PROJECT R8197 [FTR Part 2]
APPENDIX 1. Development and validation of the IPM system
REPORT OF THE ENTOMOLOGIST [October 2002]
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Aims:

- To identify the key insect pest problems in cotton in the two current IDEA cotton activity area – Kasese in the West and Pallisa in the East.
- To assess the likely impact of current control operations against these species and to design an improved system incorporating the principles of Integrated Pest Management (IPM).
- To prepare draft workplans and scouting systems for IPM implementation and to test and refine these with IDEA staff who will then train demonstration formers in their use.
- To help put in place a continuing support and monitoring system to ensure that the proposed IMP practices are validated within the current cotton season, with a view to obtaining greatly expanded adoption of refined practices in the 2002-3 season.

Activities:

Following discussions at IDEA HQ in Kampala, an initial two-day visit was made to the Kasesse area of W.Uganda, followed by 2 days in the Mbale area of the Pallisa district. In each area, a number of widely separate fields were examined for insect pests and damage and discussions held with the farmers as to the type and extent of problems and the accessibility and effectiveness of available control practices. Discussions were held with IDEA staff - in particular the IDEA National Cotton Co-ordinator – David Luseesa.

A delayed start to the second rains in Kasese meant that planting was late, with the IDEA demonstration planting only just over when we arrived. This gives the opportunity for trailing an IPM package over the full cotton season but did mean that only early season pests were present on the plants.

Consequently I returned to the Kasese are for three days a the end of the visit to select IPM –package testing areas and to train IDEA staff in IPM principles and the proposed scouting practices. These IPM test areas will run for the 2002-3 cotton season with the intention that a refined programme would then be implemented on much larger areas from 2003 onwards.

The Kasese and Pallisa areas differed significantly in their pest management context. The Kasese cotton area are large scale, continuous, blocks of cotton on the relatively narrow (1-2 Km) strip between the Queen Elizabeth National Park and the Rowenzori foothills. As such it offers a good target for IPM practices, especially those which benefit from ‘area-wide’ adoption.

The Pallisa area, by contrast, largely comprises small (0.1-1ha) plots of cotton, integrated into a multiple cropping system of maize, cassava, banana and other crops. This may provide some IPM benefits in terms of alternative hosts for beneficial insects, close to the cotton area, but equally it provides alternative hosts for a number of pests, notably Lygus, African bollworm and the stainers.

Pest problems:

Aphids:
In many, but by no means all, areas, cotton aphid (*Aphis gossypii*) is the key early season problem – exacerbated by the dry weather. Significant young leaf and shoot damage by aphids was in evidence. Several species of ladybird (inc. *Cheilomenes* sp. known to be important in Uganda) and syrphid (Hover-fly) larvae were widespread in unsprayed fields and actively feeding on the aphids. To be effective, spraying needs to either achieve good under-leaf coverage or to use materials which will translocate through the leaves (as with certain organophosphates such as dimethoate).

Jassids:
Varietal characteristics – particularly leaf hairiness – appears to be checking jassid numbers and we did not see a problem with this pest.

Lygus:
Lygus bug (*Taylorilygus vosseleri*), a tissue-piercing mired, is widely reported as a serious problem in early/mid-season, attacking both developing leaf and fruit buds. The leaf damage manifests itself in a leaf tattering or 'shot-hole' effect on the expanded leaves. However, much of the leaf-feeding damage seen was caused by crickets and other leaf-feeding insects – not lygus. As the loss of photosynthetic area to leaf-feeders is generally not as significant as the damage to leaf and shoot primordia by lygus, it is essential that the developed IPM system provides sufficient training to avoid farmer confusion of these damage types, if unnecessary sprays are to be avoided. The insect itself is secretive and cannot be easily sampled without sweep-nets and then only early in the day, making scouting by damage assessment a necessity. Sufficient damage was seen to confirm that this is a key pest in both Pallisa and Kesese.

Bollworms:
Polyphagus -
The African (or American) bollworm (*Helicoverpa armigera),* is an important reducer of yields, through fruiting point damage – buds, flowers and young and mature bolls. This pest is expected to appear with the first fruiting bodies around 60 days after germination, migrating from surrounding host plants, with oviposition particularly at the commencement of the rains. In consequence, very few African bollworm were seen and all were young instars. However, farmers had no hesitation in identifying African bollworm as a key pest in both areas.

Spiny bollworms (*Earias insulana and E.biplaga*) are present as shoot-tip borers early in the season, moving to flowers and young bolls as these become available. Several bored shoot-tips were seen and a number of larvae were found feeding on the anthers in flowers. Farmers were less familiar with these species. Control measures directed against *H.armigera* are likely to be effective for *Earias* species.

Oligophagus -
P*ink bollworm* (*Pectnophora gossypiella*) is a caterpillar pest of malvaceous plants only – which in Uganda effectively limits it to cotton and Hibiscus species (esp. to the edible *H.dongalensis*). In may situations pink bollworm passes the non-crop season in diapause in old boll and cotton stem trash – one reason for instigating cotton-free close seasons in most producer countries. Uganda's position on the equator precludes the diapause in pink bollworm. Pink bollworm can therefore be effectively controlled by a period of at least 70 days free from both growing and dead stalks of cotton. Unfortunately, the bye-laws to this effect are ignored by some farmers – perhaps particularly those renting, rather than owning, land. These farmers are leaving standing cotton over the 'off'-season. We confirmed that this trash does indeed harbour significant PBW larval populations which will move into the new crop as adults. Pink bollworm is an internal (endocarpic) feeder and is less well known to farmers as it is less visible. However, the SERERE entomologist Dr Sekamatte confirmed that this species is of less significance than the African and spiny bollworms in the Kasese area. Chemical control has to include thorough boll coverage as the eggs are generally laid on the fruiting structures and the hatching larva enters directly into bolls when yhey become available.

Stainers:
The *cotton stainers* are heteropterous hemipterans which pierce bolls, causing premature boll-splitting and allowing ingress to fungi (*Ashbya* (formerly *Nematospora*) species). Damaged young fruit shed from the plant. Those slightly older are reduced in size as well as having the lint stained. Attack on older bolls produces yellowish or brownish stains on the lint, with the darker colours originating from the earlier infestations. These are responsible for the downgrading of harvested cotton which is typical of stainer attack. There is also a considerable loss of seed (and its oil and weight) from stainers feeding in normal open bolls. Stainers will also feed in other malvaceous plants and some species at least will feed on sorghum and millet. Of the larger, red or reddish, species, *Dysdercus haemorrhoidalis* is generally given as the main species in Uganda but other *Dysdercus* species are no doubt present and the dusky cotton stainer (a much smaller and darker species usually seen as mating pairs on open bolls) is a significant problem. Unpicked cotton rapidly builds up large populations of stainers which will continue to feed on seeds throughout the off-season if given a chance and will re-invade new cotton fields. All stainers are readily killed by pyrethroid and organophosphate insecticides (although insecticide resistance development has been recorded in Kenya as far back as 1982). However, good phytosanitation, in particular the removal of standing cotton in the off-season, also assists greatly in keeping numbers down.

Cotton Helopeltis sp.
This red and black hemipteran sucks the outside of bolls causing unsightly scab-like blotches on the boll surface. These were seen on the cotton, but as the damage is largely cosmetic, no specific action is recommended against them.

Beneficial organisms:

World bank cotton sub-sector project reports by Heneidy and Sekamatte suggest that the major beneficial predators are:

- Lady beetles – *Cheilomenes* sp. and *Scymnus* sp.
- Anthocorid bugs – Orius sps.
- Hover-fly larvae – *Xanthogramma* and *Syrphus* sp.(mainly on aphids)
- Staphalinids – *Phaedrus* sp.
- Earwigs – *Diaperasticus* sp.
- Black ants – *Pheidole* and *Myrmicaria* sps as in Kenya (although identification of such ants as were collected from cotton during my last visit to Uganda, support the suggestion that the *Lepesiota* sps (nginingingi) are likely to play the major role).
- Spiders generally are seen as important.

Heneidy and Sekamate list 30 species of parasitoid from cotton pests. 4 from aphids, 10 from African bollworm, 11 from spiny bollworm and 5 from pink bollworm.

On this visit, the prevalence of predatory lady-beetles was confirmed – especially in unsprayed, or not recently sprayed, blocks. They and their larvae will impact on aphids and younger lepidopterous larvae. No *Orius* were seen but syrphid larvae were recorded feeding on aphid infestations. Spiders were present and no doubt play a useful role. *Lepisiota* ants were widespread, sometimes in considerable numbers and are no doubt predators of young lepidopterous larvae. Dr Sekamatte has good research data showing their role in the destruction of aphids in maize. However, in so far as accurate identifications could be made in the field, despite the extensive presence of nginingingi on young cotton plants, no evidence was seen of their removing *Aphis gossypii*. As this would be a major reason for manipulating black ant populations, this requires further study. Dr Soloman Ogwal, a cotton entomologist at Serere who has a mandate to work on the role of black ant manipulation in cotton systems, may have data on this but no reports were made available to the NRI team. Not surprisingly, no direct evidence of the presence of parasitoids was seen. Aphids in particular would repay more study in this area.

It should be noted that although evidence from Kenya and Uganda has shown significant mortality of pests (especially African bollworm) from beneficial organisms, it has not yet been possible to show a functional response i.e. that the beneficials can control the pests below economic thresholds, though clearly, reducing their impact through spraying of broad-spectrum insecticides, is undesirable where it is avoidable.

It is also worth noting that experience elsewhere would suggest that the better managed, fertilised, plots of the IDEA high-input demonstrations are likely to attract more severe pest damage, due to their higher nitrogen status and the relative absence of beneficial-friendly weeds. There is also more yield to protect. These factors promote higher insecticide use.

The current IDEA pest management system

The 2002 IDEA demonstration insecticide provision system was changed form that of the previous (first) season. In 2001, in 7 districts, IDEA had issued free of charge, sufficient material for the two insecticide applications recommended by the Cotton Development Organisation (CDO). In 2002, in line with the CDO policy of selling insecticides via the ginneries, insecticides were made available to farmers at approximately half the full commercial sots i.e. c.1000/- per unit, which is deemed sufficient for an application on half an acre.

The insecticide use recommendation remains as it has for many years:

- Ist application at 35 days after germination i.e. shortly after thinning and before first squaring.
- Three further applications are then recommended at 14 day intervals.

The provided materials to any given farmer are two of:

- Contra-Z - a mixture of 500gm chlorpyrifos (an OP) and 50g of cypermethrin (a pyrethroid)/litre in an EC formulation
- Fenkill – 200gm/litre of fenvalerate (a pyrethroid) in an EC formulation.
- Ambush – 200gm/litre cypermethrin.

Advantages of the current recommendations

- They are easy to use, being based on calendar sprays
- Several pieces of work have shown that using two or more insecticide applications significantly increases yield over that in unsprayed plots. Recent work has suggested that this is an economically viable recommendation.
- The limited cost of just a few sprays limits the risk of financial problems should the yield be poor due to weather or other factors.
- CDO and the ginneries can calculate the quantity of each material required and make these available to the farmers either direct from the ginneries or thought the cotton co-operative offices.

Problems with the current recommendations

- The recommendations do not take account of pest populations – indeed most farmers do not know why they are spraying at any particular time. As the timing of pest infestations by particular species varies by location and season, this is highly inefficient.

- The particular materials to be applied to meet a particular pest situation are not being specified. For example, the widespread spraying of pyrethroids on the upper surface of leaves for aphid control early in the season is of low value because a) over 60% of fields examined had no significant aphid problem at this time b) Aphid colonies are on the underside of leaves and in shoot terminals. Pyrethroids sprayed in the current manner are therefore almost ineffective. (Certain Ops, such as dimethoate and to a lesser extent chlorpyrifos, have limited systemic action which may be more effective in controlling aphids. Strongly systemic Ops such as monocrotophos are too toxic to mammals to recommend in this situation).

- Broad spectrum insecticide spraying (OP/pyr) are heavily damaging to beneficial insect populations including ladybirds and ants.

- Active ingredients in the same chemical class should not be applied consecutively, as this is a recipe for the build up of evolved resistance.

- The recommended 4 sprays, at the recommended intervals, covers the plant up to 77 days from germination. The growing season is c.120 days and some pests (pink bollworm and stainers for example) are like to be most numerous late in the season.

Proposal for an IPM system to overlay on the IDEA demonstrations

Principles

- Should delay the first broad-spectrum insecticides as long as possible and preferably up to 60 days from germination.
- Should be founded on need-based spraying.
- Should comprise appropriate materials and rates.
- Should be applied only when threshold insect numbers or damage levels have been exceeded. These action threshold levels should balance the need to protect yield with the need to avoid destroying beneficial organisms and the risk of stepping on to the 'pesticide treadmill'.

Details of the proposed IPM system

The **plant** should be the sample domain i.e. the farmer scores each plant as damaged or not, according to the criteria below. Farmers should sample up to 25 random (see below) plants per half acre – a compromise between accuracy and practicability. With such a small sample of the c.20,000 plants per acre, it is essential that the plants be sampled randomly. Based on experience the following method is recommended.

1. Start at any position in from the edge of the field (different positions on each sample occasion).
2. Take 5 steps up any row.
3. Sample the fifth plant up the row from where you stopped.
4. Step three rows to your right.
5. Repeat steps 2- 4 until you have sampled 25 plants or an insecticide spray threshold has been exceeded.

This pattern results in a diagonal sampling of the field, with the precise plants sampled not directly selected by the farmer. Sampling 25 plants in this fashion takes 10-25 minutes depending on the age of the plants and the level of insect attack.

Key pests
Aphids – especially early season, stunt plant growth. Scientifically developed thresholds use a scoring system for aphid numbers (1-3) on samples of 100 plants and 300 leaves. A total of the scores is then used as an action threshold. This is

impractical for farmers. A threshold of 1 aphid-crinkled leaf per plant in the top four young leaves, with interventions above 5 damaged plants out of 25, is an easy and realistic threshold and broadly corresponds to a scientific threshold score of 60/100 plants which is not too aggressive.

Lygus bug - without sweep-netting lygus cannot be reliably sampled directly. Therefore, although the key damage may be to early leaf and fruit buds, a threshold of 5 plants in 25 with 'shot-hole' damage in at least one of the top 4 young leaves, is practicable and should pick up the presence of damage before lygus move to the fruit.

*Bollwor*ms – Shoot-tip damage by spiny bollworms appears to be uncommon and the site is, in any event, not accessible to sprays and the damage has been done before it is noticed. African bollworm is the most damaging species, as larvae will destroy several young squares or bolls in the course of their lives if left unchecked. Fruit buds which are attacked (even relatively superficially) are shed by the plant within 2-3 days. During that period, the bracts open to reveal the bud within and a gradual dying and yellowing occurs. Such drying and shedding can also occur for physiological reasons and therefore the 'flared squares' need to be examined for evidence of insect presence. All green bolls need to be examined for signs of larvae (holes or frass) at the base of the bracts. Note that this should also pick up pink and spiny bollworm entry holes in the bolls. The farmer therefore checks each plant for damaged flowers and flared squares and examines each boll for the presence of a larvae or 'fresh' damage. Of one *fresh* insect damaged fruit or bollworm larva is found the farmer scores the plant as damaged. The action threshold is 3 damaged plants per 25 sampled. This threshold may be relaxed to 5 per 25 plants later in the season. On an average 15-fruiting-point plant, this examination takes only 10 seconds or so.

Stainers – Stainers (esp. the red (*Dysdercus*) stainers) are highly visible species, even as nymphs, and are often present on the plant as mating couples. Damage to lint quality commences with the first puncture of bolls, therefore an intervention thresholds of 3 plants with any stainers on them in the 25 plant sample, constitutes an over-threshold population.

Recording method:
Keeping track of the number of plants sampled and the number of damaged plants for each pests is not something which can be done mentally but paper/pencil use occupies the hands needed for scouting and is, in any event, alien to these (and most) farmers. Therefore we will trial the use of 'pegboard' scouting. A c.20cm x 8cm x 0.5cm piece of wood has 5 columns of 25 +1 shallow holes drilled in it. At the top of the board, the head of columns 2 to 4 have a simple but recognisable outline picture of one key pest (aphid, lygus, bollworms and stainers). The first column is reserved for plant counts. A string attached to the sides of the bottom of the board is used to carry the board round the farmer's neck. *See paper 'pegboard' attached atthe end of this document*

Matchsticks sit in each of the '+1' holes at the top of the board before scouting begins. As the farmer scouts each plant the matchstick in the first (plant) column is moved down one hole. If damage or insect numbers of each pest is sufficient to score the plant as damaged, the matchstick in that column is moved down one hole. The threshold values are marked in red across the appropriate holes (row 3 or 5) for each species. The farmer scouts weekly until *either* the 25 sample is complete **or** until a threshold is crossed, triggering and intervention.

Interventions:
>5 Aphid damaged plants /25: soapy water (20ml of liquid soap per 15 litre tank or bar soap which has been rubbed in the water for three minutes) is sprayed **slowly**, with the nozzle of the backpack sprayer pointing upwards close to and below the plant canopy. Soapy water drowns aphids easily but good under-leaf and shoot-tip cover is essential as it has no residual action. These sprays do not have a major effect on beneficial insects. Note that heavy rain will reduce, but not necessarily eliminate, aphid populations. The generation time is short at 3-4 days.

Lygus: spray of organophosphate (chlorpyrifos or dimethoate preferred but only the Contra-Z pyr/OP mix is available this season).

[*Note*: Contra-Z is effective against a wide range of pest species but this mixture selects resistance by a range of metabolic and target-site mechanisms.]

Bollworms: Pyrethroid (20ml/15 litres) with a preference for Fenkill over Ambush as, although the efficacy against the pests is similar, fenvalerate has been shown to be rather less toxic to beneficials in Uganda than cypermethrin.

Stainers: These are relatively susceptible to most insecticides. Given that they are mostly late season pests, and that a pyrethroid for bollworms is likely to have been the preceeding spray, the preference is for an organophosphate insecticide (or Contra-Z if that is the only OP containing material available).

Spray interval: One week for soapy water (more frequent sprays are not worth the sprayer hire and labour costs). Insecticide applications would not normally be made at less than 10 day intervals (an average persistence for these insecticides applied with reasonable efficiency is around 10 days, more frequent spraying is therefore unnecessary). If, following an application, pest numbers/ fresh damage is still over threshold the following week, then an application 3 days later is acceptable.

Expected effects

Note that with threshold-based spraying, applications are made when pests are present in potentially damaging numbers. If well done, it follows that yields should not show any clear relationship to the number of sprays applied, as the less-sprayed plots did not need the extra applications.

Based on what was seen in the limited window of early season pests at Kasese and mid-season pests at Pallisa, it is expected that spray events should vary from 0 to 4 or 5, with an expected mean of 2-3. The improved targeting should raise average yields relative to those in ‘normal’ IDEA demonstration plots by a sufficient margin to cover any extra costs of scouting/spraying. Evidence for this will be examined after the 2002-3 season at Kasese.

Validation of the IPM system in 2002-3

Validation of the benefits of the IPM system requires:

a) Adequate farmer training in the principles (to appreciate the need for accurate sampling and targeted spraying) and practice in scouting and peg-board use.
b) Data from IPM plots, non-IPM plots and farmers fields which demonstrate:
    - That the pegboard system tracks insect numbers and damage adequately.
    - That pest numbers do indeed vary significantly from field to field and place to place (enough to justify the intensive scouting effort).
    - That the interventions proposed provide an added benefit compared with not spraying or calendar spraying which has a value at least equal to the costs of the work involved in scouting.

Proposed scouting for validation:

Given the late season at Kasese it is proposed that:

- Two clusters of 5 IPM plots be set up on top of currently unsprayed IDEA demonstrations.
- Five matched 'normal' IDEA plots act as sprayed controls (full recommended programme of 4 applications at fortnightly intervals from 35 days after germination) in each cluster.
- Five unsprayed farmers fields in the same area be used to track insect numbers in the absence of interventions in each cluster. *NB* Yield comparisons with farmers fields will not be useful as the other components of the IDEA package will have influenced both the potential yield and the likely pest pressure. The control is for the timing of changes in pest numbers in the absence of interventions.

Practical validation set up for 2002-3

1. 3 IDEA site co-ordinators to be appointed as IPM scouts/farmer trainers for each of the 2 clusters of 15 plots to be scouted and their payments substantially increased to account for the extra work (payed in 3 instalments)
2. IPM scouts will work separately for weekly farmer data collection and in groups of 3 for collection of the validation data, but each is responsible for the results in a specified 5 of the fields, and payment of the incentives reflect this.
3. Scouts to be trained in IPM principles and the pegboard scouting method.
4. Scouts will train farmers in the principles of IPM and in scouting/pegboard use, working beside the farmer to ensure good weekly data collection and that feedback on the method is obtained. IPM agents will transcribe the farmer pegboard information onto the paper pegboard sheets for comparison with the intensive scouting data.
5. Scouting by pegboard will be done *separately* for the normal-IDEA and IPM-IDEA high and low input plots every week.
6. Detailed validation scouting will be carried out on all plots (and on IDEA high and low input plots separately) every 2 weeks.
7. Validation scouting on each of the **50** plants per plot comprises (*see sheet attached*):

- Aphid scoring (Maximum of the individual scores(1=<10/leaf, 2=10-25/leaf, 3=>25/leaf) from the top 4 leaves).
- Aphid leaf damage – number of leaves/plant
- Lygus sweep net counts (insects/50 sweeps early in morning)
- Number of lygus damaged leaves per plant
- Number and species of bollworm counted.
- Stainers/plant (2 species) counted
- Number of squares/flowers/green bolls/open bolls/damaged bolls counted on *at least 30* plants.

Progress with the 2002-3 plan

- A second visit to Kasese was made on 1-4 October accompanied by:
  - David Luseesa, National IDEA cotton Co-ordinator
  - Dennis Kaijalahoire, Kasese district IDEA organiser
  - Dr Ben Sekamatte, NARO Serere cotton entomologist

[Dr Sekamatte is the cotton entomologist who carried out and published the IPM component of the World Bank Cotton Sector Promotion Programme up to 1996. His published work, with team leader Dr El-Heneidy, remains the most thorough and detailed work on cotton pests in Uganda and forms most of what is known about the current status of cotton pests in the country. Dr Sekamatte is very enthusiastic about practically applying the results of his earlier work in large-scale demonstrations which would enable his IPM principles to be validated. Although currently a member of the Oil-Crops Section at Serere, the Serere director, Dr Lastus Serunjogi, kindly agreed with the CPP project leader that Dr Sekamatte could support the setting up of the IPM trails, the training of IPM facilitators and the threshold validation work at Kesese this year, in addition to his other duties. Dr Sekamatte will provide on-going support to the IPM team in Kasese though two-weekly visits until the end of the 2002 season (prob. Jan 2003) or until he feels that the facilitators are doing an adequate job unsupervised. Any costs associated with this field work will be administered though IDEA, not Serere.]

- Two groups of farmer sites were identified. One in W.Kasese, in the Katojjo area on migrant farmers' blocks on the Queen Elizabeth park side of the main road. The IPM scouts were identified as: Andrew Bwambale, Sande Felix and Edson Kamerha. A second cluster of plots was placed in the central Kasese, in the Kabirizzi area on the slopes above the road with IPM scouts: Kambere Asef, John Kyakora and Kule Kamarha. The IPM scouts are all current IDEA site supervisors. Supervision of these staff is to be provided by Dennis Kaijalahoire.

- A general IPM theory training and an introduction to the biology of the main cotton pests and the theory of their control was carried out in the field with such limited visual material as could be organised at short notice.

Workplan for 2002-3 cotton season

IPM facilitators

- Training of farmers in IPM/IDEA plots immediately.
- Weekly scouting of the IPM/IDEA fields with farmers and recording of **farmer-collected** data.
- Week 8-12 Oct and then 2 weekly to 31 Jan 2003 – Plant and insect validation scouting in 10 IPM/IDEA, 10 IDEA and 10 farmer plots, with separate scouting in the High and Low input plots – therefore 50 scoutings per 2 weeks. Technical support to be provided by Dr Sekamatte. Data to be provided to Dr Sekamattee and so to myself.

Dr Sekamatte

- 8-15 Oct – procure 12 magnifying glasses, 12 sweep-nets and work with IPM facilitators to carry out validation scouting (probably with 2 technical staff from Namulonge) and refine the scouting procedure as necessary.
- To share and discuss with myself the data from the farmer scouting and validation work as it becomes available.
- To provide copies of existing training material and Uganda cotton IPM information to myself for incorporation into the training material for 2003.
- To take part in the March 2003 training of a much larger number of IPM facilitators (at least the 60 staff from Kasese and possibly Pallisa and other areas)
- To provide revised values for the 2002 IDEA cotton demonstration yields from the 7 districts (Kasese already available) - immediate.

Dennis Kaijalahoire

- To supervise regular weekly farmer scouting work by the six site co-ordinators.
- To supervise the fortnightly validation scouting of all blocks with Dr Sekamatte and the site co-ordinators.
- To buy and provide bicycles/coats/boots/clip-boards/bags for IPM facilitators and to pay them in three installments from the DFID/IDEA Training and Extension budget.

Derek Russell

- To develop training material for the March 2003 training of IPM facilitators and provide to IDEA for printing as required.
- To ensure that the World Cotton Conference-3 abstract on the IDEA work is complete on receipt of the information of 2001-2 yields from David Luseesa and Ben Sekamatte and returned to Dr Sekamatte by 18 Oct for submission to the organisers.
- To check incoming data and work with Dr Sekamatte and to refine the scouting system if required.
- To analyse the preliminary data from the 2002 season in Jan 2003 and help to prepare the consequent World Cotton Conference Paper.
- To visit Uganda for enlarged IPM facilitator training in Kasese (and Pallisa?) in mid-March 2003.

Estimated guideline for Kasese Budget for DFID year to end March 2003.

		UK Pound
NRI – Training materials -		250
T&S Uganda		2,250

		2,500
		Uganda/-
IDEA – Material for IPM scouts		930,000
Incentives for IPM staff		900,000

		1,830,000
NARO staff -	Technical support for scouting	
	Dr Sekamattee 24 days	2,400,000
	Technical staff 48 days	4,800,000
	March 2003 TOT	2,000000

		9,200,000

PAPER PEGBOARD – KESESE 2002

Date: **Observer:** **Field:**

Scouting method

- Walk 5 paces along a row and examine the 5th plant from the point where you stop.
- Now move two rows to the side, advance 5 paces along the row and examine the 5th plant from where you stop
- Continue until you have examined 25 plants or an insecticide spray threshold has been exceeded.
- Count any plant with the signs listed below as a damaged plant.
- If you pass 5 aphid damaged plants but have not reached the threshold on the other insects continue in case it is necessary to spray an insecticide rather than soapy water.

Aphid threshold – 5 plants with clearly damaged leaves in the top 4 on the plant.
Lygus threhsold - 5 plants with FRESH 'shot-hole' damage to the 4 top leaves
Bollworm threshold – 3 plants found with at least one bollworm larva or 3 plants with FRESH damage to squares (flared) or bolls
Stainer threshold – 3 plants with stainers on them (however many per plant)

.

Plant	*Aphid* **5 plants with damaged leaves**	Lygus **5 plants with damage on top leaves**	*Bollworm* **3 plants with larvae**	*Stainer* **3 plants with stainer adults or nymphs**
1				
2				
3			**XXXXXXXXXXX**	**XXXXXXXXXX**
4				
5	**XXXXXXXXXX**	**XXXXXXXXXX**		
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INSECT DATA SHEET- TWO WEEKLY - KESESE – 2002

Date: **Observer:** **Field:**

Plant No	Aphid Score (1-3)	Aphid leaves	Lygus count	Lygus damaged leaves	Bollworms			Stainers		BEN		
					Spiny	African	Fresh square/boll damage	Dusky	Red	Lady-beetle	Hoverfly larvae	Spi
1												
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3												
4												
5												
6												
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Scouting Instructions for the detailed two-weekly counts

Pests and damage to be recorded on *each* plant:

Aphid score –	turn over leaves. Score 1-10 aphids (nymphs or adults) per leaf as 1 Score 11-25 as 2 Score >25 as 3 If more than one leaf is infected, take maximum scores for *each plant*
Aphid leaves –	count the number of leaves per plant showing the typical aphid-induced curling
Lygus count –	count of lygus on the plant (most likely on top leaves and squares) from 50 sweeps of the sweepnet
Lygus leaves –	number of the top 5 leaves on plant showing ‘shot-hole’ damage
Spiny bollworm –	count larvae – look in damaged shoot tips and cut open suspicious bolls
African bollworm –	count larvae - look in ‘flared’ squares and look at all flowers and bolls.
Dusky stainer –	count nymphs and adults
Red stainer -	count nymphs and adults

Beneficials:

Ladybeetle -	count nymphs and larvae (all species)
Hover-fly larvae-	count (feeding on aphids)
Spiders-	count on plant
Ningininingi ants -	presence/absence, few/lot
Other-	others on plant (describe and count)

TWO WEEKLY FRUITING BODY COUNT
KESESE – 2002

Date: **Observer:** **Field:**

Plant No.	Square No.	Flower No.	Green boll No.	Open boll No.	Fresh damaged squares	Fresh damaged boll number
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						
Total						
Mean						

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Extending IPM practices into Ugandan cotton pest management

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Abstract

Since the 2001 cotton season, a USAID programme has been demonstrating the capacity of improved agronomy and the use of fertiliser and pesticide inputs to allow Uganda farmers to come closer to the yield potential of their cotton varieties by doubling or trebling conventional farmer practice yields. In the 2002 season a weekly peg-board-scouting based IPM system was overlain on the programme practices on a trial basis. Only the key pests: aphids, lygus bug, bollworms and stainers were scouted. Where possible, intervention thresholds were based on simple to observe plant damage on 25 plants/ half acre. Liquid soap replaced insecticides for aphid control and proved effective. Rotation of effective insecticides was attempted as far as the limited range of available chemicals allowed. Compared with the standard recommendation of 4 insecticides (at 35 days after planting and at two week intervals thereafter), average insecticide use was reduced by 50%. The high yields of the USAID programme were maintained. The standard calendar spray programme suppressed bollworms and stainers adequately. Additional advantages for bollworm and lygus control could be achieved with the IPM system. Compared with normal farmer practice in the same area, bollworm, lygus and cotton stainer impacts were reduced dramatically to economically acceptable levels. With the additional cost, labour and health impact improvements of the IPM system, these results have encouraged expansion of the IPM system, initially to nine hundred growers in Kasese and Palissa in 2003.

Introduction

Uganda's reported average cotton yield was c.100 Kg of lint/ha, or less than 300 kg/seed cotton/ha in from 200,000ha 2001 (ICAC 2002). Even allowing for overreporting of planted area and underseportingo f processed cotton, this is below the averages for other countries in Eastern Africa and well below potential of the BPA and SATU varieties grown. Low soil fertility, poor crop management, disease spread though the deregulated seed system and the depredations of the key aphid, lygus bug, bollworm and stainer pests are believed to be responsible (El-Heneidy *et al* 1995). To rectify these shortcomings, the Investments in Developing Export Agriculture (IDEA) project of USAID began a large-scale, long-term, programme in 2001 to demonstrate the benefits of uptake of earlier research in nine cotton districts. A relatively low input system (appropriate agronomy, fertilisers and some pest control on a calendar basis) was compared with a high input option (adding herbicide to save labour and to gain the benefits of low tillage). A system of part-time area co-ordinators, appointed and modestly funded by the participating ginneries, operate as extension agents and resource persons for small groups of farmers (normally 10 per co-ordinator) under the supervision of district organisers. Each demonstration farmer has half an acre in the 'low' input trial and half in the 'high' input trial. The 2001 work across the nine districts showed that, compared with the normal farmer practice yields of 574Kg/ha (itself much better than the national average), the yield on the low input plots doubled to an average of 1,057kg/h and the yield on the high input plots trebled (mean 1,809 kg/ha). However, the insect control recommendations remained as calendar spraying of four pyrethroids and pyrethroid/OP mixtures commencing at 35 days post planting, and at 14 day intervals thereafter, which were suspected of being ill-targeted and sometimes unnecessary.

Uganda has used only very limited amounts of insecticide on cotton (or other crops) and most of this has been made available through the government and ginnery run input-enhancement programmes. While it is desirable to obtain the yield benefits of increased input use, there is concern that Uganda should avoid stepping onto the ‘pesticide treadmill’ as has happened in so many other countries. Consequently the IDEA programme and the ginners combined to explore the prospects for incorporating IPM principles uncovered in earlier programmes (especially the IFAD/World Bank Cotton Small-holder Rehabilitation Project (1993-96) and the subsequent Cotton Sub-sector Development Project which ran from 1994 to 2000), to ensure that the productivity increases gained are sustainable.

The following are the major pest species. Aphids, *Aphis gossypii* Glover, stunt growth in the early season. Lygus bug**,** *Taylorilygus vosselori* (Poppham), feeding on leaf primordia, create ‘shot-hole’ damage in the emerging leaf. The cotton, or African, bollworm, *Helicoverpa* armigera (Hubner) is a major destroyer of multiple fruiting points. The spiny bollworm, *Earias insulana* (Boisduval*)* and spotted bollworm, *Earias vitella* Walker, cause minor damage as shoot tip borers early in the season and flower and boll damage later. *Pectinophora gossypiella* (Saunders) and *Cryptophlebia leucotreta* (Meyrick) are endocarpic feeders, particularly on the seeds and tend to be a late season problem in Uganda. Stainers, *Dysdercus* spp., cause piercing damage to developing bolls and secondary lint quality damage by allowing the entry of staining fungi. The smaller dusky stainer is also widespread. Early damage has most severe consequences and overwintering populations can be very large on any crop trash, raining the risk of harmful carry-over of pests between seasons. Whiteflies (*Bemisia tabaci* Gennadius) are a minor threat, although the position could change if insecticide use were more widespread. Semi-looper and leaf-folder caterpillars, although causing visible effects, are probably of little economic significance as cotton can tolerate a considerable reduction in photosynthetic area without impact on yield. *Helopeltis* sp. suck the outside of bolls causing unsightly scabs and occasionally allowing the ingress of bacteria or fungi, but infestations are rarely serious and easily controlled with the available insecticides.

Data on beneficial insects in the cotton system is largely limited to surveys of predators and parasitoids. El-Heneidy and Sekamatte (1998a and b and unpublished reports) report four species of parasitoid from cotton aphids, 21 species from the cotton bollworm complex (including nine new records for E.Africa) and placed these in their temporal context in terms of bollworm life cycles. El-Heneidy and Sekamattee 1996a cover the changes in bollworm predator numbers throughout the season. Ladybeetles, hover-flies, spiders and ants (esp. *Lepisiota* spp.) are important. Epieru (1997) examined predator incidence in cotton/bean intercropping in eastern Uganda focussing on the role of spiders. As yet, however, there is no data on beneficial/prey functional responses and there are no practical recommendations for manipulating the role of beneficials in the cotton system.

Work on the development of control action thresholds, particularly for lygus bug, was undertaken by Sekamatte and El-Heneidy (1998) who recommended a threshold of 10-15 insects per 50 sweep net samples and a mean lygus bug/cotton bud ratio of 0.09-0.15 using a 30 plant sample at 7-112 weeks after germination. Application of this threshold by technical staff resulted in a reduction in spray applications from four to two per season but the method is cumbersome and impractical for farmers. Similar work on the bollworm intervention action thresholds for American bollworm (Sekamatte and El-Heneidy 1997) at Serere Research Station identified an action threshold which, while maximising yields, was extremely conservative and would result in spraying if any larvae at all were found in a 25 plant sample. This may well have been an artifact of the very low *H.armigera* populations at Serere at the time and does not represent and appropriate recommendation to pass to the national extension system. No other threshold work has been undertaken in Uganda but some useful work at Serere explored the potential for trap cropping (El-Heneidy and Sekamatte 1996b). This showed the attractiveness of sorghum to lygus bug and cotton stainers, of maize to stainers and of beans to whiteflies and jassids. These associations are been tested for their practical benefit in intercropping trials taking place in 2003. Sekamatte (1994) examined the pest status and control options for cotton aphid and Sekamatte and Ogena-Latigo (1999) looked at the efficacy and impact of chemical control on the cotton aphid and its predators.

Materials and Methods

In the 2002 season, trails began to overlay an IPM system on the IDEA demonstration plots, to rationalise and possibly reduce insecticide use, while improving pest control through better targeting.

Insects are often difficult to see (e.g. the nocturnally active lygus bug), to count (e.g. jassids and whitefly) and then to translate the counts into a risk of economic damage. The scientific thresholds therefore required to be simplified for farmer use, avoiding the need for sweep-nets, fridges and complex calculations etc, but also reducing the time input and focussing on the visible damage to plants. Action thresholds were developed, which, while taking into account the earlier work, were practical and based on evidence of a real risk to yield. Inevitably, however, such proxy assessments reduce the accuracy of the assessment of pest numbers. For example, the lygus bug damage of most significance to yield occurs in the fruiting phases, but the presence of a certain level of current damage to leaf primordia as seen in the youngest, unfolding, leaves can be used to detect an over-threshold population and interventions can prevent the majority of the economic damage which would otherwise follow.   On the other hand, cotton stainer damage to lint can only bee seen when it is too late to rectify and therefore a threshold of live insects on the plant was chosen.

Sampling system: The sampling domain of 25 plants is a compromise between the increased accuracy of higher sample numbers and the time-use difficulty occasioned to farmers in scouting when plants reach their full size. The sampling system comprises a random starting point within the field, stepping across five rows, walking 5 paces along the row and then examining the 5th plant along the row from the point at which you stop. The procedure is repeated for the second and subsequent plants and results in the farmer taking a zig-zag course across the field. To avoid the need for written notes to be made during weekly scouting, pegboards (as pioneered in Zimbabwe fify years ago and now used in Zambia and S.Africa) were used. These were wooden boards c.20cmx10cm with columns of holes drilled capable of holding match-stick sized pieces of wood or grass stems. The first column represents the 25 plants of the sample and the stick in this column is moved down as each plant is examined. The other four columns are for aphid damage, lugus damage, bollworm larvae or damage and stainer presence. As the plant is the sample domain, the insect columns are marked for action at the number of affected plants according to the criteria below. If the threshold for any pest is exceeded at or before 25 plants are examined, an intervention is called for and scouting can cease for that week. The exception is aphids. As soap is effective against aphids but not the other pests, even if the number of aphid damaged plants is over threshold, scouting continues to ensure that an insecticide, rather than soap, spray is not required.

Action Thresholds (per 25 plants examined):
Aphid: 5 plants with any aphid-crinkled leaves in the top four young leaves
Lygus: 5 plants with at least some ‘shot-hole’ damage in the top 4 leaves young leaves
Bollworms: The farmer checks for insect 'flared' squares, larvae in flowers and damaged bolls. 3 plants with any fresh fruiting structure damage (squares, flowers or

bolls) or with living larvae. This may be relaxed to 5 damaged fruiting points or larvae in the second half of the season
Stainers: 3 plants with any stainers present.

Damage has to be fresh (not more than a few days old) in order to avoid repeat sprays for the same damage.

IDEA site co-ordinators staff were given a day's theory training in the principles of IPM, pest identification and scouting and a day of field practice in identification, scouting, decision making and spray practices. This should enable them to train farmers in the significance and practice of the IPM system. In this trial year, the technical team worked with the site co-ordinators to train and support farmers.

IPM practices incorporated:

- Scout for pests (using pegboards as decision tools) on 25 plants in a half acre using the specified random plant selection system.
- Spray only when thresholds are exceeded
- Avoid spraying toxic materials as long as possible to maintain beneficials. Soap sprays were used to control early season aphids.
- Spray the least widely toxic material which will be effective in control of the over-threshold pest.
- Apply at a minimum spray interval of 10 days.
- Rotate chemistries to reduce resistance risks. – not really possible with the restricted pyrethroid and pyrethroid OP mixes currently available.
- Stalk destruction in the late season to reduce carry-over of stainers and pink bollworm.

Given the desire not to enhance resistance problems, the schedule of spraying if over threshold was:

- Aphids - liquid soap (20 ml/litre water)

- *Lygus - Organophosphate*
- *Bollworm - pyrethroid (fenvalerate preferred over cypermethrin at first spray, organophosphates if previously sprayed with pyrethroids (Sekamatte and El-Heneidy 1987).*
- Stainer - Organophosphate if previous spray was pyrethroid for bollworm, otherwise pyrethroid

Chemicals, as bought on the tender market in 2002 and made available to farmers though the Cotton Development Organisation/ginners scheme were:
Contra-Z - 500g chlorpyrifos (OP) + 50g cypermethrin (pyr)/litre
Fenkill - 200g fenvalerate(pyr)/litre
Ambush - 200g cypermethrin (pyr)/litre
Ambush-Super - 200g lambda-cyhalothrin (pyr.)/litre
Rogor - dimethoate (OP)
Generally only one or two of these would be available for collection from the ginnery at any one time

To trial the practicality and benefits of the IPM overlay, a pilot study was run in 2002 in the Kasese cotton district of W.Uganda, utlising IDEA site co-ordinating staff form Nakatonzi ginnery. A three-way comparison was made between:

1. Normal farmer practice (10 plots), with irregular agronomy and variable attempts at pest management.
2. IDEA demonstrations (10 plots – high and low input). Four insecticides at 35 days after planting and 14 days intervals thereafter.
3. IPM practices overlaid on IDEA plots (high and low inputs).

IDEA demonstration co-ordinators from Nyamatonzi Co-operative ginnery (normally with 10 farmers per co-ordinator) acted as the extension agents for trial. Two groups of five farmers participating the IDEA demonstration programme, at the centre and western end of Kasese district (Kabrizi and Katholu zones) were matched with two sets of controls. The IDEA co-ordinator helped the IPM farmers to learn how to undertake weekly peg-board scouting on each of their low and high input half-acres and to make appropriate pest management decisions. These fields were also scouted on a more intensive basis (50 plants with insect counts) at fortnightly intervals by the co-ordinators assisted by the technical team, as a check on the appropriateness of the pest management decisions from the farmer scouting. The first controls were neighbouring farmers who were part of the IDEA demonstrations and whose low and high input fields were scouted fortnightly by the co-ordinators and the technical team, but who did not apply the IPM practices (pest management was calendar spraying). The second controls were matched non-participating farmers from the same areas whose fields (0.5 to 1 acre) were also scouted fortnightly by the technical team but whose agronomy and pest management was the normal practice for the area (and was therefore very heterogeneous).

Results:

Weekly farmer scouting ran from mid-October 2002 to mid-January 2003 assisted by the site co-ordinators. The fortnightly detailed scouting by the technical team from NARO ran from 23 Oct to 15 January. Scouting half an acre took an average of 20 minutes after the first three, learning, sessions.

The IDEA control plots were sprayed an average of 3.4 times (less than the four intended due to poor insecticide availability) starting from 35 days after planting. The control farmers applied an average of 1.6 insecticides, the low number being caused in part by poor availability but this is probably typical for the region. Half the IPM plots required one application of soap for aphid control. On average 1.6 other insecticide applications were made in the IPM areas (figure 1). The high and low input plots had similar insect profiles throughout the season and the great majority of spray decisions were the same for the two (contiguous) high and low input plots in the same week.

Bollworm numbers, Lygus bug damage and the proportion of lint stained following the activities of cotton stainers, were all much higher in the farmer practice blocks (figure 2). The bollworm numbers were low in the IDEA control plots and the experimental IPM plots and the resulting damage was modest (<5%). Lygus bug damage was substantially higher in the standard IDEA plots than in the IPM plots. In both the standard IDEA plots and the IPM plots stainer numbers and consequent damage were low.

The use of the standard IDEA low input agronomic and pest management practices again enhanced yields by an average of 2.7 fold compared with farmer practice and the high input system increased yields three fold. There was no significant difference in yields caused by the addition of the IPM practices to the IDEA plots. The saving in time spent spraying in the IPM fields, compared with the standard four spray recommendation, was sufficient to undertake 10 scouting sessions on the field, and more if the need for water carrying for spraying is included. There were, of course, additional financial and health hazard exposure benefits gained from the IPM system.

Conclusions

Improving farmer understanding of the biology of the major cotton pests in Uganda has enabled the incorporation testing of an IPM system incorporating the use of insecticides only at action thresholds, following the scouting of pest and their damage using pegboards. Insect control (esp. of lygus bugs) was improved over the standard calendar spraying programme, although this itself was a major improvement on normal farmer practice in terms of incest control and yield protection. The IPM practices used no more toxic material than the farmers practice and only half of that in the recommended calendar spray system, without adversely affecting the cotton yield improvements obtained with the IDEA programme. There were, however, difficulties of timely availability of appropriate spraying materials in these trials which must be resolved. Assessing the costs and financial benefits of the different systems is difficult in these small trails, as the additional inputs were provided free to the IDEA programme participating farmers and very considerable technical advice and support was provided to the trial farmers. The IPM components should add no cash cost beyond that of the pegboard (which can be home-made) to the costs of the IDEA system. The additional time spent on scouting (average 20 minutes/half acre/week) was more than compensated for in reduced spraying time and costs in the current trials. It should be clear, however, that the benefits of any pest management system which carries intervention costs is going to be proportionately higher when there are better yields to protect, as in the IDEA demonstrations. A full evaluation of the IPM system will be made following its expansion to hundreds of farmers in a number of sub-counties in two cotton districts (Kassese and Pallisa) in 2003.

Acknowledgements

The addition of the IPM component to the IDEA/SPEED project of USAID on cotton in Uganda is funded though a project of the Crop Protection Programme of the UK's Department for International Development. The cooperation of the extension staff at Nyamatonzi ginnery led by Dennis Kaijabahoire is greatly appreciated as is the scouting assistance from technical staff from Makerere University.

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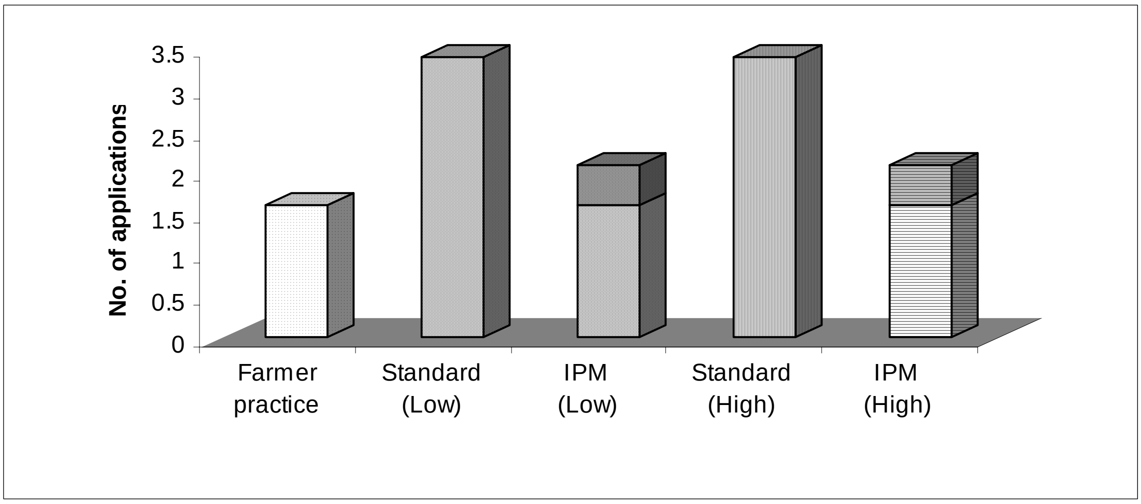

Figure 1: Pesticide use.
Shaded areas are liquid soap applications for aphids. *'Standard' refers to the normal IDEA/SPEED practices as detailed in the text. IPM practices replace the pest management component of standard practices while retaining the other components.*

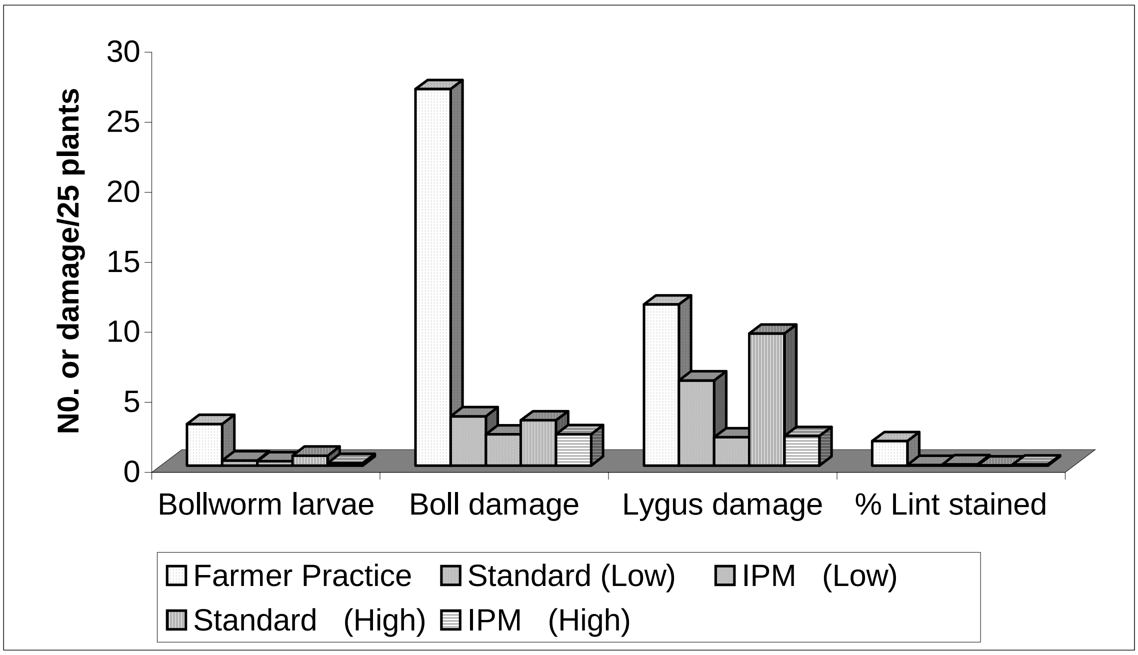

Figure 2: Insect impact on cotton

Bollworm larvae: number per 25 plants, Boll damage: bollworm damaged bolls per 25 plants, Lygus damage: number of damaged plants, Lint stained: % of 4kg sample.

'Standard' refers to the normal IDEA/SPEED practices as detailed in the text. IPM practices replace the pest management component of standard practices while retaining the other components.

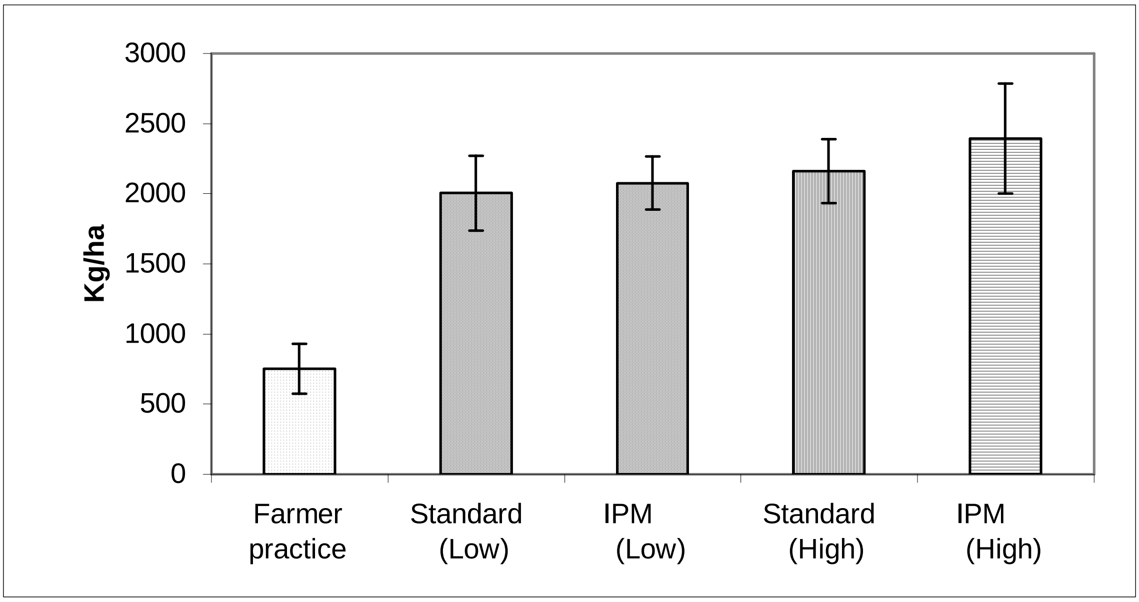

Figure 3: Seed cotton yield (Kg/ha +/- s.d)
'Standard' refers to the normal IDEA/SPEED practices as detailed in the text. IPM practices detailed in the text replace the pest management component of standard practices while retaining the other components.