Extending IPM practices into Ugandan cotton pest management

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ABSTRACT

Since the 2001 cotton season, a USAID program has been demonstrating the capacity of improved agronomy and the use of fertilizer 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 program 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 four insecticides (the first applied at 35 days after planting and at two week intervals thereafter), average insecticide use in the IPM trial plots was reduced by 50%. The high yields of the USAID program were maintained. The standard calendar spray program 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 in the standard and IPM trial plots. With the additional cost, labor 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 from 200,000 ha in 2001 (ICAC, 2002). Even allowing for over-reporting of planted area and under-reporting of 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, program in 2001 to demonstrate the benefits of uptake of earlier research in nine cotton districts. A relatively low input system (appropriate agronomy, fertilizers and some pest control on a calendar basis) was compared with a high input option (adding herbicide to save labor 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 coordinator) 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 574 kg/ha (itself much better than the national average), the yield on the low input plots doubled to an average of 1,057 kg/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 programs. 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 program and the ginners combined to explore the prospects for incorporating IPM principles uncovered in earlier programs (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, creates 'shot-hole' damage in the emerging leaf. The cotton or American bollworm, *Helicoverpa armigera* (Hübner), 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. sucks 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, b; 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 (especially *Lepisiota* spp.) are important. Epieru (1997) examined predator incidence in cotton/bean intercropping in eastern Uganda focusing 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 seven to 12 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 maximizing 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 being 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.

Experimental procedure

In the 2002 season, trials 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 focusing 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 five paces along the row and then examining the fifth 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 South Africa) were used. These were wooden boards c. 20 cm x 10 cm 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, lygus 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	Five plants with any aphid-crinkled leaves in the top four young leaves
Lygus	Five plants with at least some 'shot-hole' damage in the top four leaves young leaves
Bollworms	The farmer checks for insect 'flared' squares, larvae in flowers and damaged bolls. Three plants with any fresh fruiting structure damage (squares, flowers or bolls) or with living larvae. This may be relaxed to five damaged fruiting points or larvae in the second half of the season
Stainers	Three 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 coordinators 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 coordinators 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/liter 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	- 500 g chlorpyrifos (OP) + 50 g cypermethrin (pyr)/liter
Fenkill	- 200 g fenvalerate(pyr)/liter
Ambush	- 200 g cypermethrin (pyr)/liter
Ambush-Super	- 200 g lambda-cyhalothrin (pyr)/liter
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, utilizing IDEA site coordinating 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, starting at 35 days after planting and 14 days intervals thereafter.
3. IPM practices overlaid on IDEA plots (high and low inputs).

IDEA demonstration coordinators from Nyamatonzi Co-operative ginnery (normally with 10 farmers per coordinator) acted as the extension agents for trial. Two groups of five farmers participating the IDEA demonstration program, at the center and western end of Kasese district (Kabrizi and Katholu zones) were matched with two sets of controls. The IDEA coordinator 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 coordinators assisted by the technical team, as a check on the appropriateness of the pest management decisions from the farmer scouting. The first controls were neighboring farmers who were part of the IDEA demonstrations and whose low and high input fields were scouted fortnightly by the coordinators 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 covered the normal range of practices 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 coordinators. 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 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 (especially of lygus bugs) was improved over the standard calendar spraying program, although this itself was a major improvement on normal farmer practice in terms of insect 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 program. 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 trials, as the additional inputs were provided free to the IDEA program 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

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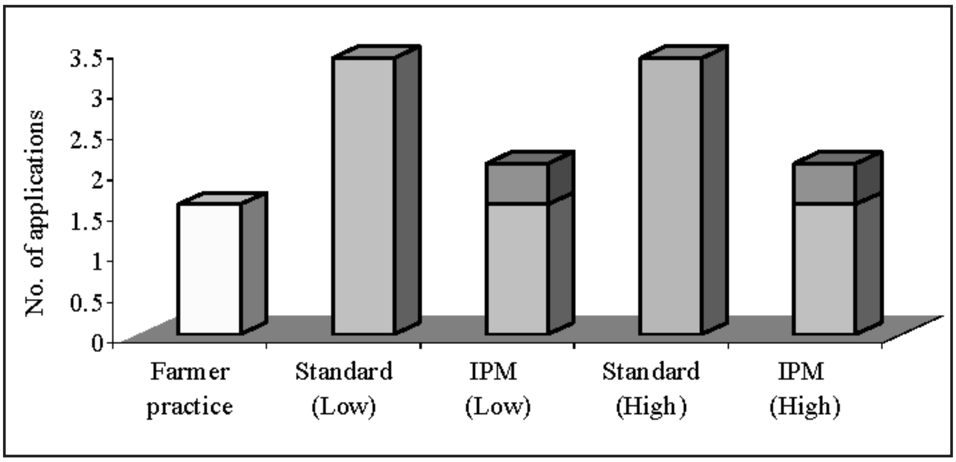
Figure 1. *Pesticide use. 'Standard' refers to the normal IDEA/ SPEED practices as detailed in the text. IPM practices replace the pest management component of standard practices while retaining the other components. The small shaded areas in the IPM treatments are liquid soap applications for aphids.*



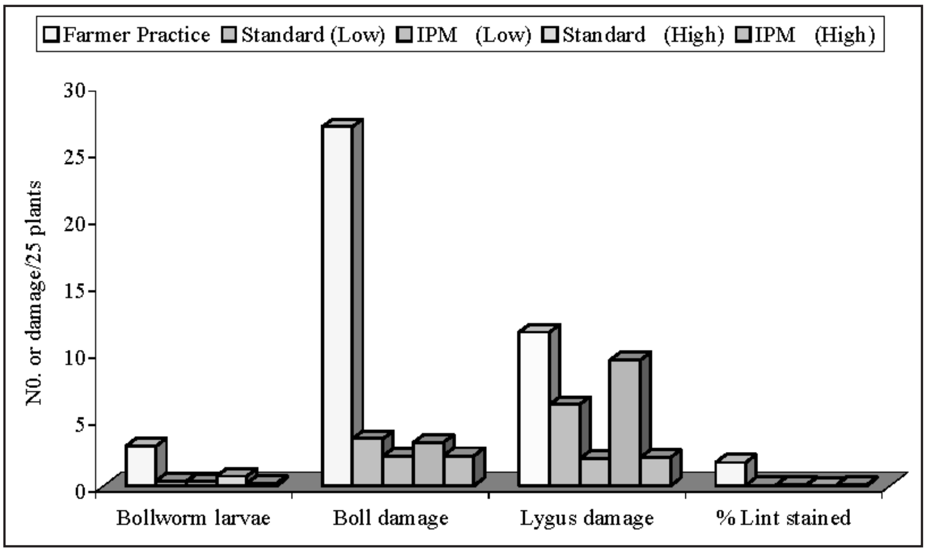


Figure 2. *Insect impact on cotton. Bollworm larvae: number per 25 plants, Boll damage: bollworm damaged bolls per 25 plants, Lygus damage: number of damaged plants, Lint stained: % of 4kg sample. 'Standard' refers to the normal IDEA/SPEED practices as detailed in the text. IPM practices replace the pest management component of standard practices while retaining the other components.*

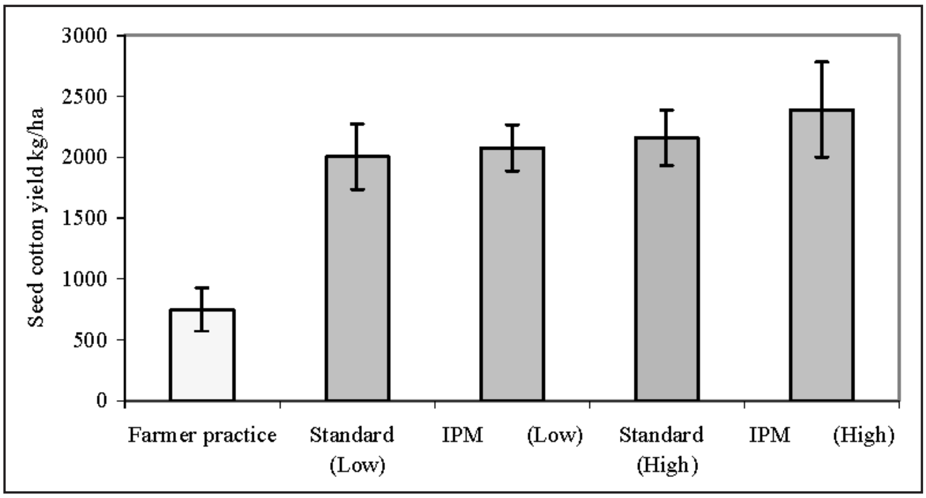


Figure 3. *Seed cotton yield (kg/ha ± s.d). 'Standard' refers to the normal IDEA/SPEED practices as detailed in the text. IPM practices detailed in the text replace the pest management component of standard practices while retaining the other components.*