Annex 1

Planning Workshop On The Development And Implementation Of Improved Forecasting And Novel Control Methods for Armyworm in Tanzania

Report of a Workshop held at
Eastern and Southern Africa Management Institute,
Arusha,
Tanzania

9th - 11th October, 2001

Acknowledgements

This workshop report is an output from 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. R7954, R7966, Crop Protection Research Programme. The Ministry of Agriculture of Tanzania invited the project staff to hold the workshop and gave its support to the endeavour. The workshop was facilitated by Dr Jon Knight, Imperial College, UK, and was organised by Pest Control Services, Tanzania, and CAB International Africa Regional Centre, Kenya.

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EXECUTIVE SUMMARY

A three-day problem specification and planning workshop was held at Arusha, Tanzania, from 9th to 11th October 2001. 22 participants attended the workshop, representing farmers, District Agricultural Officers, chemical suppliers, extension officers and various Government departments such as pesticide registration and district management. There were also scientists from Kenya and the U.K.

The main aim of the workshop was to explore the current state of armyworm control with regard to forecasting and the control methods used. This information was then used to develop appropriate plans, a) for the testing and introduction of novel control methods such as the use of nuclear polyhedrosis virus and b) for the further development of existing forecasting methods for the early warning of armyworm outbreaks. The body of the report describes the workshop process and the gives details of the discussions which took place and the ideas which emerged.

Context for the workshop was provided by two technical presentations, one on forecasting and one on novel methods for control. The current intentions of the two projects on these topics were also summarised and it was stressed that the activities of the projects would be reviewed in the light of the workshop.

A role-playing game proved effective in engaging all workshop participants in the possible problems faced by the farmer in making decisions about armyworm monitoring and control and whether to alter their behaviour on receipt of an armyworm outbreak forecast.

Brainstorming was used to identify key variables affecting all aspects of armyworm management. Trends in these variables over the last 30 years were estimated. There was perceived to be a decline in information flow for armyworm forecasting as well as devolution in decision-making and a decline in subsidies. There was also thought to be a trend towards larger farms and towards increased knowledge of armyworm by farmers, though very few farmers were thought to be able to recognise the early stages of armyworm larvae. For pesticide application, there was perceived to be a trend towards replacement of HV application technology with both ULV and LV. OP's and pyrethroids were the main agents thought to be sold for armyworm control. Availability of products such as neem was thought to be very limited.

The occurrence of armyworm outbreaks was examined in relation to the cycle of activities over the farming year. It was very apparent that large regional differences occur. The response of the farmer to armyworm outbreaks may be strongly influenced by geographical zone. For example, in some places, replanting may be possible following armyworm attack whilst in others it may not.

Policy implementers, forecasters and trap operators, agricultural and extension officers, and farmers gathered as separate groups to consider their objectives and constraints. Some common themes emerged. Information often did not reach farmers in time for them

to take action. Costs of some pesticides were high and in short supply during outbreaks. Lack of funding at all levels severely limits the ability of national and local government to offer support to farmers. Farmers tend not to budget for uncertain events like armyworm outbreaks. Some farmers lack both access to extension officers and the resources to treat armyworm infestations.

Alternatives to the current model for the operation of the armyworm forecasting service were considered. The National (current) model offers a single point of contact for everyone from the Minister of Agriculture to the farmer as well a more comprehensive forecast that can take advantage of country-wide trap information and satellite data. It is prepared by highly experienced staff using a centrally maintained historical database as a key resource, allowing continued improvements in forecasting. The national model is easy to administer with limited training implications.

The National model was compared with proposals for District and Community models in which the responsibility for day to day forecasting operations is devolved to different degrees. The Community Model is expected to overcome most communication difficulties because the forecast would be made by the same community that uses it. Increased ownership by the farmers and a good fit with present policy for farmer-led approaches are other advantages. The District model devolves forecasting to the districts. This would give clear responsibility for forecasting to the district office, and have fewer training implications than the Community model.

Appropriate approaches to novel control methods were explored by considering the benefits and constraints of different controls and application technologies that might pertain to three categories of farmers with different levels of resources. The type of formulation required was thought likely to be determined by any application equipment already available. Cash crop farmers were thought particularly likely to make use of NPV in LV or ULV formulations. The smallholder cereal farmers with fewest resources would probably not have any equipment or, indeed ability to buy pesticides. The idea of granular formulations of NPV was raised as an interesting possibility.

Following the workshop, a socioeconmic survey is planned and the workshop helped to define the issues it should address. In particular, the need to examine the feasibility of community-based forecasting, motivation to control armyworm in the context of the farmers other problems, and resources available to different groups of farmers to carry out control should be examined.

INTRODUCTION

Armyworm (*Spodoptera exempta*) is an important problem in several countries in east and southern Africa. Its special biological characteristics make it one of the most difficult pests that the farmer has to face. From the perspective of the farmer it may appear to come from nowhere and so strike with little warning. Outbreaks are also very patchy, so one district or ward may be affected whilst an adjacent locality may not. The larvae can occur at very high densities when damage to crops and grazing can be devastating. The armyworm problem poses challenges that are not simply technical but political, social and economic. It is for this reason that this workshop was important as a means to consider the armyworm problem as a whole.

The United Kingdom Department for International Development (DFID) is funding research on armyworm because it recognises the importance of this and other migrant pests for agricultural communities and the livelihoods of people on this continent. DFID has sought to support the long-standing efforts of armyworm management programmes in the region and recognises the valuable work that the Tanzanian National Programme has done. The new DFID-funded armyworm projects aim to support the Tanzanian Government and the Department of Agriculture through collaboration with Pest Control Services, District Offices and local communities. DFID’s broader objective for the projects is to improve the livelihoods of people through improved armyworm management.

This workshop was held because DFID has commissioned two research projects on armyworm, one on forecasting and one on novel approaches to control. An overview of these projects, as currently planned, will be provided later. The workshop was concerned with defining the scope of these projects, and considering changes to the projects in the light of the workshop will be an integral part of the follow-up. The workshop was designed to look at all aspects of the armyworm problem, from issues of forecasting and control technology those of funding, logistics and effective implementation. While the current projects can only address some of the problems, they can also at least draw attention to other areas of need.

Armyworm Workshop 9 – 11 October 2001

OPENING ADDRESS

United Republic of Tanzania
Ministry of Agriculture and Food Security

OPENING ADDRESS BY ZONAL DIRECTOR OF RESEARCH. MINISTRY OF AGRICULTURE AND FOOD SECURITY DURING A WORKSHOP ON IMPROVING ARMYWORM FORECASTING AND CONTROL IN TANZANIA

ARUSHA. 9 OCTOBER 2001

1. The Chairman
2. Distinguished Guest,
3. Workshop Participants
4. Ladies and Gentleman

May I, on my own behalf and on behalf of Ministry of Agriculture and food security welcome you to this important workshop on armyworm. I am informed that researchers from United Kingdom and CAB International are represented and I welcome them to Tanzania and in particular to this workshop. Special welcome goes to Natural Resources Institute Scientists, who for long time have been in the for front in developing strategies to reduce the impact of armyworm for the benefit of poor farmers.

All of you please feel at home while in Arusha, “The Geneva of Africa”.

Let me now on behalf of the government of the United Republic of Tanzania. and on my own behalf, thank the government of the United Kingdom which through its Department for International Development (DFID), facilitated all the necessary arrangements for conducting this workshops.

Mr. Chairman, each year armyworm outbreaks occur in Tanzania but the extent and severity of these outbreaks vary year after the year. Tanzania also serves as the starting point for armyworm outbreaks, which then spread to other countries in Eastern and Southern Africa. In 1999 Tanzania suffered a major outbreaks that devastated 311,000 hectares of cereal crops and range land in 20 Regions. Farmers who were late to control the infestations suffered up to 100% loss of cereal crops. Also affected were livestock keepers whose cattle died after feedings on infested grasses

Those who are devoting their time and resources to arrest the armyworm outbreaks are many and cannot be mentioned individually here. However, the British government and the institutions NRI, CAB international deserve special mention. Their efforts have restored hope to the farming community and the nation as a whole.

Mr. Chairman, the economy and livelihood of Tanzanians depend on agriculture. In an environment of unpredictable weather conditions, high costs of farm inputs, pest out breaks like armyworm, and intensive labour requirements, farming becomes a very challenging enterprise. This is what the Tanzanian farmers is confronted with, and therefore any effort directed towards improving productivity and reduce crop losses is a motivation and a great contribution to the survival of the majority of Tanzanians. This workshop will address key issues, like armyworm forecasting and control methods and I am optimistic that it will critically analyse the present situation as fundamental to a process of finding practical solutions to emerging problems.

Mr. Chairman, most farmers in Tanzania depend almost exclusively on chemical insecticides to control armyworm outbreaks. However, chemical insecticides are not environmental friendly and they are dangerous to people carrying out control operations, leave alone unaffordable prices. Most of farmers suffer great crop losses because they don’t recognise armyworm outbreaks in their crop at early stage, a best stage to effect control measures before they cause a considerable damage. Without speculating the reasons for this weakness, I leave the workshop to discuss and deliberate on how to rectify the situation.

Mr. Chairman, farming community wait with the great hope the results of NPV trials, a bioagent which causes mortality to Africa armyworm. We understand that we are very close, to realise the result from this control methods. We look forward to continue co-operation and support in this programme both by donors and relevant scientific institutions.

It is my hope Mr. Chairman that this workshop will further refine forecasting system, taking into account that most of farmers are always taken unaware by armyworm outbreaks.

WORKSHOP RATIONALE AND PROCESS

The successful implementation of innovative technologies in agricultural production depends on the quality of the technology, the extent to which it is needed and how well it fits with the existing production systems. Consequently, how key stakeholders, such as technology developers and technology users, interact is critical to any innovation process.

The purpose of this workshop was to bring together the key players involved in armyworm management, to develop an agreed strategy for improving armyworm control and to specify action plans for achieving it. The workshop focused on two aspects of armyworm control, the improvement of existing forecasting services to farmers, advisers and others, and the development of potential novel control methods such as nuclear polyhedrosis virus (NPV). These are the subject of two projects being funded by the Department for International Development (DFID) under the Crop Protection Research Programme.

An outline of the workshop process is given below (for timetable details, see Appendix 3)

In the first session, two short presentations were made to provide participants with up-to-date information covering the two DFID projects, what the current state of thinking was and how the technology may be developed.

The remainder of the workshop comprised working group and plenary sessions, involving the participation of all those attending the workshop. The process and results from these working groups are described in the following sections.

FORECASTING PROJECT

John Holt and Jon Venn, NRI; Wilfred Mushobozi, PCS

The purpose of this presentation is to provide some background to the armyworm forecasting project. The aims and objectives as they stand in the project document are outlined and the current understanding of how this might help the process of armyworm management is highlighted. It is important to emphasise that the project objectives can be altered to a degree by the workshop conclusions; any proposed alterations to the project will need to be discussed with NR International who commissioned the project on behalf of the United Kingdom Department for International Development.

The project addresses four topics, all aimed at improving armyworm management:

- Resolution & accuracy of the national forecast
- Prioritising and informing national / district control operations
- Actions based on data at levels below national
- Economic analysis & policy

Resolution & accuracy of the national forecast

It is possible to identify locations where current meteorological conditions favour outbreaks. The Meteosat satellite is used for this purpose which has a maximum possible resolution of about 7km. A meteorological risk map will be combined with armyworm catch data and knowledge of the armyworm history of each location to provide an armyworm outbreak risk map at increased resolution.

Prioritizing and informing national / district control operations

The detailed spatial armyworm risk map will be combined with high-resolution data (about 1km) on land use (potential losses, and potential impact on livelihoods). Locations of highest priority can then be identified, i.e. those with highest armyworm risk AND where impact of armyworm damage is most important.

Actions based on data at levels below national

Local forecasting will be explored. Forecasting tools will be developed whereby local groups gain directly from local trap information by being able to make armyworm management decisions on the basis of a local trap and local meteorological conditions.

Economic analysis and policy

A cost-benefit analysis of forecasting and of control will be carried out to inform policy-makers and thus provide a basis to argue for appropriate resources for control, forecasting, and information flow, e.g. trap numbers, operator training, communication equipment, pesticide supply.

Summary of the project document

The project outputs fall into five areas and to achieve each output, a set of activities is planned.

Outputs

1. Problems and research activities defined
2. Forecast of armyworm outbreak risk
3. Forecast of economic risk
4. Forecasting tools for different levels: national, district, farmer
5. Policy advice tools

Activities, Output 1

- Initial workshop
- Socio-economic survey
- Nature of new and/or improved forecasting approaches considered
- Project feedback meetings during project (mini-workshops)

Activities, Output 2

- Acquiring & processing Meteosat data
- Model of meteorological risk driven by Meteosat data
- Improvements to meteorological model
- Internet link to PCS
- Collection and storage of trap data
- Linking trap data & meteorological model

Activities, Output 3

- Compile detailed digitised land-use map
- Obtain values of agricultural production by land-use types
- Estimate potential loss due to armyworm infestations
- Maps of armyworm risk and potential loss overlayed to produce economic risk map

Activities, Output 4

- Define links and information flows between levels
- Tools appropriate and different levels - degree of autonomy at each level
- Forecasting tools implemented at different levels - initial testing
- Software, websites (national), communications (all levels)

Activities, Output 5

- Costs of forecasting and control operations: chemical, manpower, transport
- Value of such operations: reduced damage due to armyworm, impact on farmer livelihoods, political support.

Following the workshop, it is the intention to revisit each of the activities in the project document and decide whether some changes should be considered.

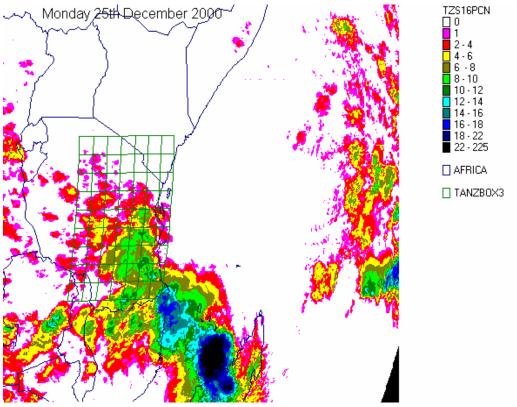
The current armyworm forecasting link between NRI and PCS

Satellite Remote Sensing

An Armyworm outbreak occurs when there is sufficient moth concentration and the necessary weather conditions. Accordingly, Pest Control Services collect moth trap data, rainfall station data and satellite remote-sensed data. This talk concentrates upon the provision of remotely sensed Meteosat data. Satellite data alone can give an estimate of meteorological risk, an indicator of the quality of the conditions for moth concentration and larval growth.

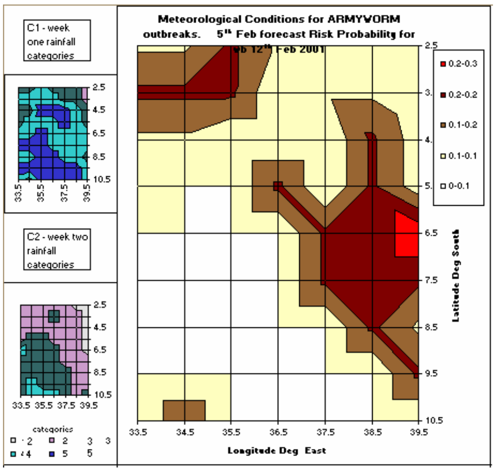
The Meteosat satellite is in geo-stationary orbit over the equator and the meridian line, so that a receiving dish in Tanzania would point to the West. Sensor sweep is from South to North, and all of the data for Africa are acquired before those for Europe. Data are received on channels for infrared, visible light and water vapour

We use the infrared channel, which is calibrated to give an instantaneous thermal record of the Earth and cloud tops scanned. A -50°C threshold is chosen to indicate rain from storm clouds. The satellite does not measure any rain unassociated with storm clouds. The sensor sweeps every half-hour and the data acquired is the number of hours that rain was recorded in a day. This is called daily Cold Cloud Duration, with values varying from 0 to 24.



These data are stored in the form of a false-colour image of the area acquired and can be displayed with coastline and political boundaries as reference. Maximum values are extracted for each degree square in central and East Tanzania. The accumulated weekly dataset is forwarded to Arusha.

Daily data are contoured, and the weekly CCD is divided into five categories:
1-“dry”, 2-“light rain”, 3-“Isolated storms”, 4-“Occasional widespread storms” and 5-“frequent widespread rain”. These categories are then also contoured and combined with the data from the previous week to give a two-week rainfall sequence. Examination of the historical Armyworm database for Tanzania shows that this is a good estimator of the risk of armyworm outbreaks during the period, October to May.



The contour chart of meteorological risk is forwarded to Arusha. Armyworm trap catch data can then be considered in conjunction with the meteorological conditions in order to reach a prognosis for the armyworm outbreak risk. This is the current state of the contribution of the remotely sensed satellite data to Armyworm forecasting for the Pest Control Service

Some possible future directions

What of the future? What changes need to be made? Are additions needed to the forecasting system for it to have a greater impact on the problem?

The resolution of the current forecast can be improved. It is already at half-degree resolution and can be finer. Is a high-resolution forecast needed for the whole region or should this just be done for local regions?

Data for forecasting is currently held in WORMBASE. The software is outdated and has limited function compared to modern alternatives. The possibility exists to use modern relational databases in conjunction with geographical information systems.

The meteorological and trap catch data could be posted to a web-site. This would be accessible to anyone with Internet access. The data could also be posted to a WAP site and be available to any WAP-enabled phone. Trap and rainfall data upload could also benefit from using the new systems. There seems to be no plans for a satellite phone system that could reach the whole country. Cellnet phone provision is concentrated only in some major towns.

NOVEL CONTROL OF ARMYWORM PROJECT

David Grzywacz (NRI, Chatham), Jenny Cory (Centre for Ecology and Hydrology Oxford) & Ken Wilson (University of Sterling)

Introduction

The idea for a project to look at novel methods for armyworm control arose from several reviews of armyworm control that took place in the early 1990's. At this time control strategy relied solely on chemical insecticides. It was found that only 30% of farmers had access to any insecticide and that high cost and lack of availability especially affected poorer rural farmers. Concern was also growing about the adverse environmental impact of a chemical-only strategy. This stimulated the search for new, more sustainable, biological controls based upon natural enemies and locally available botanicals.

Background

Nucleopolyhedrovirus or NPV is a naturally occuring disease of the African armyworm. The disease had been described by field workers as early as the 1930's though it was only identified as an NPV in the mid 1960's.

Photographs showing armyworm larvae killed by NPV in Tanzania

This NPV is specific to the African armyworm (*Spodoptera exempta*) and since it infects no other species of insect it was named *Spodoptera exempta NPV* (*SpexNPV or SeNPV*). This disease is found widely in Tanzania and Kenya during armyworm outbreak years. The NPV is rarely apparent in primary outbreaks of the pest, only appearing later in the season after which it spreads rapidly. In the later stages, 98% of outbreaks show infection and it frequently causes the collapse of later outbreaks.

The Tanzanian strain of *SpexNPV* has been safety tested following FAO/WHO recommended protocols and no evidence of toxicity in non-target hosts was found. This agrees with the findings from an extensive body of testing that NPVs do not infect vertebrates, plants or beneficial arthropods, and are thus completely safe for humans and livestock. For this reason NPVs have been recommended by FAO for controlling crop pests. Commercial NPV for Lepidoptera, including three other species of *Spodoptera* (*S.litura, S.littoralis* and *S.exigua*), are already commercially produced and used in the USA, Europe, India, Brazil, Australia and China, to control these crop pests. Trials in Tanzania in1999 confirmed that NPV, if applied at the correct time, could kill 95% of treated armyworm and that NPV deaths could still be seen in the same plots two months after treatment.

The use of neem as an insecticide has a long history in Asia and more recently in parts of Africa, including Tanzania. Neem and neem based products have attracted attention because they have been seen as safe, effective insecticides that can easily be produced in developing countries with limited technical facilities. Neem appears to have several different actions including feeding-deterrence, moulting disruption and oviposition deterrence. All parts of the plant seem to have activity, but leaf or seed extracts are the most widely used. Some initial trials have indicate that armyworm are highly susceptible to simple water extracts of neem seed at 5% w/v.

Objective of the project

The project will test, evaluate and, as appropriate, promote two new controls, a biological agent, a nucleopolyhedrovirus (NPV), and a botanical, neem, for controlling armyworm in east Africa.

Activities

The main activities that will need to be carried out to determine if neem and or NPV can be used to control armyworm successfully are as follows:

It will be necessary to carry out field trials to determine the efficacy of both NPV and neem. While both have shown promise they may both have limitations. NPV can be effective at very low quantities but does take 4-7 days to kill and is mainly active against early instars. Thus to use it effectively farmers may need to be able to scout and treat outbreaks while the larvae are still small if damage to crops is to be avoided. The great advantage of NPV is that once applied it can spread naturally both to neighbouring larvae and to later generations, and thus may provide long-term control.

Neem, on the other hand, because it is an antifeedant appears to act very quickly and is active against even large larvae. However it appears effective only at relatively high rates (20kg/ha) so that obtaining, transporting and processing the quantities needed for large areas may be both expensive and impractical. Another complication is that neem varies in activity depending on where it is grown and current evidence is that the most active neem comes from seeds grown under lowland moist conditions far from the main outbreak areas. Also, neem is very complicated chemically and not very stable once the seeds are crushed and the active ingredients extracted. Thus, neem seed extract needs to be prepared immediately before use to be effective.

Producing NPV locally on the other hand may be more straightforward. Most NPVs are produced in factories by infecting insects specially reared for NPV production. A larva, say 7 days old, is given an inoculating dose of 100-1000 NPV particles, usually on diet or leaves, then incubated. After 5-7 days the larva dies by which time the NPV has multiplied to several hundred million particles. The bodies are crushed to release the NPV and then the NPV used like any other insecticide. An application of NPV from as few as 50 larvae can be enough to treat one hectare. Such NPV factories though are costly and an alternative used widely in

Brazil is to infect natural outbreaks of insects then simply collect infected insects when they die as a source of NPV. If this could be used in Tanzania on, say, outbreaks in rangeland, it could be a very cheap production method producing NPV control at less than 1US$ per hectare.

Thus if these novel agents are to be useful then a strategy for production and provision of neem and NPV to resource poor farmers in outbreak areas of Tanzania needs to be developed and this will be an important part of the project.

In addition to studying the use of NPV as an insecticide the project intends to study in more detail the natural occurrence and spread of SpexNPV. To date, almost nothing is known of how this disease spreads and is maintained in the armyworm population. It may be that SpexNPV is an important factor in controlling armyworm populations so that understanding its occurrence may help us predict outbreaks more accurately. It is also possible that major outbreaks appear partly because SpexNPV has disappeared from most of the populations. In this case the idea of seeding primary outbreaks with SpexNPV in order to start epidemics early and so avoid damage could be a viable strategic control option.

Finally, if the novel control methods do prove viable there will be a need to identify a strategy to promote and implement novel controls in Tanzania to poor farmers. This will involve close liaison with existing control services and extension workers.

ROLE PLAYING GAME

In 4 groups, participants played a game designed to put them in the place of a farmer facing decisions concerning armyworm monitoring and control. The game creates a simplified situation in which each season a farmer receives a single forecast of either a high or low probability of an armyworm outbreak. Based on this information the farmer then decides whether to monitor his crop or not. If an outbreak occurs, the farmer can decide whether to spray or not. Both monitoring and spraying incur costs, but spraying is much more effective at reducing damage when monitoring was undertaken, as it is assumed the armyworm larvae are found while they are young and before serious damage has occurred. Seasons are either good, with a high yield, or poor with a low yield, but this is not known until the end of the season. Each season the net revenue is calculated as the potential revenue (depending on whether it was a good or bad season) minus costs (monitoring and/or spraying) minus crop loss (depending on whether monitoring and/or spraying was undertaken. The tables below give the associated values.

Crop value

Season	**Value**
Good	1000
Bad	500

Costs

Action	**Cost**
Monitoring	100
Spraying (with or without monitoring)	150

Crop loss

	Season	
Action	**Good**	**Bad**
No spraying (50% loss)	500	250
Spraying without monitoring (25%)	250	125
Spraying with monitoring (5%)	50	25

The game was played for 10 seasons, after which participants added up their total net revenue, and explained to the workshop their decision strategy and whether they found the forecast useful. After a plenary discussion the groups identified how the game differed from what the real situation might be. The results of the group work are shown below.

Group 1

Results

Year	Forecast	Monitoring costs	Outbreak	Spraying costs	Total Costs	Potential crop value	Crop loss	Final crop value
1	Low	0	No	0	0	1000	0	1000
2	High	100	Yes	150	250	500	25	225
3	Low	0	Yes	150	150	1000	250	600
4	Low	100	No	0	100	500	0	400
5	High	100	No	0	100	1000	0	900
6	Low	0	No	0	0	1000	0	1000
7	High	100	Yes	150	250	500	25	225
8	High	0	Yes	0	0	1000	500	500
9	High	100	Yes	150	250	500	25	225
10	Low	0	No	0	0	1000	0	1000
							Total	6075

Decision strategy

- Keep costs low (when forecast is low, no monitoring)
- Experience in previous year monitoring strategy
- If previous forecasts reliable reduce monitoring if forecast low
- If previous years profit low, reduce monitoring
- Forecasts helpful (if reliable)
- Disregarded forecast if previous years profit was poor

Difference from reality

- Farmers are not free to spray each year (lack of resources)
- Farmers may not have time or resources to monitor
- Very few farmers keep records so can learn from experience
- Not all farmers receive forecasts
- Farmers have own experience to help them decide if it is a good/bad year before they decide on a strategy.
- Farmers have their own criteria to decide of an outbreak is probable
- Many farmers believe armyworm years are good years

Group 2

Results

Detailed results not available, but total crop value over 10 seasons was 5975.

Decision strategy

- Always to monitor regardless of the forecast
- Always to spray when there is an outbreak
- Based on the experience we decided to continue with monitoring
- 'Historical data'/Experiences affected decisions
- Cost of information e.g. the cost of monitoring was considered low compared to the cost of losing the crop
- The forecast was not very helpful

Difference from reality

- Forecasts do not reach the farmers on time
- Monitoring is not perfect
- Spraying is too expensive so not used
- For those who spray, they do not know the right time to spray
- Farmers are victims of policy changes

Group 3

Results

Year	Forecast	Monitoring costs	Outbreak	Spraying costs	Total Costs	Potential crop value	Crop loss	Final crop value
1	Low	0	No	0	0	1000	0	1000
2	High	100	Yes	150	120	500	25	225
3	Low	0	Yes	150	150	1000	250	600
4	Low	100	No	0	100	500	0	400
5	High	0	No	0	0	1000	0	1000
6	Low	0	No	0	0	1000	0	1000
7	High	100	Yes	150	250	500	25	225
8	High	0	Yes	150	150	1000	250	600
9	High	100	Yes	150	250	500	25	225
10	Low	0	No	0	0	1000	0	1000
							Total	6275

Strategy

- Sprayed when there was outbreak
- We didn't monitor when we didn't make more than 400 in previous year
- We sprayed to avoid crop loss when there was outbreak
- We didn't believe forecasts 100%
- Forecasts guided us
- Not knowing whether it was good or bad year caused difficulties

Difference from reality

- In normal situation monitoring is necessary
- Decision to spray/monitor is made over time
- Decision is made based on costs/benefits balance
- In reality farmers don't keep records (costs incurred, produce, income)

Group 4

Results

Year	Forecast	Monitoring costs	Outbreak	Spraying costs	Total Costs	Potential crop value	Crop loss	Final crop value
1	Low	100	No	0	100	1000	0	900
2	High	100	Yes	150	250	500	25	225
3	Low	0	Yes	0	0	1000	500	500
4	Low	100	No	0	100	500	0	400
5	High	100	No	0	100	1000	0	900
6	Low	100	No	0	100	1000	0	900
7	High	100	Yes	150	250	500	25	225
8	High	100	Yes	150	250	1000	50	700
9	High	0	Yes	0	0	500	250	250
10	Low	100	No	0	100	1000	0	900
							Total	5900

Strategy

- Pre disposition toward monitoring
- When low in third year we didn't monitor and there was an outbreak so we lost
- Changed to monitoring continuously and costs covered
- When forecasting is accurate it makes sense to monitor
- In bad crop years it was best NOT to spray or monitor because that maximised crop value

Difference from reality

- All farmers are interested in meteorological forecasts
- Big farmers are more likely to monitoring and spraying: maximise profit. Whereas small farmers minimise costs so they lose
- Small farmers are usually not interested in forecasting

General Discussion

The groups showed very changeable strategies. A simple strategy of only monitoring when the forecast was high, and always spraying outbreaks would give a total return of 6375, i.e. higher than all the groups. By contrast, a strategy of do nothing, ie no monitoring and no spraying, gives a total return of 6250. This is not much less than following the forecast, and although the figures in the game are not realistic, this raises the possibility that for some farmers at least, armyworm monitoring and control maybe barely worthwhile. There is need for the socio-economic survey to determine this in more detail.

KEY ISSUES

To provide a context for the first working session on key issues, the following ideas were presented to participants.

It is important to recognise that a number of factors will influence the armyworm problem and armyworm management activities Therefore, in planning future IPM strategies, we need to be aware of these factors and the way in which they are changing over time. We need to understand where we are now, how we got here, where we would like to be in the future, and what factors we need to consider in planning how to get there.

This workshop session was designed to use the expertise of the participants to take these important factors into account in determining the key issues that need to be considered.

Two exercises were conducted, firstly looking at the development of the problem through the historical profiles. The purpose of this activity is to define the important factors in the armyworm problem including changes in forecasting and control. The purpose is to consider what has been happening over the past 30 years or so and to try and think about what may happen in the future. The factors chosen may all have some influence on the way in which the problem has developed or can be addressed.

The historical profile (Figure 1) provides limited background information on some of the important factors that need to be considered.

The second part of the exercise was looking at the events during one season and creating a seasonal profile of the activities of the armyworm and the farmers. This is useful in trying to understand the decision problems faced by farmers; for example there may be other activities that are more important to farmers than control of the armyworm. The resulting seasonal profile is shown in figure 2.

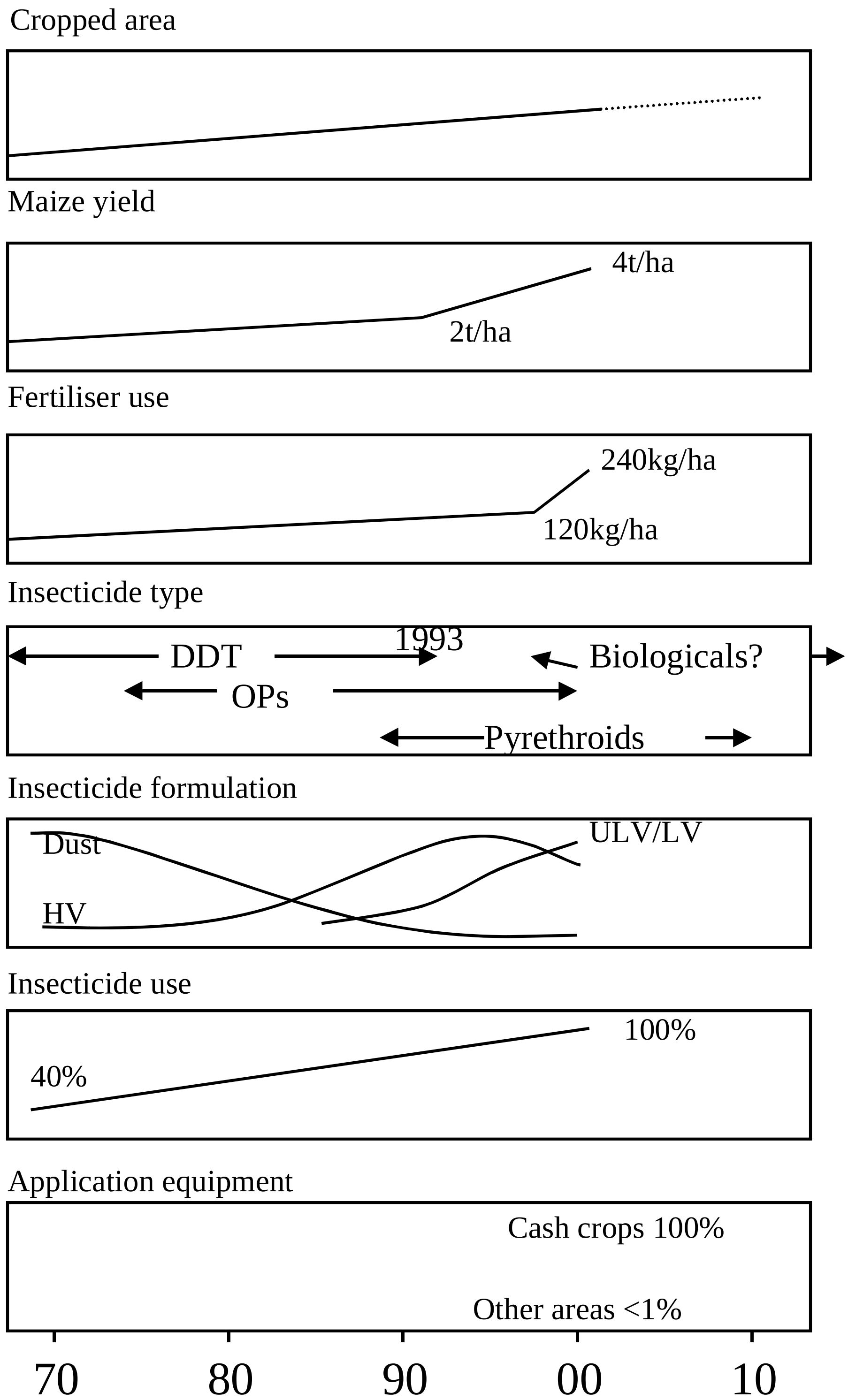


Figure 1a Historical profile for the period 1970 to 2010

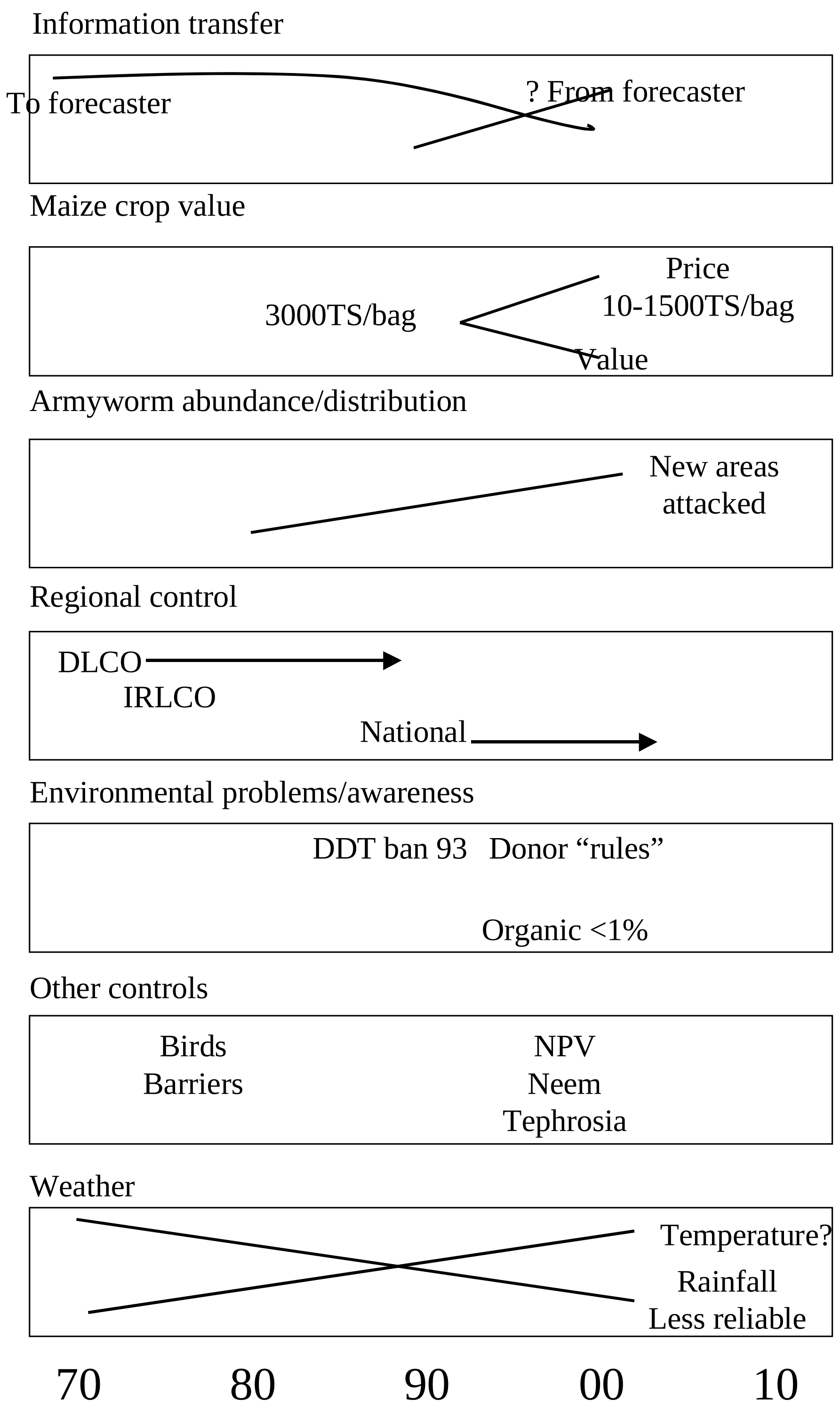


Figure 1 b Historical Profile for the period 1970 to 2010

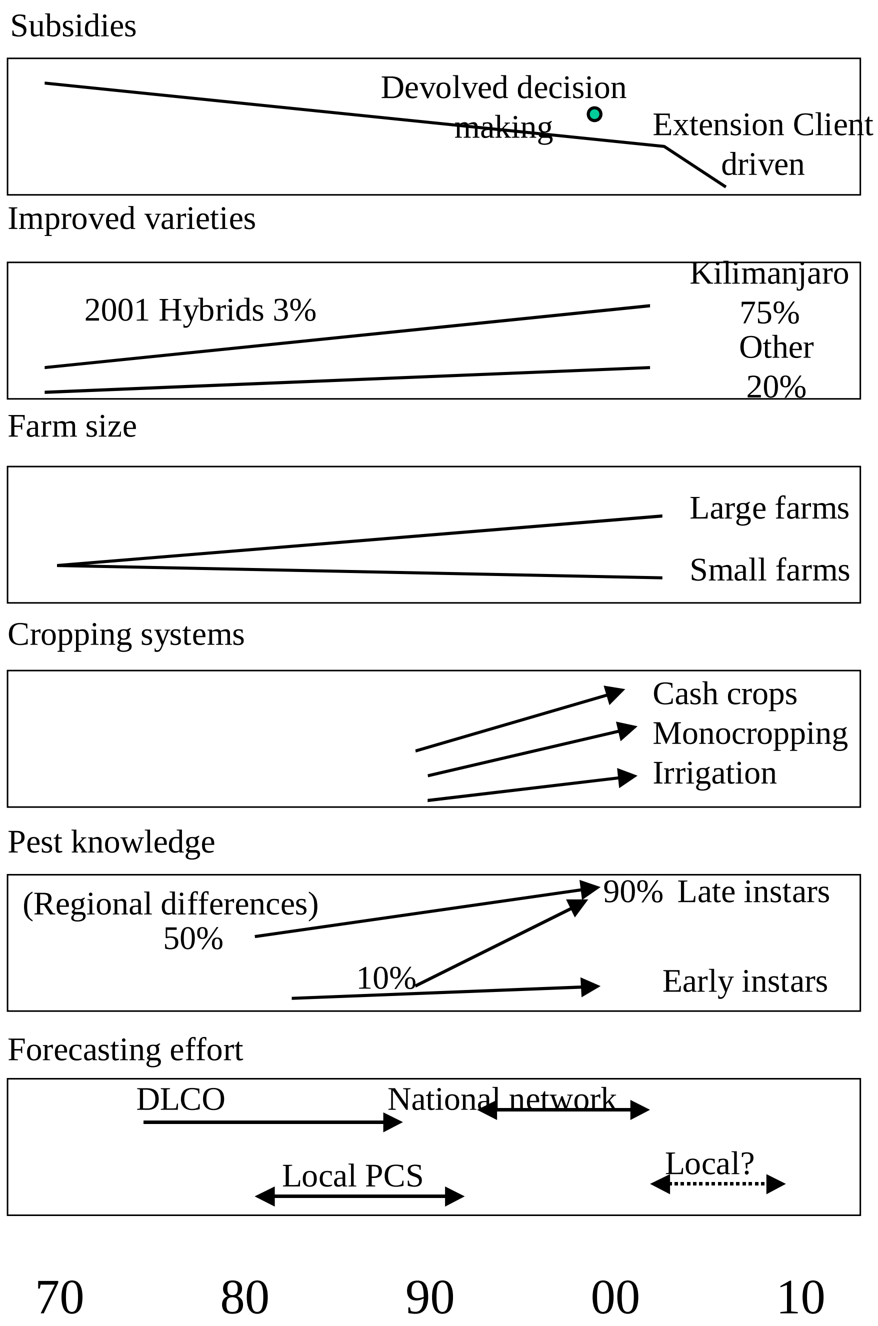


Figure 1c Historical Profile for the period 1970 to 2010

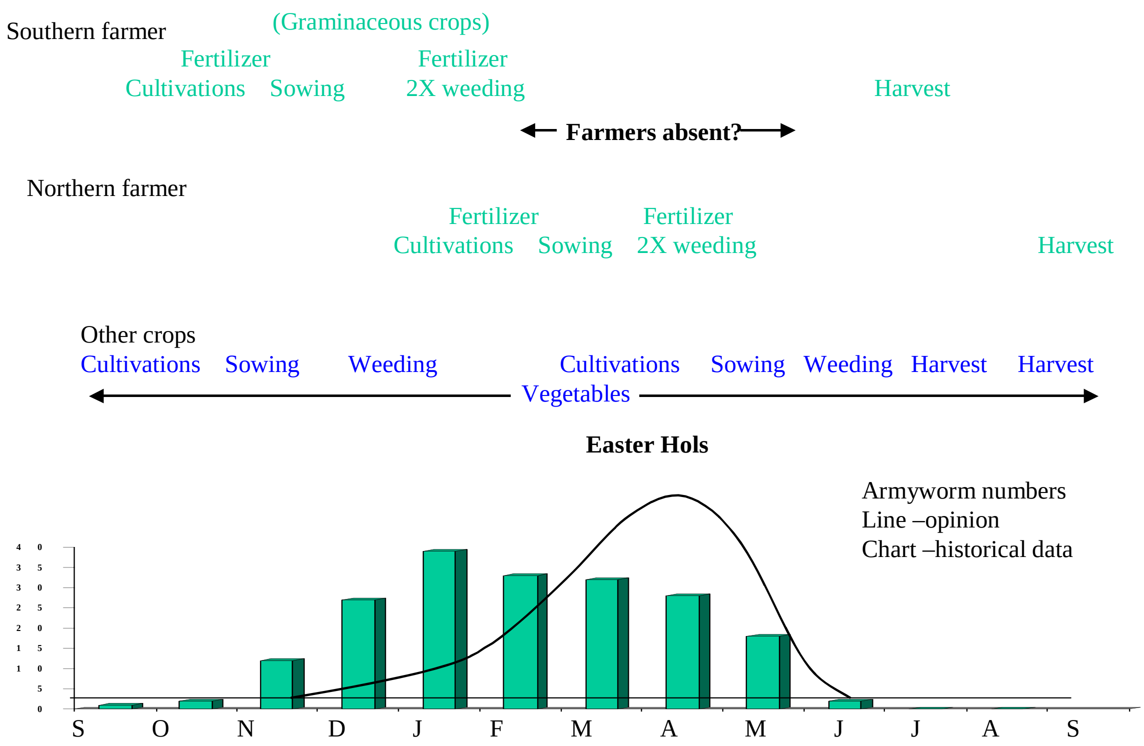


Figure 2 Seasonal profile

ROLES OF FORECASTING PLAYERS

In order to determine what decisions are taken during the armyworm season and who takes those decisions the participants were divided into a series of groups that reflected the main players in the forecasting system. The groups were as follows:

Policy implementers	Pesticide dealer, District Executive Officer, Senior Scientific Officer - Tropical Pesticides Research Institute, Agricultural Officer - Ministry of Agriculture and Food Security, Plant Protection Division.
Trapping network	National forecaster, other forecasting staff
Agricultural Officers	Agricultural Officers, District Extension Officers
Farmers	Organic farmer, large-scale farmer, medium-scale farmer

Each group was asked to write a list of what they considered to be their responsibilities, their objectives and the constraints that prevented them from achieving those objectives. The results are shown below. Not all groups kept to the suggested structure so objectives are sometimes contained within other sections.

Policy implementers

Responsibilities
Administrators

- Ensure availability of safe and effective armyworm control products to the farmers and district administration.
- Ensure physical distribution of the controls to the end users
- To educate farmers on the budgetary needs for armyworm control
- To create awareness of armyworm outbreaks and their likelihood
- Policy administration at lower levels e.g. extension, villages etc.

Pesticide Distributor

- Ensure availability of right type of pesticide at right time and place
- Estimate likely demand for pesticides
- Import pesticides and applicators
- Create awareness through publicity/advertising

Regulatory body

- To ensure registration, certification and regulation of pesticides according to Tanzanian law
- To permit importation of agrochemicals prior to outbreak
- Inspection of pesticide stocks before and after importation

Constraints/Problems

- Lack of funds for farmers during outbreaks (failure to budget)
- Poor availability of pesticides during outbreaks
- Information lag – not getting to advisor/farmers in time to act
- Poor infrastructure and transport
- High prices of some pesticides

- Stocking pesticides when no outbreak
- Pesticide shortage in serious outbreaks
- Pesticide piracy – importation of unregistered molecules/formulations
- Budget constraints of pesticide stockists

Trapping Network

Responsibilities

- To service traps on time
- Ensure reporting system is running smoothly
- Issue forecasts
- Updating the Ministry of Agriculture and Food on armyworm situation
- Mobilization (logistics) of control teams to zones
- Coordination of information – flow from traps to zones to regions
- Cross checking of outbreak reports/crop damage assessments with pesticide recommendations

Objectives

- Timely and effective control
- “Smarter” forecasts

Constraints

- Resources – funding, transport, communications, application
- Proper refined policy

Agricultural Officers

Responsibilities

- To provide forecasting services
    - Monitor the crops
    - Keep traps working
    - Report to zonal office
- To inform farmers about forecast (extension officer)
- Train village extension officers on how to deal with outbreaks
- To educate farmers about outbreaks (budgets, monitoring, group organizations
- Inform pesticide suppliers in district about outbreaks

Objectives

- To ensure food security at household level by increasing production and income
- To collaborate with all players involved in armyworm control and forecasting

Constraints

- Too few traps in network
- No funds for training of village extension officers
- In general, extension services get no finds from local government (Hai district an exception)
- Poor infrastructure – roads, communications
- Limited transport facilities for district, ward, village extension officers

Farmers

Responsibilities
- To respond to the forecast information
- To monitor
- To control armyworm in own fields
- To report the presence of armyworm at the earliest possible moment
- To set budget for next season
- To communicate with extension workers

Objectives
- To maximise yields
- To reduce costs of production

Constraints
- Lack of access to extension workers
- Low purchasing power
- Lack of credits and chemicals
- Lack of Government support for small farmers
- Lack of standards for pesticides due to poor inspection and certification

OPERATIONAL MODELS FOR FORECASTING

In this session participants were divided into three groups and requested to think broadly about alternative ways in which armyworm forecasting could be organised. Each group considered a different model for the operation of the armyworm forecasting system. The models involved placing the day to day forecasting activity at different levels in the institutional hierarchy: national, district, and community.

Centralised or National-based

Procedures

This is the current model the forecaster operates at present, with information being reported from the network of traps, currently about 70, to the central facility at Pest Control Services (PCS) in Tenggeru. Information on outbreaks and meteorological information from the trap sites and remotely sensed data is used to provide a central forecasting facility. The forecasts for the different regions are then relayed back to the appropriate agricultural officers for dissemination to extension workers, farmers and other interested parties. To make the National model work more effectively the network of traps could be expanded to provide more detailed information on the existence and abundance of armyworm around the regions. The servicing schedule could be improved to ensure that all traps were serviced prior to the start of the armyworm season. Some districts could run additional traps to the main network, in the wheat complex for example, where there is sufficient expertise to make use of the locally produced information. Reporting could be on a daily basis when moths were being caught, information being sent by phone, fax or radio. Forecasts could be issued daily and sent out to the districts via phone, fax or radio. The forecasting service would take on the role of trainers to ensure that the trap operators were able to run the traps efficiently. Any information about outbreaks should be sent to PCS for collation.

The bulk of the work is done by the forecasting body with inputs in the form of trap operation coming from the extension services. No formal input from farmers other than the large scale operations is envisaged.

Advantages

It is envisaged that this model is easier to fund as there is a single point of contact for the funding agency to deal with. Since there are a limited number of personnel it is possible to train them to a much higher standard and therefore potentially improve the forecasting. The National model is also useful in that it provides a central store of historical data and has the ability to communicate with other institutes to obtain additional data. The centralised model also has the potential to provide higher quality forecast through the inclusion of the remotely sensed data. Additional advantages are the ability to provide both normal and longer term forecasts to policy planners and a dedicated unit should be easier to administer.

Disadvantages

There are relatively few traps and there would be limited resources for expanding the network. Communications are difficult due to the poor infrastructure (roads, phones, radio etc) that adversely affects the flow of information both from and to the forecasting centre. The poor infrastructure also makes the movement of control operations difficult if this were to remain under central control. If the control was de-centralised this would overcome some of the problems. One of the biggest problems is that there is no direct link to the farmers and the system is therefore missing feedback

Resources required
A serviceable vehicle is required to maintain the trap network properly and a reliable phone connection for transfer of information is also required. Provision for radio communication at the zonal level should be made (as existed in the past). The current computer and software require upgrading in order to continue with reliable data processing and forecasting into the future.

District-based

Procedures
In this model, the forecaster would be based at the District Office. He/she would operate autonomously to produce a forecast for that district using information from the traps, the rainfall and the armyworm outbreak history for that district. Week to week forecasting operations in the district could operate without input from the national level. Should information from the national forecast be available (e.g. on the situation in neighbouring districts) then the district forecaster could also use this extra information. If a national forecast were to be maintained, then data from the district would need to be sent to the zone or national level.

A member of staff in the District Office would be allocated the task of armyworm forecasting for that district. This would involve both training for that officer and extra workload.

Districts would require armyworm traps. The more traps operating in a district, the greater the potential forecasting accuracy but the greater the difficulty both to maintain and obtain data from the traps. A trade-off was identified between forecasting accuracy and operational feasibility. One trap per division was considered (approximately 10 per district, depending on the district concerned). Each division would also need a trained trap operator and possibly, a rain gauge.

In many districts, however, communication between division and district level is very unreliable and can only be ensured by staff travelling around, often on very poor roads. The district forecaster would probably need motorised transport (e.g. motor bike) in order to collect trap data and deliver forecasts. Installation of radio links between district and division would ease information flow but this would require investment in equipment and a reliable power supply. The communication problems that were identified between national and district level also exist between district and division. Those elements of the forecasting system which rely on timely information flow to and from rural locations currently suffer problems, so it may be a good strategy to limit the reliance on information flow as much as possible.

The traps themselves also involve costs, though these are small (about US$5 per trap). Much greater is the cost of delivering the pheromone septa to each trap. Pheromone septa need to be delivered twice during the armyworm season.

Due to communication difficulties and costs it was suggested that each district have just two traps, perhaps placed in locations within the district known to be of historically high armyworm risk. Although this is a very small number of traps on which to base a forecast, failure of information flow means that current forecasts for a district are frequently based on just a single trap anyway. There are about 70 traps operating in Tanzania at the time of writing. Two traps per district would increase this number to approximately 300 traps.

Disadvantages
Without the centralised national forecast, the 'bigger picture' would be lost. The national forecaster, for example, can take into account trap catches and outbreak reports in other districts in formulating a forecast for the district concerned. The district forecaster, relying purely on local information, will only be alerted to armyworm problems once armyworm moths are present within the attraction distance of the local traps (a few km).

It is government policy in Tanzania that the farmers should be the ones responsible for armyworm control. Thus it is the farmers who are the target recipients of forecast information and they who must decide on a course of action in response to forecast information. To minimise information flow, therefore, the forecasting activity should be as accessible as possible to the decision makers. Forecasting at the district level still requires information about potential outbreaks to pass from the district to the division, from the division to the ward, from the ward to the village and to individual farmers within the village. Only the national to zone and zone to district parts of the information chain are removed when forecasting is located at the district level. Locating the forecasting operation at a sub-district level could shorten this information chain still further.

Constraints
Funding was identified as an overriding constraint. Funding would be needed for: a computer to store the trap data, the traps and pheromone septa, servicing the traps and replacing the septa, transport to visit traps, collect data and convey forecasts, radio communications to facilitate information flow, training for district forecasters, divisional trap operators, and farmers. Irrespective of the operational model, farmers require training in how to respond to forecast information.

Advantages
The closer the forecasting operation is to the decision maker, the greater the period of time available for any action to be taken, i.e. field monitoring, insecticide purchase and insecticide application. District based forecasting would allow a greater period of time to respond to forecasts than is the case with a nationally issued forecast.

If the district agricultural office has an active role in co-ordination (e.g. of insecticide and application equipment supply), then by issuing its own forecast, the district would be better placed to provide timely co-ordination.

The placing of the forecasting function at the district has fewer training implications than does placing this function at a sub-district level, at least as far as training in forecasting itself is concerned.

Roles at national, district and community levels

National
It was felt that a national forecast would still be wanted even if forecasting was carried out by the districts. Whether a national forecast in its existing form would be required was not clear. The role at national level might be to collate the district forecasts and disseminate these country-wide data back to the districts.

The national level would also have an important role in supervising and training to help the forecasters in the districts. The national forecasting centre could act as an experienced knowledge resource to which district forecasters could turn for advice.

The national level also has the important role of reporting to government to enable informed policy decision to be made during an outbreak.

District

Under this model the district carries increased responsibilities. The district would be responsible for making sure that the armyworm traps are working. There would be a staff member in each district who would have responsibility for the forecasting operations in the district. This would include collating the local trap, and rain data, comparisons with historical data and forecast production. This person would also be responsible for co-ordinating the dissemination of the forecast throughout the district and for reporting to the national level. The district role would also include the process of obtaining feedback both from farmers and from the national level on the appropriateness and timeliness of the information sent out by the district.

Farmer

The role of the farmers would be to respond to the forecasts by taking appropriate action. Chiefly, this involves monitoring for armyworm larvae on their crops when outbreaks are forecast. Recognition of the early larval stages of armyworm is thought to be poor. Such recognition is vital if control is to be timely and crop damage avoided. A key training need exists to enable farmer to recognise early instar armyworm larvae. If early instar larvae are found, control agents need to be procured and applied before the larvae become large enough to cause extensive crop damage.

It is thought that most farmers do not budget for the possible eventuality of armyworm control being required. As a result they may not be in a position to purchase insecticide and may therefore not be in a position to respond to forecasts with any crop protection measures. Insecticide application in response to forecasts is regarded as the responsibility of the farmers, though many farmers regard armyworm control as the government’s responsibility. The role that the farmers are prepared to take may be a matter of attitude and expectation as well as knowledge and funding for inputs.

Project

In this district-based model for implementation, the forecasting project would provide forecasting tools for each district. These would need to furnish the district forecaster with the information, methodology, and equipment to make a forecast. The information would take the form of the historical armyworm outbreak records for that district and these would need to be extracted from the WORMBASE database and collated for each district. These data would need to be updated annually as new information becomes available. The methodology would be a clear statement derived from the principles adopted by the national forecaster to produce the forecast. These principles would be translated as an appropriate protocol for local-scale forecasting and would be much simpler than the national forecast as no spatial component is involved. This protocol would be tested and revised though feedback from the district forecasters and the performance they achieve. The minimum equipment required would be a pheromone trap and possibly a rain gauge, though the simple observation of whether rain occurred or did not occur on each day would be a basic requirement.

The project would also continue to develop the tools available at the national level. More accurate and higher resolution forecasts produced at the national level would enable improvement in the information available to make forecasts at the district level. How much effort to invest in national tools depends critically on its likely uptake. An important component of uptake is information flow. District-based forecasting may have the side effect of increasing armyworm awareness and understanding with a corresponding increase in interest in the national forecast and so increased communication between national and district levels. Such a virtuous cycle would increase the value of the national forecast.

Community Forecasting

Procedure

Community forecasting could be undertaken by a small group of community members (farmers). This could be at the level of the village (about 150 per district) or the ward (comprising 3-5 villages). Based on forecasting 'rules' provided in a 'forecast pack', the community group would make a forecast for the village or ward based on the trap catch, rainfall information (perhaps using a rain gauge) and historical outbreak probabilities.

Role of the community

A small group would be responsible for the trap and rain gauge. At village level the village authority should be involved in selection of the group; the village extension worker could also advise, but should not impose. At ward level the ward councillor would be involved in selecting an appropriate group. Schools were suggested as a possible group though there was no consensus on their relative advantages and disadvantages. The selected group would collect the data and issue forecasts for the village/ward, as well as inform the District Agricultural office.

Role of the District Agricultural Office (DAO)

Initially the DAO would sensitise communities and ward councils to the need for community forecasting. The DAO could also serve as the distributor for the traps and lures. Who would bear the cost of this was discussed, and it was agreed that ultimately the farmers should pay, but that initially the DAO could subsidise the price and subsequently phase in full cost recovery. Possible involvement of the private sector was discussed, but it was felt that the market would be too small to interest them. The DAO would also forward data and information from the wards/villages to the central forecasting unit (CFU), perhaps once per season rather than weekly for real time use.

Role of the Central Forecasting Unit (CFU)

The CFU would be responsible for developing and distributing the community 'forecasting pack'. As data accumulated, the CFU would also refine and adjust the local forecasting rules to improve accuracy. The CFU would train DAO staff who would then sensitise and train ward/village groups doing the forecasting. The CFU would be responsible for import and distribution of traps and lures to DAOs. The possibility of local traps was discussed; if this was appropriate, the CFU would need to ensure that local designs were effective. Information sheets to supplement the forecast pack would be prepared for distribution with traps and lures.

Advantages

A major advantage of community level forecasting is that communication of the forecast to those who need it would be very rapid – word of mouth might be sufficient – avoiding the current delays in communication. There might also be increased ‘ownership’ of the process, and thus willingness to act on the forecast. In this respect the approach fits very well within national policy moves to greater autonomy for local government and increased participation by farmers. Thus the time might be right for this approach. The technical knowledge required by community forecasters would not be excessive, and there are appropriate mechanisms (including local extension systems) for its implementation.

Disadvantages and Problems

Sensitising and training communities would be time consuming, and thus the approach would need piloting first. Similarly, distribution of traps and lures would require considerable organisation. Although data would not be expected to be sent to the CFU more often than monthly, given communication difficulties this might not occur very efficiently. A practical point noted was that if the traps say ‘poison’ on them, there may be some resistance at the community level. While the approach would circumvent problems with forecasts reaching farmers, it would not necessarily enable them to act on the forecast, particularly if pesticides are unavailable. There might be some difficulty in persuading communities of the value of forecasting, and if it was inaccurate early on in the pilot, this might put people off. It was felt that the approach would be difficult to implement where outbreaks are rare, so might only be appropriate in frequent outbreak areas.

NOVEL CONTROL - PRIORITISATION, STRENGTHS AND WEAKNESSES

The historical profile review identified that there were several different client groups (users) for any novel control technology. Their different socio-economic situations meant that they had very different needs and access to resources that would constrain their ability to adopt control options. It was decided therefore to analyse the needs, strengths, weaknesses and capacities of these groups separately to determine what control options would be appropriate to each.

Smallholder cereal farmers

These were characterised as the poorest farmer households, they generally grow one staple crop (maize) with minimum inputs and resources on small home farms (< 0.5 ha). They produce only one crop because they farm in areas where there is only one reliable rain per year and this limitation of rain is a primary cause of their poverty. They generally have no or little access to spray equipment for applying armyworm controls. The cereals they produce are primarily for home consumption and are the mainstay of the family food security. If their crops are attacked they currently have no recourse to control measures and crop damage results. In these areas the rains are often too short to permit the household to plant another crop and severe hardship results if armyworm destroys the crop. The individual economic value of the crops they produce is low, yields are low as little fertiliser can be afforded, however the crop is crucial to the family's food security and therefore has a very high value in terms of household livelihood.

Their criteria for a usable control option are

- It needs to act quickly; these farmers rarely monitor pests and only notice armyworm outbreaks in the later stages.
- It must be usable without use of sprayers as these farmers do not posses or have access to sprayers and pesticides. The areas they live in are low income so that agrochemical suppliers are scarce or largely absent with minimal stocks.
- It must be cheap; these users have very little access to cash or credit to purchase armyworm control products.

The conclusion drawn was that the only appropriate option for these households was a technology formulated as granules or baits as these could be applied by hand without the need for application equipment.

In considering the advantages and disadvantages of existing and proposed options

1. Existing chemical pesticides are fast but are too expensive.
2. Neem is fast acting, through its antifeedant effects, but if formulated as bait the antifeedant action might prevent the armyworms consuming enough to kill them. Processing Neem into a form stable enough for baits might mean it cost too much to be acceptable.

3. NPV is slower to kill than Neem or chemical insecticides but could probably be produced as cheap stable baits. Many pest species consume NPV avidly so bait shyness is unlikely.

The conclusion was that while none of the two agents NPV and Neem was a priori ideal baits of both should be developed and evaluated further initially through laboratory trials and then in the field as these were the only viable control options for this priority group of households.

In considering possible production and distribution of novel controls some Neem is available currently but supplies are limited and expensive. Local production of novel technologies through on farm, village or collective ventures might be the best low cost option but quality and storage might be problematical. Processing large quantities of Neem might be difficult due to shortage of water and the need for dedicated grinders.

If new controls were to be developed adoption might require training of these farmers in crop monitoring to recognise armyworm attacks in the early stages if control by either Neem or NPV baits was to be effective. This could be through existing MoA network of village scouts who themselves would need to be trained.

Cash crop farmers

These were farmers who in addition to cereal staples grew cash crops. They live in areas that have two rainy seasons and grow as staples maize, wheat or rice, all of which are attacked by armyworms. In addition they grow cotton, coffee barley or vegetables as cash crops. The farms range in size from smallholder plots of, <. 0.5 ha, to medium to large farms of up to 50ha. They have access to application equipment, primarily for cash crop production, either through ownership, through hiring or neighbours sharing.

Currently these farmers do conduct some armyworm control operations though the cost of pesticide means the smaller farmers have to rely on government provision of insecticide, currently funded by an international donor (Japan). In most areas subject to attack the government can at most provide 10-30% of the demand so in most areas such small farmers' lack adequate access to control options. However where the rains occur over a longer period or twice then replanting the crop after attack can be a viable option although yields are reduced. The income from cash crops and a second cereal crop can insulate the larger farmers in this group from the impact of armyworm but smaller household farms can have their livelihood serious impaired. These farmers can be characterised as follows:

1. They usually have good awareness of armyworm, and have the means to hear forecasts (mainly via radio programmes)

2. They are economically aware, they are used to paying for plant protection products and have some knowledge of their use.

3. Growing a range of crops they look to broad spectrum products they can use on both armyworm and other pests

4. Have access to application equipment either HV or ULV. Most small farmers use HV apparatus but in recent years ULV has increased in popularity especially in dry areas or on larger farms where HV is difficult or more time-consuming.

5. There is reported to be a subgroup, small at the moment, who are aware of natural and botanical control and favour these for ethical, financial or access reasons.

Any novel control suitable for them would have to be compatible with existing application apparatus HV and ULV. It would also be an advantage if it were compatible with other agrochemicals such as fertilisers or fungicides that are routinely applied during the armyworm season. These farmers except for the smallest have little interest in on farm production of insecticides but prefer to buy inputs from dealers.

In considering production options. Neem is available currently but only in limited quantities. There may be problems expanding the supply as tree plantations may take many years to get established and to reach significant yields. However it was felt that existing Neem capacity in Tanzania goes largely to cosmetic oil uses so that only 5-10% is used for insecticide. If Neem formulations were effective there might be Neem production capacity that could be diverted into armyworm control products. NPV cheaply produced from natural outbreaks in the field might be a most appropriate mechanism if easy to prepare stable formulations could be developed as per AgNPV. However for both NPV and Neem products there would need to be quality control and registration issues and the pesticide board would need training in registering or monitoring quality. It was suggested that these clients could use both HV and ULV formulations of Neem as well as use baits on occasions.

NPV	Neem
Compatible with bait	Might not be viable bait due to antifeedant effect?
Specific to armyworm not active against other pests	Broad spectrum activity
Slower action 4 days to cease feeding 5-7 to cause death	Fast antifeedant action
Recycling and secondary infections could reduce need to reapply	No recycling, persistence is reported to be poor.

It was concluded that this client group would be strong potential users of ULV and HV formulations if efficacy and cost were acceptable.

Strategic or large scale users

Large-scale users included the large-scale private commercial farmers, state farms and potentially national or regional strategic campaigns to suppress primary outbreaks. The users are likely to have significant experience and be well resourced. They are reactive to pest forecasts, and can benefit from economies of scale. Many already adopt effective monitoring and have resources for intervention.

The main application system here is ULV though some HV is employed. Neem would be suitable for ULV and its fast action and efficacy against late instars would be attractive. However for ULV use it might need expensive extraction and processing so costs could be higher than conventional pesticides. NPV has advantages that it could be produced locally but cheaply both as ULV or HV, though HV aqueous or kaolin formulations would probably be least expensive at below $1 a hectare. NPV for strategic control would have the great advantage that it can recycle and spread both horizontally and vertically. Production for large-scale users could be through local companies using field outbreak production. Some very large agricultural concerns might support in house production.

Issues that will need addressing in respect of all groups included

- Registration, the need to provide technical assistance to Tanzanian registration authorities in registering new types of products.

- Quality control, how to establish appropriate quality control systems for new products, especially if produced at farm or community level.

- Need formulation with very good shelf life as major armyworm outbreaks may only occur every two or three years in each area.

- Need for assistance (technical or financial by donors) to establish local production perhaps through private public partnerships.

THE SOCIO-ECONOMIC SURVEYS

The objectives of the socio-economic surveys for the forecasting and control project are;

1. To identify the current problems and constraints in the armyworm forecasting process and control.
2. Evaluate the organization and economics in terms of resources, costs and manpower of armyworm forecasting and control at different levels.
3. Identify and evaluate current armyworm control measures in terms of viability, efficacy, cost and relevance.
4. Collect economic data on the value of crop production for different land use systems/types and the loss in value associated with armyworm infestation in order to come up with an economic risk and potential loss map.
5. Assess the suitability, availability and supply of neem for the control of armyworm.
6. Assess the feasibility and the economics of the production of neem and NPV and the control of armyworm using the same for different resource endowed groups.
7. Participatory testing and evaluation of neem and NPV to establish relevance and acceptability by farmers.

Issues raised

1. The need to focus on a model of community based armyworm forecasting given recent policy changes in the country.
2. The control of armyworms should be taken in the context of farmers' other problems and the relative importance of farming compared to other activities
3. The most appropriate time to do the surveys-during the armyworm season or not?
4. The need to look at those most affected i.e. the poor.
5. Specific data needs for the novel control project such as the number of ha of small-scale farms requiring pesticide treatment, farmers' access to spray machines and type of spray machines that they have.
6. In the next few weeks, during the development of the questionnaires, we will keep e mail communication between all collaborators on any further issues on the socio-economics work.

Implementation of the surveys

The socio-economic surveys would be implemented in 4 districts. The criteria for the selection of these districts was based on the level of armyworm outbreak risk (high or low), Level of wealth (high or low), number of cropping seasons (one or two), crop mix (those with cash crops and those without). The districts selected were Hai (high wealth, high armyworm risk, 2 cropping seasons and cash crops), Dodoma (low wealth, high risk, one cropping season, no cash crops), Korogwe (low risk, low wealth, two cropping seasons) and Kilosa (high risk, low wealth, no cash crop). Kilosa District was also selected as the pilot district for the community based forecasting. Two socio-economic surveys would be carried out, one in the next few months and the other in the last year of the project. Participatory testing of the neem and NPV controls would be started after more trials have been done.

Two implementation levels were discussed, group discussions and individual surveys. The group discussions will aim at obtaining general information on farmers' perceptions of the forecasts and of armyworm control methods, reasons for use or non-use of forecasts and control and will assist in classifying farmers as users or non-users and into different social categories. The individual surveys will be used to get more specific data. Actual sample sizes were not determined but a compromise would be made between representativeness and statistical validity.

APPENDIX 1

Review of the activities of the armyworm forecasting project in the light of the workshop

(Compiled following the workshop by J. Holt)

1.1 The workshop had an important role to play in defining some specific questions for the socio-economic survey . In addition, it now seems that the survey should emphasise farmer-level economics rather than those of centralised control operations.

1.2 As planned. Demonstations of the new software tools will also be produced to help with their specification.

1.3 Workshop was held as planned.

1.4 As before. The next review meeting may take place in June 2001 in the UK, taking advantage of an already-planned visit by the National Forecaster.

2.1 As before.

2.2 It is now proposed to collate the Meteosat data using a digitised map of the administrative districts of which there are about 150 in the country as a whole. A meteorological risk could then be attributed on a district by district basis.

2.3 As before. An additional item has been put forward as a high priority by the national Forecaster: a new windows version of Wormbase including some additional features.

2.4 As before.

2.5 Consideration will be given to ways in which PCS could add trap and outbreak information to a web site directly. This activity is constrained by the problems experienced in the reporting of trap results by trap operators.

2.6 As far as it is available, point data of armworm trap catch results will be overlaid on the district-resolution meteorological risk map for weekly dissemination under activity 4.2 below.

3.1 It is now government policy for farmers to be principally responsible for control, so economic analysis is most valuable for decisions made by the farmer. It is nevertheless possible that the government will provide some help with such things as pesticides and application equipment in times of severe outbreaks. It is now proposed that economic data should focus on the individual farmers to provide information for a modified activity 5.1. It was noted that farmers are likely to have very different attitudes to armyworm control depending on their circumstances.

3.2 For the reason stated in 3.1, land use and potential value of losses appears less relevant on a geographical scale than it is on a farmer or community scale. Farmers and communities know what they are growing and its value. This activity is still thought to be of some value to guide any centralised actions during outbreaks.

4.1 It is proposed that an increased proportion of the effort in the project be given towards developing and supporting local forecasting tools. From various approaches discussed, community-based forecasting was regarded as having most potential.

4.2 The community-forecasting model is less dependent on the dissemination of forecasting products from the national to the district level. The approach now proposed in the project is simply to make the national product available on a web site, though it is recognised that only some districts and individuals will have access to this. (Jon Venn to put district resolution meteorological risk onto web site?)

4.3 Centralised forecasting tools are already covered in the project document. It is now also proposed to pilot the community-based forecasting approach in selected wards in Kilosa district. There are important operational issues to be resolved as to how this might be implemented. Discussion with community groups in selected wards necessary, a. to explain the idea, and b. to ask community groups to decide how they might want to run things. PCS & CABI will set up the pilot with back up from the rest of the team?

4.4 Training is needed for National Forecaster, especially if a new version of Wormbase can be developed. It is likely to be more sustainable if new Wormbase is implemented as much as possible on the standard software with programmed interfaces & macros only where essential. This requires a greater level of understanding of the software by the National Forecaster. It would be useful, therefore, if National Forecaster could come to NRI/IC for training. There is also an extensive training requirement at the ward level for the community-based forecasting approach that is now proposed. Training to be carried out in selected wards in Kilosa by PCS with back up from rest of project team?

5.1 The most pressing need is for cost-benefit analyses of community-based forecasting and armyworm monitoring and control actions by the farmer. This appears to have a higher priority than the planned cost-benefit analysis of control operations organised by government / local government.

5.2 If the farmer is the cost-centre, then the proposed geographical analysis of losses is less relevant and might therefore have reduced emphasis.

Possible new operational model for armyworm forecasting in Tanzania

Under the present system, forecasting is carried out centrally. Information on trap catches and rainstorms is obtained from trap operators and other district personnel around the country. After collating all these data, the forecast is issued centrally and has to be delivered by some means to those expected to take action. It is government policy that the farmers should be responsible for their own armyworm control.

Problems were identified with the present system, information flow being a major difficulty. Trap information is not reliably sent to the national forecaster and no consistently effective and timely means exists for sending the forecast to those who need it. The lack of a clear link between information sent (by the trap operators) and information received (from the centre) may be a disincentive to trap operators. Sometimes farmers fail to respond to forecasts even when the information flow is good. This may suggest a lack of armyworm awareness or that forecast information does not relax other constraints on crop monitoring or control actions.

In addition to the national forecast which is received with varying degrees of reliability, some farmers (mainly large ones) and some districts carry out armyworm forecasting themselves. This is based on the local information available, i.e. armyworm trap catches from the one or two traps they run themselves, plus local rainfall data. This local forecast is not likely to be as accurate as the national forecast because no account can be taken of the armyworm catch results from the trap network as a whole. It can be argued that a less accurate forecast that impacts on the end user is better than a more accurate forecast that often does not.

It is proposed therefore that an attempt be made to move to an operational model in which the routine forecasting activity is carried out at the local, i.e. community, level. Research is required provide the forecasting tools to allow local forecasts to be accurate as possible and provide protocols so that the forecasts are consistent between locations. This requires analysis of historical data to calibrate each local trap. As more traps are added to the network, a period of calibration would be required for each trap. Along with current trap catches and rainfall, the historical probability of armyworm outbreaks is also an important ingredient of the forecasting process. This probability is location-specific and would need to be determined and updated annually for each trap location. Existing historical data provide a starting point for this.

The local forecast could be carried out at the ward level. (A ward usually comprises three or four villages.) The workshop discussed the mechanics of such community-based armyworm forecasting and there was some agreement that ward level was both close to the end-users but could provided a structure whereby someone would be responsible for the trap and the forecasting operations. Every ward has an extension officer responsible for that ward. The ward committee may wish to decide how the local trap is run, either by the local extension officer or perhaps a designated farmer. Training would be required in the operation of the trap and in the forecasting method.

A major advantage of community-level forecasting is that there is a much greater chance of an incentive being maintained to run the trap and collect the data. The link between high catches of armyworm moths and the subsequent occurrence of outbreaks should become clear. Farmers may become more interested in the forecast and more likely to take action as a result. A further advantage is an increased time interval between the time of the forecast the time appropriate for control operations. This would give farmers longer to prepare for armyworm control by acquiring the necessary chemicals.

Allowing autonomous forecasting to take place locally is not mutually exclusive with the maintenance of the national forecasting effort. When the information systems fail, however, the local forecast will still be available. Indeed, community-based forecasting may increase interest in the national product.

It is proposed that community-level forecasting be piloted in a number of wards in a district where armyworm frequently occurs; Kilosa was suggested during the workshop. Before considering how to set up the pilot, it will be important to establish existing farmer attitudes to armyworm control and the value of forecasts. This will be done during a forthcoming socio-economic survey. It will also be necessary to develop and produce local forecasting protocols. These will need to include some clear rules to interpret current trap catch data and rainfall information.

The work involved in piloting the community-based forecasting involves additional activities, especially, in logistics and training, in Tanzania. Additional funding would be needed and we would like to discuss this with NRInternational.

New Version of Wormbase

Wormbase contains data on armyworm trap catches and outbreaks. Each year, the National Forecaster routinely adds new data to Wormbase. These data can be broken down in various ways and summarised graphically to allow comparison of historical perspectives for specified places or seasons. The data resource becomes more useful as data accumulate and has now been in active use for more than a decade.

Even with a community-based forecasting approach the need for a centralised database is just as great. Each ward requires historical records upon which to base its forecast. These location specific records can only be provided by interrogation of the database. This exercise should be repeated annually to take advantage of the previous seasons data. The wards may wish to keep their own records but the maintenance of a central database remains the only way integrate data from across the trap network.

Wormbase is currently written in rather out of date non-windows software and the range of functions available is severely restricted compared to modern software. It no longer makes sense to try and add new functions to the software when today’s database and mapping software could be used far more easily. In addition, maintenance of the old software is becoming a problem with Wormbase crashing several times in the past two years.
We propose a new version of Wormbase as an additional project activity. The new version might employ an Access database and Idrissi or Arcview for the mapping. Again, additional funding would be needed and we would like to discuss this with NRInternational.

APPENDIX 2

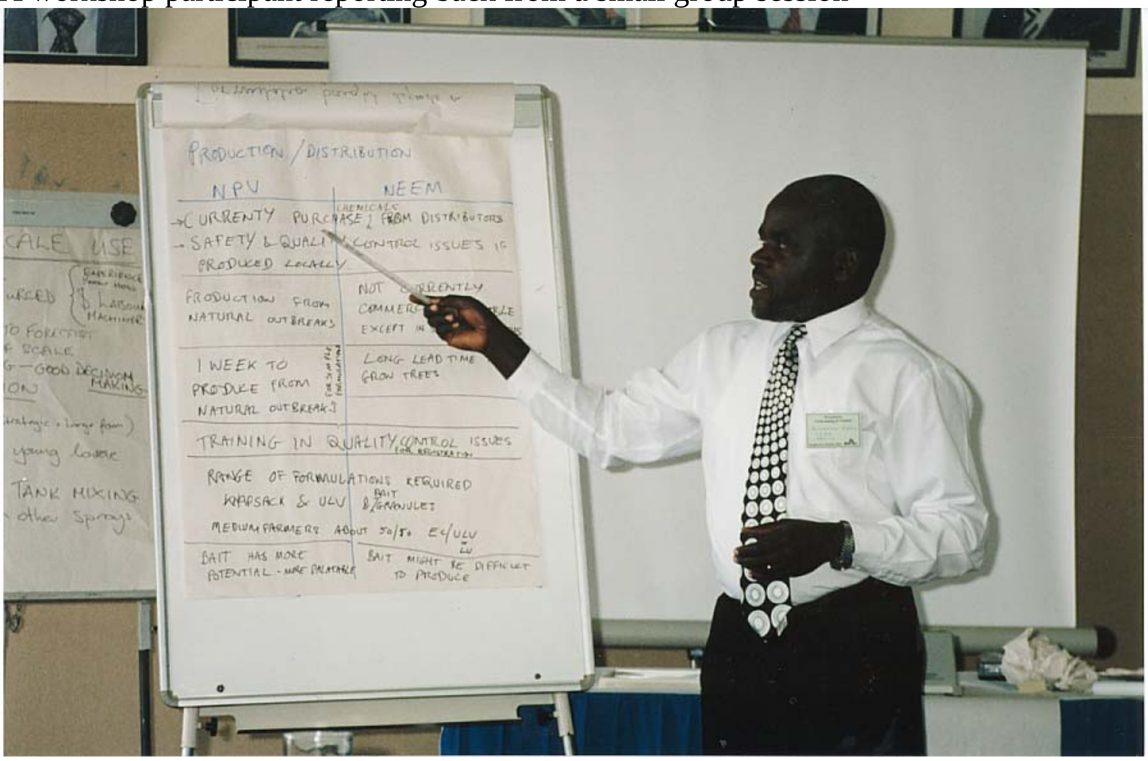
Workshop Evaluation

The workshop was briefly evaluated by participants writing on cards what they liked and disliked about the workshop, and what they were going to do as a result.

I liked…	I didn't like…	I'm going to…
Novel Control Project Group discussions Group contribution Organization Arrangement of topics covered Novel Control The Rat Selection of participants New solution (NPV) for controlling armyworm Participants contribution The beer selection Workshop organization The way it was conducted Interactions Lunch & Tea timing Making some new friends Finding out new things Facilitators' approaches The view of Mt. Meru Participatory (sharing of ideas) Educative Internet access Group discussions Mints Role-playing game Participants contributions	None Electricity blow out CNN Exposure of the site to wind Staying at the 14^{th} floor Winds Noise from tea room My brain becoming full on the final afternoon The stairs None Thinking The lack of a staircase from 14^{th} floor No practicals Laundry facility Alcohol Rooms Telephone noise from tea room Sleeping upstairs Brainstorming after 4.00 p.m. Time was short for such an important subject The drive to town was too long TV. Especially CNN	Advise farmers to use organic pesticides (Neem) against armyworm Introduce to my superior Think about implementing 2 projects Try not to forget Tell others about the workshop and prepare to act Have communication with Roger (I need your address) Move some goal posts Buy a trap and put down all necessary records Panic - Because there is so much to do, so little time Follow-up biopesticides Improve moth trap reporting to P.C.S Inform other staff on the importance of the workshop for future control Find out more about biopesticides and share with others To pass the new information I got to District authority Discuss about NPV and Neem Neem trees planting Budget for accessing trap Improve the project(s) Make a PCS Web site

The workshop participants

A workshop participant reporting back from a small group session



Small groups discuss the issues

Socialising at the end of the workshop

Participants feedback on workshop

APPENDIX 3

Workshop Timetable

Tuesday 9th October

9.00 Registration

9.30 Welcome
Mr. Wilfred Mushobozi,
Pest Control Services

9.45 Introduction
Dr J Holt/Mr D Grzywacz, NRI

10.00 Opening
Director of Research (Northern Zone)

10.30 Tea & Photograph

11.00 Participants introductions

11.30 Workshop objectives

12.00 Forecasting project

1.00 Lunch

2.00 Novel control project

3.00 Tea

3.30 Role playing

5.30 Close

Wednesday 10th October

8.30 Descriptive analysis – historical profiles

9.30 Descriptive analysis – seasonal profiles

10.30 Tea

11.00 Descriptive analysis – decision profiles

1.00 Lunch

2.00 Objectives/constraints analysis

3.00 Tea

3.30 Objectives/constraints analysis cont'd

5.30 Close

Thursday 11th October

8.30 Armyworm forecasting/control procedures

9.30 Prioritisation of forecasting/control procedures

10.30 Tea

11.00 Strengths & weaknesses of control options

1.00 Lunch

2.00 Socio-economic survey plans

3.00 Tea

3.30 Discussions

4.30 Closing remarks
Mr. Wilfred Mushobozi,
Pest Control Services

4.45 Closing remarks
Dr J Holt/Mr D Grzywacz, NRI

5.00 Close

6.00 Reception

Workshop

Armyworm
Forecasting and Control

9-11 October 2001

Eastern and Southern African Management Institute, Arusha

Organised by
Pest Control Services, Arusha
CAB International Africa Regional Centre, Nairobi
Imperial College, London, UK
Natural Resources Institute, UK

Funded by
Department for International Development, UK

APPENDIX 4

List of participants

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