# 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

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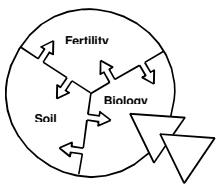
CABI Bioscience/ Natural Resources Institute (NRI)

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## ACKNOWLEDGEMENT

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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 NRInternational. 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***

## ANNEX 2. Workshop opening address: Dr Sarah Simons, CABI-Africa Regional Centre

**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 NRInternational.

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.

Insert presentation

## 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.

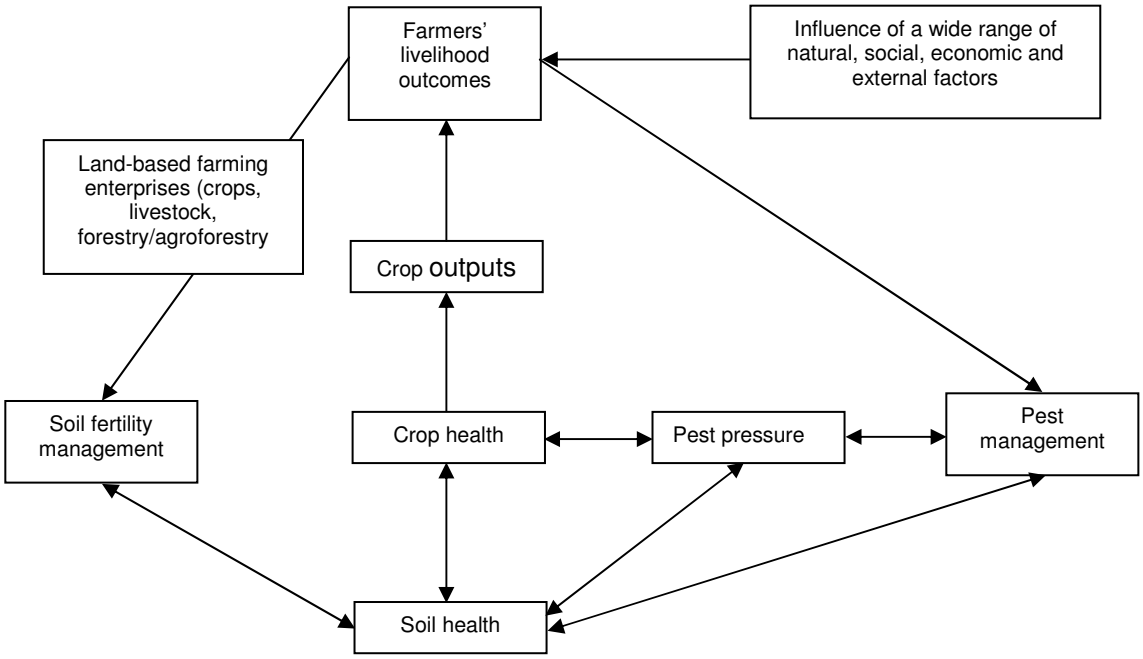


Figure 1. Simplified diagram identifying key linkages between pest and soil fertility management, and farmers' livelihoods

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.

| Treatment | BSM infestation / dead plant | % Plant mortality due to BSM | Yield / plot |
|---|---|---|---|
| Chemical seed dressing | 2.6 a | 7.9 ab | 573.9 ab |
| 1/2 DAP + ½ FYM | 2.2 a | 4.6 bc | 840.0 a |
| Earthing up | 2.0 a | 12.7 a | 341.6 b |
| Mulch | 2.3 a | 7.8 ab | 323.6 b |
| Control | 4.0 a | 11.8 a | 490.5 b |
| $LSD_{(0.05)}$ | 2.1 | 5.6 | 272.8 |

(after Ogecha, J. 1999[1])

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-

[1] Ogecha, J. 1999. Participatory development of IPM for bean stem maggot in western Kenya. Annual Report, Project IP-2: Meeting demand for beans in sub-Saharan Africa in sustainable ways. CIAT 1999.

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.

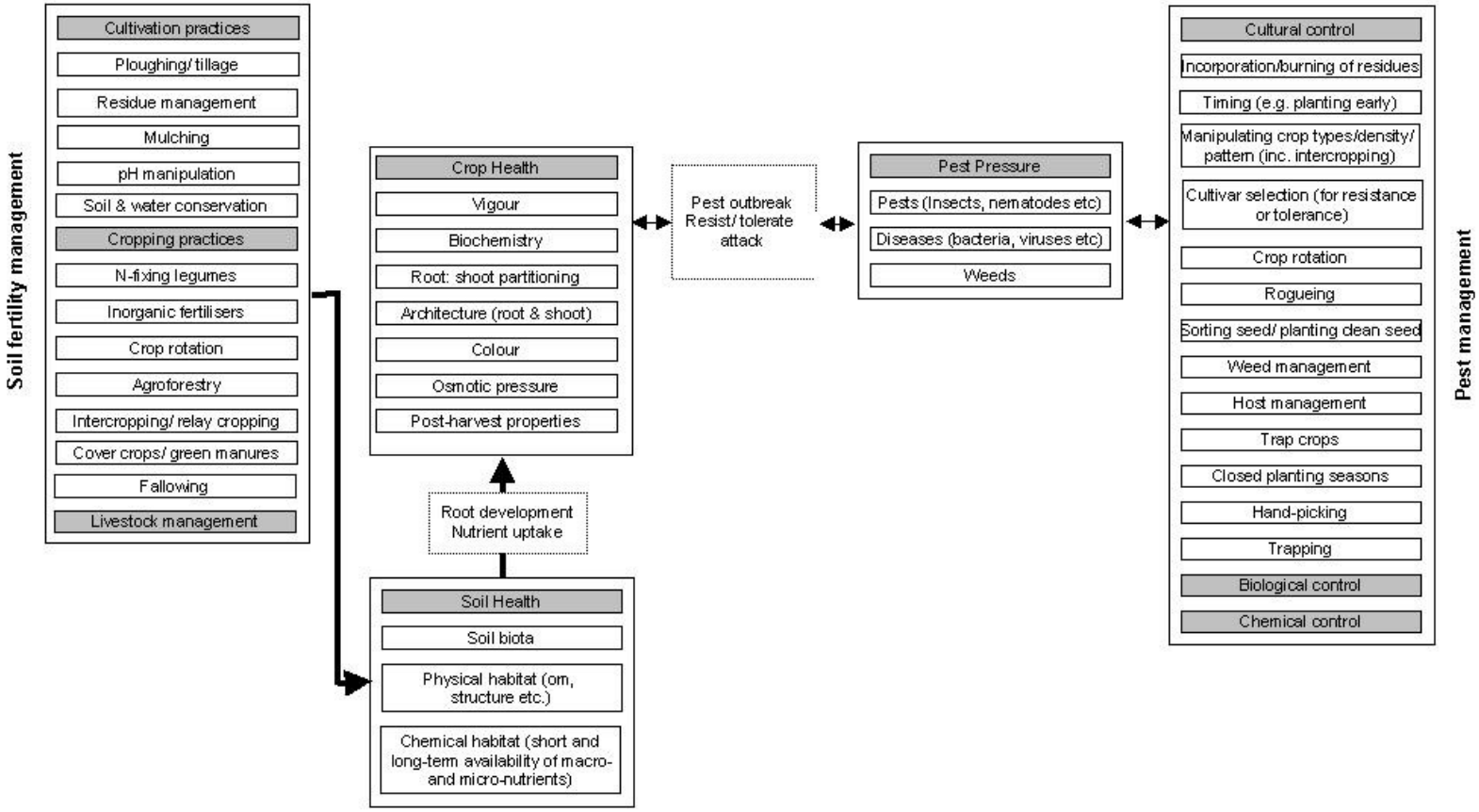


Figure 2. Crop health mediated interactions between soil fertility management and pest management

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.

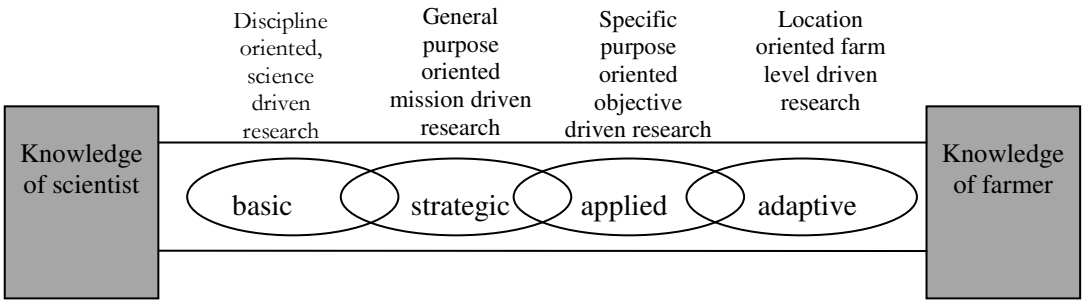


Figure 3. Adapted from Greenland *et al.* (1994[2])

**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.

[2] Greenland, D. 1994. *Soil, water and nutrient management research - A new agenda*. IBSRAM position paper

## 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

<u>Lack of holistic approach</u>
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.

<u>Complexity of experimental design to study interactions</u>
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 studies 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/cop 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.

<u>Different types of research collect different types of data</u>

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 vegtable 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 | SACDEP |
| AHI | NARO | CIMMYT |

| | | |
|---|---|---|
| UNDP | FARMESA | LOCAL |
| FAO | ICIPE | NGOS |
| CABI-ARC | ICRAF | PELUM |
| CARE | ASARECA | RELMA |
| ABLH | Universities | Plan-Int. |
| CIAT | IBPGRI | IFAD |
| Min of Agriculture | IITA | ARF |
| | CRI - CSIR | |

## 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*SFM

**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

| Research | Training | Policy | Methodology | Partnerships | Crosscutting |
|---|---|---|---|---|---|
| Xxxxx | xxx | X | xxxx | xxxx | - |
| 1. Some work done on pests (e.g. bean rot)<br>2. Limited work on beneficials (Rhizobium, mycorrhyza)<br>3. Very limited work on pest/beneficials interaction (mechanisms) | 1. Capacity building of scientists<br>2. Dissemination and capacity building (farmers, extensionists – PTD)<br>3. Awareness / knowledge | 1. Government can work behind institutions<br>2. Effective and appropriate technologies need to be developed and quantified | 1. Recommendations should aim at options<br>2. Efficient methods to determine effects of organic amendments on pests, beneficials and interactions<br>3. Support for research facilities<br>4. Multidisciplinary approaches<br>5. Participatory approaches (inc. FFS) | 1. Identify and involve relevant stakeholders<br>2. Multi-disciplinary/participatory team approaches | 1. Beneficiaries: All stakeholders at various levels. e.g. scientists, farmers, extensionists and policy makers<br>2. Gender: technology should provide options<br>3. Documentation: Applicable for all categories<br>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

| **Research** | **Training** | **Policy** | **Methodology** | **Partnerships** | **Crosscutting** |
|---|---|---|---|---|---|
| xxxxx | xx | x | xxx | Xxx | - |
| 1. To be done with farmers, on farmers fields where possible<br>2. ITK compilation and validation<br>3. Investigate inter-relationships (where, when how) | 1. Development of appropriate curricula<br>2. Develop methodologies for training e.g. trainers, farmers etc.<br>3. Methodologies for researchers (scientists, extensionists and farmers) | Examples: burning of rice straw; bush burning; ban on intercropping in coffee | 1. Novel techniques needed to look at inter-relationships, including design of studies and methods for economic evaluation | 1. Multi-disciplines<br>2. Wide spectrum of research requires inputs from NGOs, GOs, CBOs, IARCs etc. | 1. Beneficiaries: Resource-poor farmers as prime beneficiaries. Other beneficiaries are extension (NGOs, CBOs and GOs); researchers and research managers; policy makers<br>2. Gender: Special attention to role of women in cultural practices; no social categories should be disadvantaged<br>3. Documentation: Needed for all beneficiaries (different forms)<br>4. Impact assessment: Regularly (monitoring); farmers must be involved; environmental, social, economic, political impact need assessment. |

Group C: Inter-relation of SFM, plant condition* and pest damage

*includes vigour, nutrient balance, secondary products and morphology

| Research | Training | Policy | Methodology | Partnerships | Crosscutting |
|---|---|---|---|---|---|
| xxxxx | xxxx | xx | Xxx | xxxx | - |
| Limited knowledge, especially ,<br>1. mechanisms of crop tolerance and pest pressure<br>2. Negative effects are less well known<br>3. Across trophic levels<br>ITK<br>1. Validation<br>2. Good entry point<br>Fertilisers (inorganic and organic)<br>1. Quality, quantity, timing and placement | 1. Scientists- Awareness and Appreciation of general principles<br>2. Field level<br>3. End users<br>4. Farmers knowledge | 1. Education – curricula<br>2. Support of farmer participation<br>3. Inputs – use, cost, availability<br>4. Institutional change to facilitate IPM*SFM<br>5. Institutional policy | 1. FFS<br>2. Mechanisms (basic research)<br>3. ITK documentation<br>4. Conventional trials<br>5. Building on existing IPM and SFM trials | 1. multi-disciplinary (individuals, departments and institutions)<br>2. The usual partnerships, but particularly important for this topic<br>3. Include policy makers | 1. Beneficiaries - poor farmers, cheaper/available inputs, reduce pest control costs especially for poor farmers on degraded soils with high pest problems<br>2. Important<br>3. Important for all<br>4. Impact assessment – to include livelihoods and environmental |

Group D: Effect of agrochemicals on soil organisms and soil fertility

| | **Fertilisers** | **Herbicides** | **Fungicides** | **Insecticides** | **Nematicides** |
|---|---|---|---|---|---|
| **Processes +ve** | Decomposition and mineralisation<br>Nitrogen fixation<br>Phosphorus capture<br>Nutrient balance | | | | N fixation<br>Nutrient balance? |
| **Processes -ve** | Decomposition and mineralisation<br>Nitrogen fixation<br>Phosphorus capture<br>Nutrient balance<br>Soil pH<br>Physical characteristics | Decomposition and mineralisation<br>Soil pH | Decomposition<br>P capture<br>Nutrient balance?<br>Predation | Decomposition<br>Physical characteristics<br>Nutrient balance?<br>Predation | Decomposition<br>Predation |

| **Research** | **Training** | **Policy** | **Methodology** | **Partnerships** | **Crosscutting** |
|---|---|---|---|---|---|
| xxxx | xxxxx | xxxxx | xxxx | xxxxx | - |
| Some effects documented<br>Interactions very poorly researched<br>Research and development imperatives include:<br>1. Identify cropping systems with actual/potential agrochemical problems<br>2. Quantify positive and negative effects of agrochemical use on soil processes<br>3. Develop low-cost alternatives to agrochemicals which maximise positive and minimise negative effects on SF and pest management | Inter-disciplinarity / participatory methods<br><br>Researchers, extensionists, farmers | Registration<br><br>Supply<br><br>Safety | Interactions<br><br>Research methods<br><br>Participation | Stakeholders<br><br>Multidisciplinary partnerships<br><br>Institutions | Beneficiaries<br>Gender relevance requires careful consideration<br>Documentation - Little currently available for regions/ crops<br>Impact – productivity, food security, living standard, health, environment, empowerment |

## 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 $N_2$-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):

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

*Organisers - Mike Swift, Kwasi Ampofu, Janny Vos, John Butterworth

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