crop pests and soil fertility limitations interact as yield constraints, and removing one constraint will not result in increased productivity unless the other is also addressed.

The soil biota constitute a major component of the biological diversity of agroecosystems which is responsible for key functions that maintain system integrity and productivity. In addition to nutrient effects on crop plants, soil amendments (sensu lato) directly affect soil microbiota and consequent suppression of soil-borne pests through competition, antagonism and parasitism. Cultural activities undertaken primarily for pest management purposes also themselves influence soil fertility. An example here is the use of crop rotations to avoid pest accumulation; rotations also influence soil organic matter and the balance of nutrients. Careful manipulation of the components and timing of rotations can positively affect both crop health and soil fertility.

Soil fertility management interacts with crop health in a wide variety of ways, including effects on the overall susceptibility to infection or attack (predisposition), the plant’s tolerance to pests and capacity to produce yield despite pest attack and direct disease causation though nutrient stress. In resource-poor systems, soil fertility is itself constrained by soil depth and structure, and the availability of organic and inorganic nutrient sources.

The strategy presented here 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. The research themes developed target understanding of the interrelationship between soil fertility and pest management, and its relevance to system sustainability and food security.

1.1. Development of the strategy

This strategy is a joint output of two short programme development studies on aspects of Integrated Pest & Soil Fertility Management (IP&SFM) for the UK Department for International Development (DFID) Crop Protection Programme (CPP) managed by NRInternational. Both studies aimed to identify 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.

A study led by the Natural Resources Institute (NRI) in collaboration with the Tropical Soil Biology and Fertility Programme (TSBF) and the African Highlands Initiative (AHI) focused on banana, maize, and cassava-based cropping systems in East Africa. This study worked with established networks that have already linked pest management problems with declining soil fertility. The study reviewed existing knowledge on linkages between soil fertility and pest management, and especially the effects of soil fertility management on plant condition, and consequently the ability of crops to tolerate or resist pest attack. Consultations involving a multi-disciplinary group of researchers and stakeholders from the region established demand and priorities for future research in these systems.

A needs assessment study in Ghana, led by CABI Bioscience, was implemented in collaboration with the Henry Doubleday Research Association (HDRA), TSBF and various Ghanaian researchers and extensionists. The study focused on vegetable cropping systems and the needs and demands expressed by stakeholders involved in existing research and implementation projects (farmers, extensionists & researchers) that involved both pest and soil fertility management. This study identified needs and appropriate processes for further integration of soil fertility and pest management from farmers through to researchers.

The outcomes of the two studies were combined through the joint workshop ‘Integrated Pest & Soil Fertility Management: A Collaborative Workshop to Shape Future Initiatives’ that was held in Nairobi in February 2000. This meeting brought together stakeholders from four East African countries and Ghana and established parallels for each study in East and West Africa.

Through this process, the findings of the NRI and CABI-led studies were amalgamated in this strategy, which establishes a framework for potential future activities in this area under the CPP. The strategy identifies research areas 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.

This strategy draws on the more detailed outputs of the two studies:

Ampofo et al. (2000)


Russel-Smith et al. (in preparation)

Vos et al. (Eds.) (2000)

Final technical reports of projects R 7490 and R 7503
2. DEVELOPMENT CONTEXT FOR A COMBINED APPROACH TO INTEGRATED PEST AND SOIL FERTILITY MANAGEMENT

2.1. Justification

The initiative to study the integration of pest management and soil fertility improvements came about for a number of reasons. These include the outputs from CPP projects that have shown a relationship between host vigour as influenced by soil fertility and susceptibility to pest damage. However, there is often a tendency towards the polarisation of research on soil fertility management and crop protection. Such polarisation is increasingly recognised as being inappropriate in supporting the needs of resource poor, smallholder farmers who, in practise, carefully integrate the management of pests and soil fertility. The majority of formal and informal agricultural support structures, including research and extension and broader rural development policies, are discipline-derived, often inflexibly so, requiring new combined approaches to address these issues in a truly integrated way.

Intermediate and low-input agricultural systems rely on the continuing function of the soil microbial community and its relationship with organic matter to maintain the integrity of the agro-ecosystem. However, this aspect of sustainability is rarely explicitly addressed in research 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 agricultural biodiversity is treated as a ‘black box’ in agricultural research and development projects. However, the efficient functioning of soil systems is implicit in the claims made for many 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, poor soil fertility and pests, with a lack of access to the knowledge required to address these. At the same time, soil scientists have become aware of the potential for participatory approaches to work with farmers to understand the nature of soils and the value of particular fertility amendments and cultural practices.

This creates a requirement for these aspects to be addressed simultaneously in an integrated crop management approach, and to make this knowledge available to farmers in an appropriate form. Participatory processes strengthen linkages between farmers, extensionists and resource persons/researchers, and enable farmers to influence research agendas.

2.2. Links to donor and Crop Protection Programme-specific objectives

DFID has a central focus on policies and practices that promote sustainable livelihoods and lead towards the elimination of poverty. Within the framework for sustainable rural livelihoods adopted by DFID, there is also a requirement to consider the basis of the particular target group’s livelihoods holistically rather than sectorally. This entails consideration of the different types of capital assets of the farmers concerned and how these influence the processes and feasibility of the approach, and how the capital assets are themselves influenced by the research processes involved. The theme of integrated pest and soil fertility management clearly directly relates to natural capital (sustainability of production, soil fertility etc), but there are strong interactions with human capital issues (enhancing farmer skills and knowledge, human nutrition and health) and potentially with social capital through learning groups. The relative costs of inputs should also be considered within the financial capital context, and their availability and logistics for their use within the physical capital context.

In order to impact within the Renewable Natural Resources Research Strategy (RNRRS) of DFID, achievement of objectives must be time-bound and linked to the Programme purpose. The time-bound nature of the RNRRS creates a demand for phasing of research projects that build on existing knowledge and establish the underlying science within realistic time frames to deliver rapid development impact at farmer level. In order to ensure that the programmes will have the desired impact on livelihoods, the cost implications of requisite local demand studies and socio-economic inputs must also be taken into account in research planning.

2.3. Demand and uptake

Projects need to address appropriate uptake pathways and areas required for external support to achieve successful dissemination via these mechanisms. The process of upstream to adaptive research needs to be established as demand-led for each system considered, by including exploratory surveys as necessary in production areas prior to actual implementation of research. The preferred model is for farmers themselves to participate in identification of
needs and research priorities in relation to their particular circumstances and drawing on their own indigenous knowledge. The use of participatory learning schemes such as farmer field schools also allows scope for needs identified through training and experiential learning programmes to drive the research process, and for use of participatory research processes to address these. There is a need for phasing of projects (inception, research and dissemination) so that outputs from one study catalyse the subsequent work to establish underlying mechanisms and verify these for different systems.

2.4. Implementation approach

Although there has been much research on different cultural practices, the effects of those primarily designed to improve soil fertility on pest incidence and damage are generally poorly understood. The methods required for such studies are in themselves complex and require multi-disciplinary input to ensure that the integration of pest and soil fertility management is retained. The systems are complicated, particularly where less-defined soil amendments are used, as are the research approaches used which can range from replicated experiments to extensive paired comparisons. There is thus a strong need for biometrics inputs in programme design and analysis of results. Given the large influence of micro-environment and micro-ecology, there is a need for validation over both areas and seasons.

Given the strong emphasis on field-based systems experimentation and farmer involvement, consideration should be given to research approaches which directly involve farmers as researchers in their own right, rather than just the use of on-farm trials. This would immediately increase research impact and facilitate dissemination. Identification of target groups and beneficiaries should take account of the poverty elimination agenda of DFID and the impact (whether positive or negative) on women should be particularly considered. Documentation and information dissemination will be an essential part of such research programmes and there is a particular need in this context to consider dissemination outside the scientific literature, and processes that lead towards participatory learning exercises and extension materials.

2.5. Sustainability

This research strategy needs to provide a basis to assist the development of institutional policies, which support the integration of pest and soil fertility management considerations. Capacity and knowledge building at all levels need to be integral parts of the research process in order to ensure the sustainability of the approach. Environmental impacts of the work are likely to be almost entirely positive as much of the focus is on sustainability of farming systems and reducing agrochemical inputs. The sustainability of research processes requires consideration. This includes issues of how to maintain farmer participatory research processes and farmer-to-farmer knowledge-transfer systems. Sustainable livelihoods issues also require full consideration (see donor objectives above).
3. RESEARCHABLE AREAS

The studies and the joint workshop determined that integrated pest and soil fertility management offers considerable potential for collaborative research and development, and that this is likely to achieve sustainable impacts in improving the livelihoods of resource-poor farming families in sub-Saharan Africa. In particular, the integrated approach can respond to the needs of farmers cultivating soils of poor or declining fertility by reducing losses to pests, and by improving the range of integrated crop production options available to farmers with limited access to external inputs.

Four research areas for a future research agenda in integrated pest and soil fertility management have been identified. While not mutually exclusive, these represent research areas within which the development and use of new knowledge can be co-ordinated within an overall ‘integrated pest and soil fertility management’ theme. The four research areas are:

1. Investigating the effects of organic amendments on soil pests and beneficials
2. Investigating the effects of cultural practices on the inter-relationships between soil fertility and pests and beneficials
3. Reducing crop losses to pests through soil fertility management to improve plant condition
4. Determining the effects and implications of agro-chemical usage on soil organisms and productivity

It is recognised that, given the integrated nature of the theme, many specific research projects or interventions are likely to involve more than one of these research areas. Research projects may also require to adapt new techniques and methods to observe and measure the mechanisms involved, such as the development and implementation of farmer participatory training and research methods, and adapt / develop statistical techniques to cope with interactions.

3.1. Investigating the effects of organic amendments on soil pests and beneficials

This research area is targeted on improving management of soil pests and beneficials through the use of organic amendments. Organic amendments to soil include a wide range of plant and animal substances such as animal manures (including liquid manures, urine etc.), green manures, composts and mulches. Amendments are widely used by farmers to maintain soil fertility, but a further important role is in the management of soil pests (including weeds) both through suppression of harmful soil organisms and the promotion of beneficial soil organisms. The use of organic amendments to manage soil pests is inextricably linked with soil fertility management since many

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2 The term pests is used throughout to include insect pests, diseases and weeds
3 The term soil fertility is used throughout to include all soil characteristics that contribute to system productivity, including the nutrient, water, physical and biological status
amendments are used simultaneously to improve soil nutrient status or soil physical conditions (e.g. manipulation of water-holding properties).

Organic amendments are particularly important to resource-poor farmers. However, it is important to recognise that the availability of appropriate organic materials is also a severe constraint on poor farmers. Important considerations include the amount, quality, and timing of availability of organic amendments and the labour requirements, gender-specific roles, and costs associated with collection and use organic amendments. Research should therefore be focused upon strategies which can be adopted by target groups, and should not rely upon high rates of application or types of amendments which are not available to farmers.

Organic amendments may act to control soil pests directly through modification of the soil chemical, physical or biological habitat or indirectly through the impacts on biological control agents, including the effects of organic matter amendments on competition between soil biota and antagonistic effects on soil borne pests. In particular the soil biota may be influenced by the chemical composition (often termed the resource quality) of the organic inputs. Specific chemical components such as lignins, polyphenols or alkaloids have been shown to influence the rate of nutrient release through their regulatory effect on the decomposer organisms, and are also known to be active against many pests.

Research has started to highlight the important roles of organic amendments on some specific soil pests such as bean root rots and tomato nematodes. There has been more limited research on the effects on beneficials (e.g. Rhizobium and mycorrhiza) and much less focus on the interactions between soil pests and beneficials. Some specific examples of reported beneficial effects of organic amendments on soil pests include:

- green manures (e.g. Crotalaria, Desmodium) for Striga control on maize and sorghum
- use of compost on biological control of nematodes in vegetables
- control of nematodes using chicken, pigeon, and pig manures on tomato and other crops

Organic amendments may however also lead to increased soil pest problems, for example, through the proliferation of weed seeds spread in animal dung or transmission of crop diseases through the used of infected crop residues. Both positive and negative interactions remain generally poorly understood, and there is a need to improve farmers ability to optimise the soil fertility management and pest management roles of organic amendments.

Research is required to investigate the mechanisms by which organic amendments influence soil biota (including pests and beneficials), as well as ways to manipulate such mechanisms, to identify opportunities for farmers to better manage soil pests.
Work in Ghana would need to concentrate on vegetable crops; there is little present use of organic amendments on field crops in Ghana, with the exception of poultry manure on maize in some areas. Links with programmes on use of composted urban wastes and poultry manure are particularly pertinent. Relevant partners include Kumasi Metropolitan Assembly (KMA), CRI, GOAN, KNUST and TSBF.

In E Africa, there is scope for more work with animal manures on a variety of crops and consideration of different manures as well as other amendments. There are useful links here with livestock research, particularly in Kenya and Uganda and relevant partner organisations include ILRI, KARI, AHI and TSBF. In both cases there is scope for examination of the impact of green manures also.

3.2. Investigating the effects of cultural practices on the inter-relationships between soil fertility and pests and beneficials

The focus of this research area is the optimising of effects of cultural practices to improve the management of both pests and soil fertility. Cultural practices are used by farmers in the management of both soil fertility and pests. The practices are numerous and wide-ranging but include: choice of variety; crop rotation; water management (irrigation, drainage, mulching, ridging, weeding etc.); mulching (which may often also be an organic soil amendment); pruning, thinning and rogueing; mixed-farming practices; intercropping (including trap cropping), crop residue removal/management, tillage (ploughing, harrowing etc.), solarisation, burning, fallowing, and agroforestry. Cultural practices, as organic amendments which form a specific set of cultural practices (addressed in preceding section 1), are particularly important to resource-poor farmers with restricted access to external inputs for pest control. The specific practices of fertilisation or application of agro-chemicals are addressed in below sections 3 and 4.

Some examples of cultural practices and interrelationships between soil fertility and pest management include:

- burning of rice straw which helps control stem borer but reduces soil fertility
- ridging and earthing-up are used for improving soil fertility and control of soil insect pests (tuber moths and weevils) in Irish and sweet potato
- use of cover crops and manures to manage weeds and improve soil fertility in various production systems
- rotation of tomatoes and beans to control nematodes and maintain soil fertility
- use of sub-soil in vegetable nursery beds which avoids diseases but reduces soil fertility
- fallowing to reduce pests and improve soil fertility for various crops

Although extensive research has been undertaken on many cultural practices, the inter-relationships between soil fertility and pest management through cultural practices are generally poorly understood. In the past, research
efforts have largely focused on the development and promotion of cultural techniques for either soil fertility management or pest management. Impacts on the soil biota have generally been confined to specific pest or beneficial species and little consideration has been given to the potential for managing the interactions between key functional groups of the soil biota. Research is required which specifically focuses on inter-relationships, for example, where, when and how these occur, and to develop optimal strategies that balance soil fertility and pest management goals. It is expected that improved strategies will be highly location-specific and priority should be given to research with farmers participation, on farmers’ fields if possible, building upon available indigenous technical knowledge (ITK).

In Ghana, soil-borne pathogens and nematodes are key constraints to vegetable production and relevant management practices include crop rotations, green manure incorporation, cover cropping, crop choice, etc. Several such interventions are already being promoted by GTZ and NRSP projects in the Brong Ahafo and Kumasi areas. Enhancement of nematode biocontrol may be of particular relevance here.

In E Africa, in addition to vegetable crop pests as for Ghana, principal targets include the complex interactions between banana mulches and habitat preferences for weevils, suppression of nematodes, tolerance to foliar pathogens and susceptibility to matooke wilt.

3.3. Reducing crop losses to pests through soil fertility management to improve plant condition

An important set of interactions between soil fertility and pests occurs through the impacts of soil fertility and its management on plant condition, which influences the ability of plants to resist or tolerate pests. These include those relationships that arise due to effects of soil fertility on plant properties or functions such as vigour, nutrient balance, secondary products and morphology. The interactions occur due to effects of management on soil chemical, physical or biological fertility and may occur during crop growth, or post-harvest. Interactions may well occur across several trophic levels.

In general there is limited understanding of the specific mechanisms which affect pest pressure and crop tolerance through interactions between soil fertility and pests, and both positive and negative interactions are poorly documented. There is a need to validate and build upon indigenous knowledge in this area, and to undertake targeted research on the effects and mechanisms of interactions.

Some of the pests which are known to be influenced by soil fertility, and where manipulation of such interactions through the plant are likely to be important components of crop protection strategies, include:

- stem maggot/root rot complex of beans reduced through improved soil fertility
- weevil and nematodes of bananas managed through improved soil fertility
• *striga* of maize managed through improved soil fertility
• aphids on vegetables and citrus managed through balanced nitrogen fertilisation
• bacterial wilt on solanaceous crops reduced through improved soil structure / drainage

Interactions between soil fertility and pests, and between the management of soils and pests, through the modification of crop condition is generally a complex and under-researched area. This applies particularly in the case of smallholder farming systems in developing countries, although there is a body of research evolving in response to perceived pest problems in areas with problems of soil fertility decline associated with increasing intensification of agriculture (e.g. the East African Highlands). Such intensification can reduce the temporal buffering effects of fallowing and rotations and the physico/chemical buffering of organic matter, and increase the seriousness of negative pest/fertility interactions.

### 3.4. Determining the effects and implications of agro-chemical usage on soil organisms and productivity

This research area aims at managing the effects of agro-chemicals on soil organisms and productivity. The use of agro-chemicals (synthetic fertilisers, herbicides, fungicides, insecticides, nematicides etc.) is now recognised to have a wide range of positive and negative influences on soil biota and soil fertility. In addition, there is a conflict between short-term yield gains associated with the use of (novel) crop protection chemicals and a potential longer term damage to productivity associated with side effects on soil organisms. The impacts on soil organisms are of critical importance but remain poorly understood. Some of the soil processes, or properties that are influenced through the impacts of agro-chemicals, include: decomposition and mineralisation, nitrogen fixation, phosphorus capture, soil pH, and predation.

Although some effects are well documented, in general the interactions are very poorly researched. Research and development imperatives should include:

• identify cropping systems with actual/potential agrochemical problems
• quantify short- and long-term positive and negative effects of agrochemical use on soil processes
• develop low-cost alternatives to agro-chemicals which maximise positive and minimise negative effects on soil organisms and soil fertility

Cropping systems with (potential) problems associated with over / mis-use of agro-chemicals include banana in East Africa and vegetables in both Ghana and East Africa.

**Cross-cutting theme:**

There is a need for a review of methodologies for studying the effect of soil fertility practices on crop protection. In light of the complexity of the soil
ecosystem, it is realised that reductionist, comparison and correlation experiments all have a role to play. For example, paired comparisons and other methods have proven good alternatives to standard replicated trials or to farmers experimentation in comparing organic and conventional farming and it's effects on pest problems. In addition, participatory methods of farmer research and training should be reviewed to assess the most appropriate ways to use such approaches in combining pest and soil fertility management.
4. FRAMEWORK FOR APPROPRIATE IMPLEMENTATION

4.1. Partnerships

Activities bringing together pest and soil fertility management will by their very nature require the involvement of partnerships between individuals and organisations able to provide the necessary breadth of skills and approaches. In the developmental context of this research, appropriate partnerships will have to include expertise in participatory approaches across the research spectrum. Both for needs assessment, validation and dissemination, links should be made with on-going farmer field school (FFS) programmes both in Ghana and in East Africa and their networks of trained farmers and extensionists. In such a way, farmers can be empowered through educational tools to understand soil pests and biological processes so that they can build more sustainable livelihoods and act as environmental custodians.

While farmers by nature have a holistic perspective, researchers often do not, implying that a multi-disciplinary approach will be essential in this research. Effective partnerships in integrated pest and soil fertility management should be founded upon a stakeholder analysis and a detailed understanding of each other’s policies and priorities. Key principles for effective partnerships include: commitment to openness and communication exchange between partners, realistic time-scales and funding and genuine partnerships established from the outset. Partnerships will benefit from the extension or co-ordination of existing networks (e.g. networks concentrated on soil fertility or IPM) and collaborative pilot projects.

**Partnerships in research**

Partnerships in downstream research are likely to include farmers, FFS/farmer/community groups, churches, schools and councils, GOs, NGOs, extensionists, researchers and other resource persons (private sector), donors and regional networks. Farmer participatory research (FPR) will be a key element of the downstream research activities, in which farmers are key players in determining the agenda for research, as well as in implementing, observing and evaluating experiments.

Partnerships in upstream research may include links between IARCs and NARS, with researchers, project leaders and farmers participating in downstream projects and between IARCS. Given the huge investment and time required to develop partnerships, consideration should be given to the support of existing initiatives which have already begun to address the integration of pest and soil fertility management. Existing networks and initiatives in pest and soil fertility management include the African Highlands Initiative (AHI) and the Tropical Soil Biology and Fertility Programme (TSBF).

The AHI is an existing eco-regional effort to improve natural resources management in the eastern and central African highlands. AHI has addressed as one of two core research themes: management strategies to
protect crops from pests and diseases resulting directly from the decline in soil fertility due to intensification in land use. The initiative is an existing consortium of NARS, IARCs and NGOs working in the region and includes active IPM and soils working groups. Countries of focus include Kenya, Tanzania, Uganda which are all CPP target countries under the high-potential or hillsides production systems and others including Ethiopia and Madagascar.

The TSBF programme includes the African Network for Soil Biology and Fertility (AfNet) which brings together scientists from NARS and IARCs in Africa. Areas of activity include the integrated biological management of soil (e.g. organic matter management, the role of the soil community), improving soil biological technologies (e.g. N fixation, mycorrhiza, soil structure management and the control of pests and diseases).

**Partnerships in funding and development of the research agenda**

An initiative in integrated pest and soil fertility management offers potential for development of a joint agenda and partnership funding with a number of other programmes and agencies. These include:

- Other DFID programmes
- Other bilateral donor agencies
- Multi-lateral agencies

Research under most of the four research and potential cross-cutting areas, offer considerable scope for development of cross-programme projects with other bilateral programmes funded under DFID’s Renewable Natural Resources Research Strategy (RNRRS). The Natural Resources Systems Programme (NRSP) is the most likely partner. The NRSP has a history of funding research work in soil fertility management, and are actively involved in integrated nutrient management. The programme focuses on all six NR production systems of DFID’s natural resources research portfolio and currently is limited to activities in up to three countries per system: high potential (Kenya, Bangladesh, India), hillsides (Uganda, Nepal, Bolivia), semi-arid (Tanzania, Zimbabwe, India), forest agriculture interface (Ghana, Nepal, Brazil), land water interface (Ghana or Uganda, Bangladesh, Caribbean) and peri-urban interface (Ghana, India). Other programmes where joint activities might be appropriate include the Livestock Production Programme (LPP) (Research area 1) and the Plant Sciences Programme (PSP).

Potential linkages with multi-lateral programmes could be developed with the activities of the World Bank / other bilateral donors, and the European Union. In June 1999, the Rural Development Department of the World Bank and the Global IPM Facility held an Expert Consultation on integrated pest and soil management. The Global IPM Facility assists the development of integrated plant and pest management programmes in a range of countries, for which funding is provided by other bilateral and UN-donors, among which DGIS, DANIDA, SDC, AUSAID, UNDP, etc. The INCO DEV programme of the European Union could also potentially provide additional funding for European
organisations involved in research in integrated pest and soil fertility management with a regional project focus. The current INCO DEV call (which closes in September 1999) offers support for systems research ‘on new or improved systems for agricultural production…for marginal conditions’. It has a focus on cash crops and includes support for research on ‘cost-effective and environment-friendly pest and disease management, particularly using integrated approaches’ and ‘agricultural practices for improved production’ such as fertilisation, intercropping and crop rotation, biological nitrogen fixation and the role of mycorrhiza.

4.2. Geographic focus and extrapolation to other regions and cropping systems

This study has assessed the demand for research in integrated pest and soil fertility management in West and East Africa - the focus of the studies and the workshop. It is clear that there is a strong demand from developing country research organisations in both West and East Africa for the research agenda to develop improved linkages between pest and soil fertility management, and this is already happening in some countries.

The needs assessment exercise carried out as part of the CABI study in Ghana resulted in outputs that were, according to the joint workshop, highly transferable to the East African region and potentially elsewhere. In addition, experience in farmer field school programmes on vegetables and field crops in Asia indicate a similar need in that region, justifying further programme development studies focused on other regions. For example, in Bangladesh a study under NRSP is examining linkages between soil fertility, soil borne pests and livelihood sustainability. In Eastern India, a rainfed farming systems project in resource-poor areas, supported by DfID, showed a clear need to address soil fertility improvement and pest management in tandem, particularly in solanaceous crops. In Vietnam, a DGIS/AUSAID funded farmer field school programme conducted a special farmer participatory study on the impact of compost as a soil amendment on soil-borne diseases in vegetables, following specific IPM farmers requests for such an initiative.
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