CROP PROTECTION PROGRAMME

Promotion of IPM for smallholder cotton in Uganda

R8403 (ZA0631)

FINAL TECHNICAL REPORT

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NRI

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Executive Summary

Cotton is second in importance to coffee among Uganda's agricultural export crops. It is grown almost all over the country although concentrated more in certain key districts where it is one of the main sources of cash income for smallholder households.

The purpose of the project was to contribute to making cotton more profitable for smallholders by improvements in crop and pest management. This was done by validating and demonstrating crop production and crop protection technologies to decrease labour input and increase cost effectiveness of input use. The outputs of the project have added-value to the previous project by further promoting IPM in an expanded demonstration programme of more than 7000 on-farm demonstrations. As the contact farmer is changed after 2 years and each farmer is asked to bring at least 15 friends and neighbours to the plot, the technology has been promoted to over 180,000 cotton farmers in Uganda which is a significant majority of all cotton farmers in the country. To support the demonstration programme 700 ginnery staff were trained as trainers in IPM.

Our IPM model was promoted through strong partnership between research and the private sector with 22 ginning companies actively engaging in agricultural service delivery.

Our M & E activities have shown that on-farm demonstrations are an effective way to transfer knowledge and there has been considerable adoption of improved cotton crop management methods. Insect control and yields are improved in demonstrations farms implementing the IPM component. However, in order for the Ugandan cotton system to take maximum benefit from the training and demonstration system, longer and more detailed training of trainers is required and they in turn need to be able to support the demonstration farmers with more frequent visits. For example, although most contact farmers owned an insect scouting peg-board and understood its use, promotion of regular use of scouting to inform spray interventions is help back by the logistics of provision of suitable intervention chemicals at the time when they are required. The facilitation of further, frequent, contact between farmers and service providers will gradually create a better awareness of the long-term benefits of adopting IPM.

The high labour requirement for land preparation and weeding is a major constraint to smallholder cotton production. The project has shown that use of animal draft decreases labour input and we produced a training manual for using Draught Animal Power. As a result of our work, APEP will be introducing training in the use of DAP in their cotton demonstrations from 2006 using the instruction manual produced in this project.

The outputs of the project have contributed to DFID's development goals by promoting and helping to embed technologies that make it more profitable for smallholders to participate in commercial farming in Uganda. While Uganda has a competitive advantage in the growing of quality cotton, current low world prices and subsidies in developed countries result in low returns to investment in cotton for Ugandan farmers. However, in partnership with the CDO/APEP demonstration system, we have demonstrated that cotton growing can still be a worthwhile livelihood strategy if practices are adopted to decrease labour and improve the cost-effectiveness of input use. The project has shown that increased use of animal draught is highly labour-efficient and that adoption of IPM increases yields and maximises the return to optimal insecticide use.

Background

In developing and promoting IPM systems for cotton smallholders, the project in Uganda [R8197] builds on the success of the previous CPP-funded cotton IPM projects in India [R6734 and R6760] and adds to the knowledge gained in first two-year phase in Uganda [R8197]. In both regions, the bollworm *Helicoverpa armigera* is one of the main insect pests.

Under R8197, we developed a collaboration with the US-AID-funded IDEA project [now superseded by APEP], that was promoting improved crop management, but without an IPM component. Based on our earlier biological and socio-economic surveys, an IPM system was designed and applied to the IDEA demonstrations. Success of the IPM system in 20 demos in Kasese in 2002-3, decreasing sprays from 4 to 2.5 and improving insect control and profitability, led IDEA/APEP to trial our IPM system in 300 demos in Kasese and 300 in Palissa in 2003-4 with similar success. The system was then (2004-5 season) adopted in all 6,000 demonstrations in all the major cotton districts.

The project was based on two innovations. Firstly ,the new national extension promotion system of working with private sector ginning companies which invested in crop development by providing the extension officers and limited inputs, provided a highly motivated work force whom we trained in IPM within the APEP demonstration system. Secondly, we developed training materials, a rational and tested insecticide use programme and a peg-board-based scouting system so that farmers could base their spray timing and materials on simple pest thresholds following the examination of a sample of plants in the field. When required, the first insecticide spray has previously been directed against aphids but this disrupts natural enemies. In the IPM system, soapy water is recommended, rather than insecticides for aphid control. Subsequent sprays are informed by scouting for Lygus bug, bollworms and cotton stainers with chemical applications, where needed, following best IPM practices in terms of timing, dose, application, material and the avoidance of resistance development. Pesticide use is better targeted using the scouting system and decreases insecticide use in seasons with low pest pressure. Better targeting increases the cost-effectiveness of insecticide inputs

Taking the whole ICPM system, the use of reduced tillage with herbicide is cost-effective, eliminating the need for one ploughing with longer lasting weed control..

Six hundred cotton extension workers employed by ginning companies have been trained as trainers, each of whom works with 10 demonstration farmers. Each of these demonstrations is, in turn the focus for a further c 15 farmers who formally observe the progress of the cotton production over the system and learn from it. The programme therefore impinges on cotton production practices of c.90,000 farmers per year, around a quarter of the total number of cotton farmers in the country.

As the demonstration programme has scaled up, maintaining training and supervision quality has become increasingly important. The project set out to support the training, develop improved weed control systems and to assess the impact of the IPM component of the demonstrations in particular, with a view to further refinements of the process in future seasons.

Project Purpose

Uganda and other countries in the region have a competitive advantage in cotton production. Despite poor world prices, cotton remains an important source of cash income for around 250,000 households, mainly in eastern and north-western Uganda. Low world prices mean that efficient production systems are required to maximise yields. However, average yields are low, due mainly to poor crop management.

The purpose of the project was to contribute to making cotton more profitable for smallholders by improvements in crop and pest management. This was done by supporting the validation and demonstration of crop production and crop protection technologies aimed at decreasing labour input and increasing the cost effectiveness of input use.

This phase of the project shared activities on animal draught with a project under the Livestock Research Programme

Research Activities & Outputs
Activities were carried out in Uganda in partnership with APEP, NARO's cotton team and the private sector ginning companies.

Activities carried out

1. Technical support to the APEP on all aspects of IPM, including the debate on introduction of Bt/HT cotton

2. Design of training literature and courses and an exploration of the capacity for Busitema Cotton Training College to become a national cotton extension training centre.

3. Monitoring and evaluation survey of cotton ICM technology adoption.

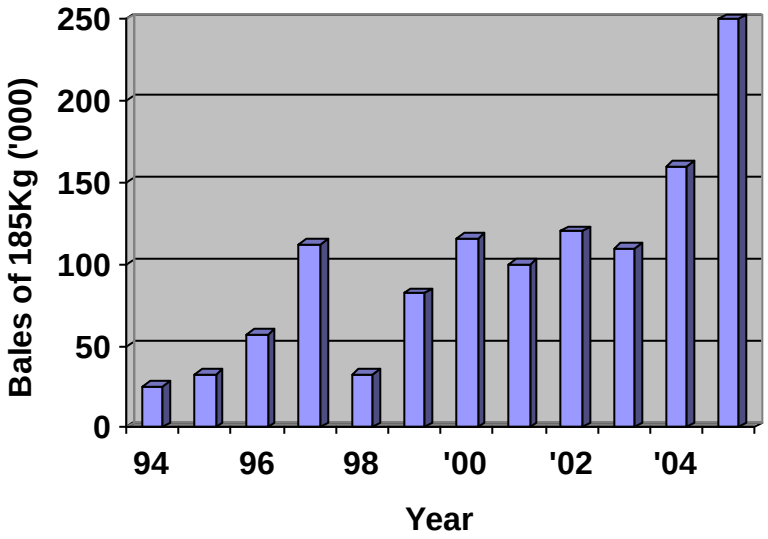
4. Field trials to validate and demonstrate the use of animal draught for inter-row cultivation as a cost-effective labour-saving technology.

Outputs

OUTPUT 1: Capacity developed to support scaling-up of IPM system from 600 to 6000 demonstrations.

Progress in production enhancement:
CDO announced at the International Cotton Advisory Committee Plenary Meeting in Liverpool in Sept 2005 that Uganda had produced 253,000 lint bales (of 185kg) in the 2004-5 season, up from 158,000 bales the previous year. The 2004-5 average yield nationally appears to be c.350kg seed cotton acre (c. 300kg lint/ha at a ginning out turn of 35%). This would suggest a cotton acreage of 381,000 acres if the average is correct. This is a terrific result, more than doubling national production since the start of the CPP project. The Director of CDO confirmed from the platform that the APEP programme had contributed strongly to this positive result (mentioning the CPP-supported contribution by NRI specifically).

Fig 1: Ugandan cotton production since liberalisation in 1993. (1998 was an El Nino year) (data ex CDO statistics)



This achievement is the cumulated result of the effects of the Cotton Development Act of 1994 which liberalised the sector (with World Bank and IFAD support 1994-2000), the rationalisation of ginnery holdings away from the underperforming Farmer Co-operative Unions (only two remain, Nyakatonzi and Lango) and the entry into the ginning market of international players (Dunavant (USA), Paul Rhinhart (Swiss) and a number of Indian Companies, joining the long established North Bukedi Mills (S.Africa/UK) and Bon Holdings (Kenya) and the technical extension effort initiated by CDO and supported by the new Ugandan Ginners Association (60%) and later USAID's APEP programme and its predecessors (40%). Ginners were expected (and from May 2005 required), to make extension investments in the districts from which they are buying. The widespread prevalence of 'side-selling' led to a strengthening of these zoning arrangements (8 production zones each with a lead ginner) under elements of the Cotton Development Act and the results can be seen in the national productivity figures. This government/ private sector/ donor partnership is proving very successful in Uganda.

<u>IPM components of the Demonstration Programme</u>
With experience over the last four years, the insect control component of the demonstration package has been pared down to these elements.

Aim: to economically minimise the impact of pests on yields without adversely affecting human or environmental health or long-term sustainability.

Practices:
Control pests over thresholds after scouting.
Scouting weekly – 25 plants per plot on specific selection pattern
Thresholds:

Early season pests	aphids	3 plants with damage in the top leaves
	Lygus bug	3 plants with fresh shot-hole damage in the top leaves
Mid-season pests	Bolloworms	5 plants with larvae or fresh damage to bolls or shoots

Late season pests Stainers 5 plants with any stainers present

Monitoring method – wooden 'pegboard' with rows of holes for plants examined and pest/damage encountered. Wooden peg is moved down the row and action is triggered when the pre-marked threshold number is reached.

Insecticidal practice for overthreshold insects

The recommendation:

avoids early season toxic sprays
avoids the use of mixtures
rotates active ingredients to avoid resistance
uses the most effective chemical group on each pest species

Stage of pest incidence	Product group
Aphid	Soapy water sprayed upwards on the underside of leaves
Aphid plus Lygus bug	Single systemic insecticide (usually an organophosphate)
Early bollworm	Single pyrethroid
Late bollworm	Single organophosphate (or a pyrethroid if there have been no early bollworm sprays)
Stainers	Either a single pyrethroid or a single organphosphate – not the same group as the last material sprayed

Trainers introduce the principles of IPM; provide information (and visuals) on the key pests and beneficial organisms; discuss the rationale for the use of particular thresholds and pesticide groups; and train farmers in the practice of scouting and pest identification/ pegboard use.

Results from the application of the IPM programme

Benefits in pest reductions and yield increases were demonstrated for the IPM system under the preceding project [R8197] for the 2002-3 harvests. The expansion of the IPM component to 600 demonstrations in two districts in 2003-4 was the last opportunity to collect comparative data from non-IPM versus IPM demonstration plots. The CPP project (IPM) data was collected and was to be contrasted with the USAID SPEED project data. This was collected from thousands of farmers but appears never to have been analysed. Repeated attempts by APEP and NRI staff to locate the data sheets have failed and a major opportunity for validation of the IPM programme has been lost***.***

A very large scale (2,000 farmers) assessment of the progress of the APEP programme in general was undertaken by the APEP monitoring unit at the end of the 2004 cotton season. This is a very valuable, but subjective, with farmers asked for their views on the training, rather than measuring directly their impact.

Respondents ranked cotton production practices for ease of understanding and level of adoption. Scouting and peg-board use were unfamiliar to both trainers and lead farmers and the most difficulty was experienced here (Fig.2). Full adoption of the pegboard for example was achieved by only around 21% of respondents as opposed to the 'best understood' component, fertiliser use, at 30% full adoption (Fig.3). However, when full and partial adoption are summed, both pegboard utilisation and fertiliser utilisation had a 57% uptake.

Fig. 2. Demonstration practices reported as 'difficult to understand' by c.2,000 farmers surveyed by the APEP monitoring unit (all cotton zones except W.Nile) in 2004. (figure from APEP monitoring unit study of adoption 2004) **LF – lead farmer, CF – collaborating farmer, OF – other farmers**

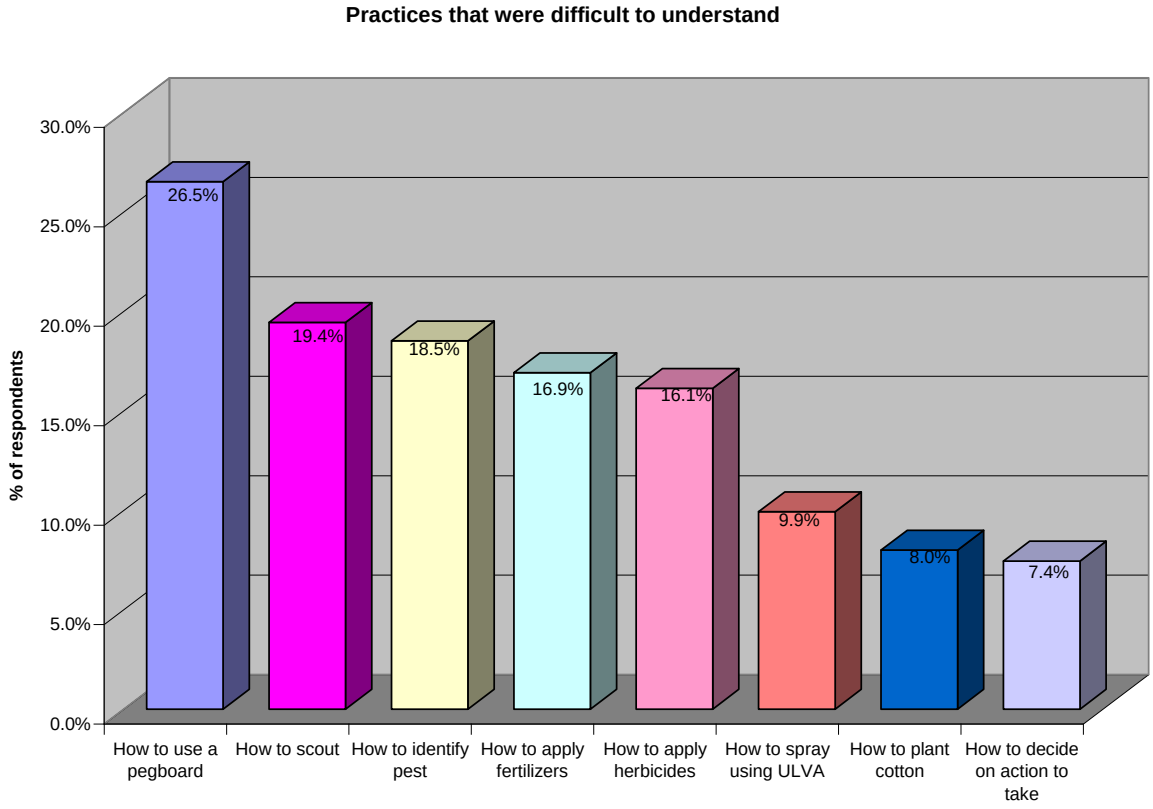
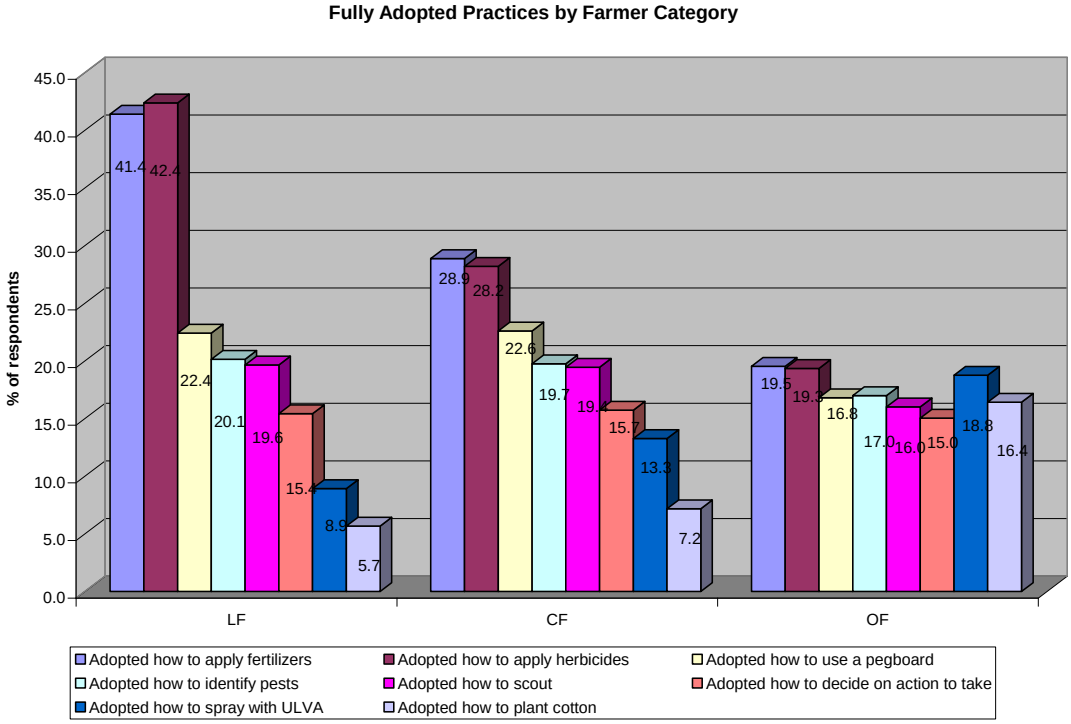


Fig.3. Demonstration practices reported as 'fully adopted' by c.2,000 farmers surveyed by the APEP monitoring unit (all cotton zones except W.Nile) in 2004. (Figure from APEP monitoring unit study of adoption 2004**)** LF- lead farmers, CF – collaborating farmers, OF-other farmers



These were all farmers in their first year of demonstrations, nonetheless the stated full adoption rates were low (even for planting correctly). It is clear that more support and encouragement can be given in the field during the season, through the trainers to the lead farmers and so to the collaborating farmers, the more impact the programme is likely to have.

By the 2004-5 all demonstration plots were IPM plots. Core trainer experience was well developed but the rapidly increasing number of demonstration plots was stretching capacity to quality control the operation and to provide adequate input and follow up on technical matters. Problems are itemised below. In order to confirm the continuing benefit from the demonstrations, we undertook a small confirmatory examination of the efficacy of the IPM programme in 2004-5, with the Makerere University Technicians employed under the project visiting 10 IPM demonstration plots and 10 non-demonstration farmer plots in the surrounding area in each of four districts, every two weeks. Table 1 has the summarised results.

Table 1. Effects of the agronomy + IPM demonstration system in 2004-5. Means of 10 demonstration plots and 10 non-demonstration plots per district. Data collected twice monthly by technicians.

District	% change in indicator in the IPM demonstration plots			
	Number of insecticide applications (inc soap)	Bollworm numbers in demonstration plots	Mean yield of seed cotton per acre	Mean Yield in Kg of seed cotton in demonstration plots
Mbale	+41%	-41%	+63%	336 Kg
Palissa	+66%	-42%	+69%	220 Kg
Lira	+78%	-85%	+43%	417 Kg
Kassese	+13%	-87%	+60%	583 Kg

Taken over the four districts this was a 59% increase in cotton production when compared with local non-demonstration farmers. This was a small confirmatory trial only, but there are some elements worth noting. The demonstration system continues to provide very significant yield increases in all area. The reduction in bollworm numbers undoubtedly contributes to this. In the higher yielding volcanic soils of the south – at Kasese, farmers already use approximately an appropriate level of insecticides but the IPM programme greatly improves the timing of these and appropriate materials are used and bollworm reductions were highest (87%) in Kasese. It is not possible to partition the yield increases to the effects of improved pest control or the other components of the demonstration system, but this study confirms the continuing value of the package as a whole.

Of course these effects have been achieved partially through increases in pesticide use. Levels of use in the demonstration plots should reflect the need to control pests as decided by the scouting process. However, other than in the demonstration plots farmers are generally spraying 1-2 times if they are buying the material themselves, or up to 4 times (the old national, calendar, recommendation) if the insecticide is provided by the ginner as part of the extension process. The apparent increase in applications therefore represents access to materials at the right time, and no district had an average of over 4 insecticide applications, which would generally be regarded as a light spray programme internationally. The pesticide is bought in bulk on tender and supplied 'free' to the farmer, and the economic benefit of increased targeted spraying in the absence of the demonstration system cannot be accurately quantified. However, even in the district with the poorest yields, the retail cost of the additional pesticide used was less than one third of the value of the yield gain.

Support for the IPM component of APEP

The APEP demonstration programme has continued to grow. In the 2005 cotton season all the ginners nationally were formally a part of the process, although the level of input provision and extension advice support naturally varied with the smaller and newer companies playing a lighter role. Lead ginners in each zone were very active however, and 7,000 formal demonstration plots were set up and managed, with a further c.1500 run by the ginners but these were beyond the support capacity of APEP. The ginners provided staff (off season ginnery staff), financial support for aspects of the demonstration and the cost of inputs (mainly pesticides). APEP provided the technical trainers and logistics for the farmer training. The current project supported APEP in the development and provision of training programmes

and materials and, to the extent possible under the limited travel budget, direct training of trainers. Revisions (and subsequent reprinting) was done of the 'Insect Control in Cotton' trainer and farmer handbooks, informative 'stickers' produced to simplify pegboard use and the pest and beneficial insect chart for farmers was revised.

APEP produced steel templates for the pegboards and thousands of these were made and distributed by the lead ginners in the cotton zones. Handbooks and training material were produced for all trainers, lead and demonstration farmers with financial support from the project. Information on appropriate choice of pesticides for purchase was provided for ginner use and reports provided to APEP and CDO on aspects of the on-going programme.

Issues with the on-going IPM component of the demonstration programme

1. Training staff:
The single largest problem faced is that the demonstration programme is a victim of its own success and effective promotion. The current training staff – essentially 3 key personnel who are not full time on cotton, cannot run the number of Training of Trainers courses required to cover all the ginning zones in the country, given that each of the 3 seasonal trainings provided should occur just before the time at which the information will be most useful. Staffing (and consequently financial resources) need to be expanded in line with the national scale of the work.

2. Training material:
Written material is not playing the envisaged role in training practice. Even the site c-ordinators were not making full use of the written information in the insect control booklets (two levels – one for trainers, one for site c-ordinators and below). Lead farmers and collaborating farmers are said to use the written material very little. This despite the fact that demand for them has been very high and APEP has reprinted and distributed several thousand of them.

The pictorial guide to pests and beneficials has gone down extremely well and everyone is confident that insect identification capacity is now good amongst demo farmers (and many others in the villages). We have re-designed this to provide a simple guide to how to scout for the pests, and the intervention thresholds.

3. Use of the pegboard:
This is a rather simple idea (started by Graham Mathews of IPARC in the early 1960s). Its advantage over paper and pencil lies in the fact that there is no requirement for literacy or numeracy, it is relatively indestructible, does not require both hands, is cheap and 'badges' the holder as as an IPM farmer. Its drawback lies in the fact that it is only available through a project or from ginners etc and requires a bit for training to use – not because it is difficult, but because it is unfamiliar. The trainers tell us that farmers uptake is not good – and we have some evidence for this form the 2004 study. There are practical issues. They need to be issued in a 'final' format though, so that identification of their use does not depend on things written on to the board during training. Unfortunately the sticker for the back of the board (with all instructions) and the new one for the front – with line drawing of the insects – although drawn up by this project were not produced this year (though APEP says they have no problem in doing so, it just got overlooked), severely limiting the comprehensibility of the system. The

monitoring report (2,000 farmers) showed that the farmers found the pegboard one of the most difficult things to understand.

In practice my feeling is that the unfamiliarity with using this sort of system on the part of the trainers has resulted in it being taught without confidence. This is supported by the very odd statement from the trainers that they had moved to farmers drawing up a pegboard on paper and recording the results with a pencil – needing a notebook and both hands, plus the need to draw up a new paper pegboard at each scouting interval. As the logic of the two systems is identical, this is a training issue. Dr Russell's view is that it is the trainers who are somewhat unhappy with the pegboards, not the farmers. Highly educated and literate people find difficulty in believing that moving a matchstick down a row of holes could be a 'real' tool, and prefer the more familiar paper and pencil, which is, however, alienating to the farmers themselves. It seems that the pegboards (often paper) are being used in training. Lead farmers are then using them a few times, getting an idea of counting insects, but rather few applications are being made as a result of the information obtained. This is partly a confusion over insect presence and over-threshold damage. Even the trainers seem not to be fully grasping the importance of this and CDO and NARO staff are undermining it on demo visits where they simply see a few pest insects in the field and tell the farmer to spray.

The other problem is lack of accessibility of chemicals. Different ginners are providing different numbers of 'free' spray rounds – normally 2 to 4. Given that the farmers spray at the first significant numbers of sucking pests and that they are finding insects over-threshold at every examination (since they are not using the proper damage criteria), these sprays are used up early, giving no flexibility for spraying in response to bollworms later – very few demo farmers are buying pesticide apparently. This is so institutionalised that some ginners are not giving out insecticide until later in the season so that there is at least some spraying for bollworm/ stainers! This removes flexibility of response by farmers and hence the point of the scouting system.

4. Provision of insecticides:

Within the demonstration system the collaborating ginner provides the insectides as required/available. Non demonstration farmers in the area receive some support in most cases but the level (1-2 pesticide applications, usually pyrethroids) or more, depends on the individual ginner and the chemical distribution system is often late in providing material to the local store and then in distributing it, meaning that most farmers, most of the time, do not have access to appropriate chemicals the right time. This is a very major on-going constraint to the adoption of IPM systems, as even if the farmers are trained, scout and are willing to follow recommendations in many (even most) cases it is not possible for them to do so.

A second problem arises from the chemicals stocked. The CPP project has provided advice to APEP and to the NARO collaborators on appropriate IPM chemicals following the principles described above. However, the recommendation to CDO from NARO, Serere seems to include all chemicals (including mixes and relatively mammalian-toxic organophosphates) which have proved effective in insect control in trials. These may or may not be IPM compatible. This list is then circulated to ginners as the 'approved pesticide' list with commercial stockists names attached. In practice, most ginners then buy cheap, usually of doubtful quality, pyrethroids and pyrethroid OP mixes. Most usually only one, or at most two of these will be available to any given farmer. This very severely limits the capacity of farmers to follow a rational IPM programme.

Discussions have been held with APEP, CDO and some ginners, but overall of this system would contribute greatly to improved performance of the IPM portion of the demonstrations and this is something which should be pursued vigorously. The project produced a guide to pesticide selection for circulation to ginners by APEP, taking into account safety, efficacy, resistance risks and potential environmental impacts of choices. More needs to be done to directly educate ginners on pesticide choice.

A further issue arises in the list of approved insecticides which APEP can recommend, which is derived from a US list provided by USAID. By 2008, the following materials will be de-recommended.

Insecide de-recommended by 2008	**Insecticides approved for use**
Organophosphates	
Chlorpyrifos	Acephate
Profenofos	Acetamiprid
Dimethoate	Azadarechtin
	Bacillus thuringinesis (Bt)
Pyrethroids	Carbaryl
Cypermethrin	Imidacloprid
Fenvalerate	Indoxacarb
Deltamethrin	Malathion
Beta-cyfluthrin	
Finitrothion	

The de-recommened materials include all the main cotton insecticides currently used in Uganda. The approved materials include some odd materials – acephate, malathion and carbaryl for example are more environmentally harmful that some of the materials being removed. Acetamaprid, imadacloprid and indoxacarb are effective in cotton pest management (though only indoxacarb is currently registered in Uganda for use on cotton) but are much more expensive than the exisiting materials. Azadarachtin (neem) and Bt sprays are environmentally benign but often of relatively low quality and cotton pest control efficacy.

Embedding of IPM principles post-projects

Need for a National Extension Training Centre for Cotton

The Ugandan Cotton Ginners Association/ CDO/ APEP training programme for cotton extension, which has been strongly instrumental in the raising of national yields and productivity will not outlive the life of APEP unless the training skills and technical knowledge is captured in an on-going entity which can provide a structure for the provision and updating of extension trainer training to the zonal and supporting ginners. Although all ginners have some APEP trained staff, these operate though the demonstration system, which again is unlikely to outlive APEP. The CDO, ginners and APEP recognise the need for some mechanism of formal on-going training facility in Uganda after the end of the APEP project (likely to be 2008).

APEP and CDO believe that the ginners will continue IPM inputs after the ending of APEP. However, the possible form of these inputs appears to be entirely undefined. Without a national training of trainers facility it is hard to see how any effective extension support, other than the supply of cheap inputs, could be maintained. Under the NADS system this support could only be funded from Government via demand at sub-county level and the availability of suitably trained individuals within private companies ready to provide that advice at an acceptable price. Although 27 districts (out of 54) have implemented the NADS system in at least some sub-counties, we are only aware of one sub-county which has prioritised cotton. NADS

has provided direct financial support into APEP this year (though the proposal was suitably worded to met NADS criteria). It may not therefore be quite impossible to get some NADS funding on an on-going basis but this does run counter to the stated NADS philosophy. It is clear that there is not even the beginnings of a training capacity in the private sector which could handle national cotton extension, far less any unified extension code (even this is against the NADS philosophy of locally adapted advice). It seems that Uganda must capture and enhance the APEP training capacity (but probably not the staff as the salary reduction is too large) if the production gains are to be maintained. CDO agrees in principle with the concept of a national training centre. If a centre could be at least commenced now, its staff could work into the APEP demos in 2006 and 2007, gaining the necessary skills for running a modified programme – with training places funded directly by the ginners, from 2008 onwards.

Relevant Institutional Experience for a National Cotton Extension Training Centre

- The only precedent for a commodity-based support institute for Uganda seems to be the Uganda Oil Producers Association's facility.
- Makerere University runs a degree course for agricultural extension.
- Connected with NADS there are eight Zonal Agricultural Research and Development Institutes. These have quite specific mandates for adaptive research and dissemination e.g. Fisheries; Animal Husbandry etc. None currently specialize in cotton. Those most relevant to cotton regions would be Mokono, Palissa, Lira and Arua. The MOA covers capital and staff costs but students are fee-paying.
- The private organizations providing extension services on a contract basis in sub-counties prioritizing cotton under the NADS system. Currently there are around half (27) of the districts with active NADS programmes in at least some sub-counties. It is thought that only one of these has prioritised cotton. The availability (short or long term) of staff with the relevant skills trained in the national programme is unknown but likely to be small.
- The CDO/ UCGA ginning school at the National College of Agricultural Mechanisation at Busitema, near Tororo. [See Appendix 8].

OUTPUT 2 : Impact of ICPM demonstrations assessed.

A random sample of 30 demonstration farmers in Pallisa District interviewed for a baseline survey in 2002 were re-interviewed in 2005 to explore the impact of new cotton technology on livelihoods. Twenty-nine farmers were located and interviewed using a structured survey questionnaire. All farmers interviewed had hosted demonstration plots in 2002 and 11 continued to host demonstrations in 2005[The full report can be seen in Appendix I].

Generally, farmers adopted only those components of the technology package that did not increase cash costs [Table3]. Of the 29 farmers only four (14 %) had adopted zero or reduced tillage which required the purchase of herbicides, only nine farmers (31 %) reported using basal fertiliser and 12 farmers (41 %) reported adopting topdressing fertilizer. The most popular components that were those that added to yield but required no additional cash outlay, such as planting in pure stand (79 %), and closer spacing of cotton plants (90 %). Since virtually all farmers reported an increase in cotton yields, this must have come primarily from the adoption of closer spacing and planting cotton in pure stand rather than intercropped with beans.

Fifteen farmers (52 %) owned a pegboard [Table 4]. Nineteen farmers (66 %) understood how to use the pegboard and reported that their decision to spray was based on thresholds obtained through scouting and counting pests. The majority of farmers in the 2005 season also scouted and based their spraying regime on thresholds established using the pegboard. The majority of farmers also waited four weeks before the first spray, but a minority sprayed earlier, including one farmer who sprayed within one week of planting. Only five farmers (17 %) used soapy water to control aphids. These findings are based on careful probing of farmer's knowledge of IPM and recall rather than direct field observation.

Income from cotton had been spent primarily on school fees. Farmers had large families and gave a high priority to secondary and higher education, which has to be paid for. This left limited scope for investment in other assets. However, income from cotton had also been invested in physical assets (housing, livestock) and in land. Income from cotton was also used to finance diversification out of agriculture, particularly into crop trading. One indirect benefit from cotton was a reported increase in yields of millet, which benefits from the tillage and weeding given to the preceding cotton crop [Tables 5 and 6].

Benefits from new cotton technology could not be attributed simply to hosting higher-yielding demonstration plots. A comparison of farmers with and without demonstrations in 2004 suggests that only 15 % of total cotton output was attributable to the one-acre demonstration plot. Farmers who had hosted four seasons of demonstration plots were more likely to have accumulated capital assets, including physical assets, livestock, and land. They also had higher outlays on school fees. But even households with demonstration plots for only one season reported that income from cotton had risen, and had acquired capital assets. This suggests that the benefits from new cotton technology have not been confined only to farmers with demonstration plots.

2004 season	With demo (n=17)	Without demo (n=11)
Area planted (acres)	5.26	3.86
Output (kg)	2880	1832
Yield (kg/acre)	548	475

New cotton technology is having a significant impact on income, even though farmers were unable to afford all the components of the new technology package. Income generated from cotton was not consumed but invested primarily in education. Hence, cotton was helping to lay the foundation for the next generation to graduate from poverty.

Table 3. Adoption of new cotton technology by demo farmers

New practice	Status of adoption of new technology		
	Adopted	Used in 2005	Used before 2005
Zero tillage (no ploughs)	1	1	1
Reduced tillage (1 plough	3	1	2
Herbicides	4	2	4
Planting with basal fertilizer	9	6	8
Planting in pure stand	23	22	23
Spacing of cotton plants	26	25	26
Topdressing with fertiliser	12	7	12
Removing stalks from field after harvest	29	28	29

Table 4. Adoption of IPM component of technology package

	Yes	No	Total
Own a pegboard	15	14	29
Understand why pegboard is used	19	10	29
2005 season			
Scouted for pests	17	12	29
Counted pests with pegboard	16	13	29
Based spraying on thresholds	18	14	29
Used soapy water against aphids	5	24	29
Waited 4 weeks before spraying	20	9	29

Table 5. Changes in physical assets since 2002

Asset	Bought since 2001		Bought with money from cotton?	
	Yes	No	Yes	No
Bicycle	10	19	10	19
Ox-plough	4	15	3	26
Ox-cart	1	28	1	28
Granary	5	23	3	26
Farm store	4	25	3	26
Iron sheets	13	16	11	18
Motorcycle	2	27	2	27
Car/vehicle	1	28	0	29
Radio	14	15	12	17
Radio-cassette	6	23	4	25
TV	3	26	3	26
Telephone	8	21	5	24

Table 6. Changes in livestock assets since 2002

Livestock	Number owned in 2005	Bought with money from cotton?		Number bought with money from cotton
		Yes	No	
Oxen	32	10	3	18
Cows	137	12	12	43
Goats	72	9	11	29
Pigs	9	2	1	7
Chickens	252	8	13	44

Case studies

Contrasting benefits from cotton

1. Jorem Soswana

Jorem (# 52) has been growing cotton for five years and has been a demonstration farmer for four years. Last year (2004) he planted two acres including a one-acre demonstration plot and harvested 1,500 kg, which he sold for 400 UGS/kg, earning 600,000 UGS. Since he started growing cotton in 2001 he has acquired an impressive number of assets. These include:

2001: He bought two oxen for 400,000 UGS and three goats for 120,000 UGS.

2002: He constructed a business house for 2.8 million UGS and built a kadero (granary) at his homestead.

2003: He bought 2.5 acres of land for 400,000 UGS, an ox-plough and cart, and a radio-cassette.

2004: He replaced his thatched-roof house with a new brick house with iron sheets for 2.65 million UGS and a mobile phone for 180,000 UGS which he uses for business.

2005: He wants to buy a vehicle which he can use to transport maize, beans, and cotton) and look for the best markets.

Unlike most of the sample households, Jorem's five children are not yet old enough for secondary school and he has no need to pay school fees. Three of his children attend primary school, and he pays for uniforms, stationery, and supplies food that is cooked for lunch.

2. Samson Makuba

A retired schoolteacher, Samson Makuba (# 46), has been growing cotton for over twenty years. He has been a demonstration farmer for the last four years and last year was awarded a bicycle for achieving a yield of 1,800 kg on his one-acre demonstration plot. Despite this success, Samson has purchased few assets with income from cotton except one radio, and some cooking utensils. The family has no livestock. The three acres of land which the family planted to cotton in 2005 all had to be ploughed using hired oxen.

Nine children in the family currently attend school. Four go to the local primary school, one is studying at O-level, two at A-level, and two are reading for degrees at Makarere University in Kampala. School fees for the single O-level student are 221,000 UGS/term, and 221,000 and 291,000 UGS/term for the two students at A-level. Fees for the two children attending university average 500,000 UGS/term. In total, the household spends 5,409,000 UGS/year on education for the children.

The cost of school fees is met chiefly from income from crops. The household sells cotton, maize, groundnuts and beans. Samson also gets a pension from his service as a schoolteacher. After paying the school fees, there is little left over to spend on other assets. The family lives in a comfortable, brick-built house with a tin roof that was built with his salary as a schoolteacher.

Assessment of the demonstration method of knowledge transfer

The second M & E activity carried our was to assess the demonstration process itself – are demonstrations an effective medium for knowledge transfer?

New cotton technology in Uganda is being promoted by demonstration plots which many now regard as outmoded in comparison to farmer field schools (FFS). The objective of this study is to explore the effectiveness of the demonstration plots as an extension tool to promote adoption of this technology package for cotton. Thirty-nine cotton growers within 15 km of the Iki Iki ginnery, Pallisa district, were randomly selected from lists of growers who had attended field days in the 2004A cotton season. Growers were interviewed using a structured questionnaire to measure their knowledge of herbicide use, planting, IPM, and fertiliser topdressing.

Results showed that demonstrations and cotton field days were well-attended [Table 7 & 8]. Of 511 cotton growers from five villages, 72 % had visited demonstration plots in the 2003 cotton season. The share of growers visiting demonstration plots rose sharply from 40 % in 2002, probably because of the introduction of the system whereby "lead farmers" have 15 "collaborators". The majority of 39 farmers interviewed had attended two field days in 2004. The average walking time for these farmers to reach a demonstration plot was 19 minutes.

Table 7. Visits to demonstrations, by village

Village	Cotton growers	Demo farmers (DF)	Collaborating farmers (CF)	Growers visiting Demo plots				Time to reach nearest Demo plot (mins)
				All growers		Non DF and CF growers		
				2002	2003	2002	2003	
Katido	28	0	6	12	23	7	17	60
Kabyonga	124	7	70	47	102	1	26	16
Kamasaba	82	1	43	24	57	1	14	28
Kameruka	196	21	67	87	114	23	36	54
Kositi	81	8	59	32	73	1	9	44
Kavule	107	3	45	35	71	6	27	6
All	618	40	290	237	440	39	129	34

Table 8. Attendance at field days at cotton demonstration plots

	Herbicide	Planting	Spraying	Topdressing
Number attending field day				
2004	33	37	36	28
2003	24	25	29	23
2002	13	15	15	12
Any	39	39	37	33
Number of field days attended				
None	0	0	2	6
One	15	14	9	12
Two	11	10	13	12
Three	13	15	15	9
Average	1.95	2.03	2.16	1.91
Average attendance, by grower				
Year	2002	2003	2004	All
Average field days attended, for growers attending in that year	2.75	3.16	3.44	7.64

Sample size	20	32	39	39
Average field days attended, all growers attending	1.95	2.03	2.16	1.91
Sample size	39	39	37	33

Demonstrations were more effective in teaching about some subjects than others. Of the growers who had attended field days on the relevant topic in 2004, almost all knew the correct answers to the six questions about topdressing fertiliser. More than half knew the correct answers to four of the eight questions about herbicides, and more than half knew the correct answers to eight of the 10 questions about planting. However, knowledge about IPM was patchier. Over half the growers could distinguish beneficial insects from pests. Two-thirds could correctly identify the use of the pegboard. But less than one fifth knew the correct time to start scouting or the correct frequency of scouting, and very few knew about the use of soapy water as a spray against aphids [Table 9].

Table 9 . Knowledge of new cotton technology by farmers attending as observers at IPM demonstration field days: integrated pest management

Question	*Correct*	*Incorrect*	*Don't Know*	*Total*
Which of these insects are harmful to cotton?				
Bollworms	*35*	*1*	*1*	*37*
Spiders	*25*	*12*	*0*	*37*
Ladybirds	*29*	*8*	*0*	*37*
Aphids	*35*	*2*	*0*	*37*
What is a pegboard used for?	*22*	*15*	*0*	*37*
How many bollworms should you count before spraying?	*5*	*14*	*3*	*37*
How soon after germination should you start to count?	*7*	*30*	*0*	*37*
How frequently should you scout?	*8*	*29*	*0*	*37*
What should you use for the first spray against aphids?	*5*	*23*	*9*	*37*
Which part of the plant should you spray when spraying aphids?	*24*	*13*	*0*	*37*
Should you use the same chemical every year against bollworms?	*29*	*8*	*0*	*36*
What should you do with the sprayer after using it?	*31*	*6*	*0*	*37*

A “knowledge score” based on the share of correct answers showed that growers received the highest score for topdressing and the lowest score for pest management. Farmers’ knowledge scores improved as they attended more field days in the case of planting and topdressing. But with herbicide use, knowledge did not improve between the second and third field days, and in the case of pest management there was no clear improvement in knowledge after the first field day. This reflects the conceptual complexity of IPM which requires its messages to be repeated several times to develop sufficient understanding to ensure the technology will be sustainably adopted.

A cost-benefit analysis showed that, over a three year period, demonstration plots achieved a cost-benefit ratio of 4.4, assuming that knowledge from demonstrations was translated into a 25 % increase in yield. A sensitivity analysis showed that, assuming a yield increase of only 10 %, returns to demonstration plots were positive with average attendance of 15 growers, and assuming average attendance of 30 growers, returns from demonstration plots were positive with yield increases of 5 % or above.

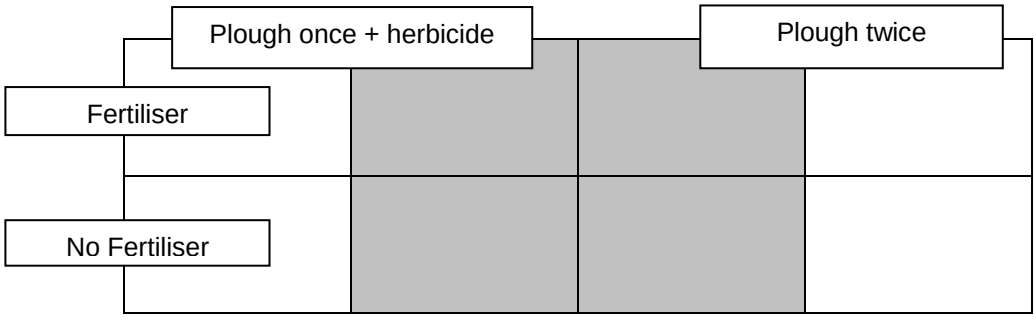
On this evidence, demonstrations are an effective and relatively inexpensive method of extending new cotton technology. They are more effective for teaching farmers about less complex topics like topdressing than IPM, which may contradict previous knowledge and requires new skills in pest identification, counting, and decision-making. Nevertheless, demonstrations and field days have been effective in introducing farmers to these key concepts which now need to be reinforced and practised.

OUTPUT 3: Integration of animal draught into cotton weed management systems promoted.

Results from SAARI trials

Fig.1. Demonstrating inter-row weeding with animal draught in Uganda

The DAP weeding and Cotton IPM projects therefore combined resources to evaluate the use of DAP weeding in cotton during the 2006 season. Trials were established at 24 sites in, Kumi (8 farms) and Soroti (16 farms) districts including in sub-counties where farmers already had gained experience of using the DAP weeder attachment in row-crops. The trials were designed to assess the profitability of the reduced tillage and fertiliser components of the APEP package further and when used in combination with DAP weeding. Farmers undertook tillage, planting and weeding with their own draft power and labour. The project laid out the plots and provided training and assistance with herbicide application and IPM. Eight plots were established at each site as shown below.



In-crop weed control

	Ox-weeder
	Hand weeding

This allowed evaluation of land preparation, fertiliser and in-crop weed controlpractices as follows:

Land preparation - Conventional tillage i.e. plough twice with animal drawn plough at two week interval with second pass the day of before planting v Reduced tillage i.e. plough once two weeks before planting followed by application of glyphosate (as the product Round Up Max (one x 100 g sachet in 15 l water applied to 0.25 acre i.e. 1 kg per ha^{-1}) on day of planting;

Fertiliser – Diammonium phosphate (DAP) broadcast prior to planting at dose of 62.5 kg ha^{-1} with top dressing of 62.5 kg ha^{-1} urea at flowering v no fertiliser.

In-crop weed control **–** Ox-drawn cultivator plus supplementary hand weeding in crop rows at 3 and 6 weeks after crop emergence v hand weeding only.

All plots were planted to cotton cultivar BPA 99, thinned to a spacing of 30 x 75 cm. Planting took place in the period 24th to 26th May (17 sites) or on 2nd June (7 sites). In order to remove pest pressure as a factor, pesticides were applied as indicated by scouting, using thresholds developed by the project.

Analysis - The basic design within a farm, for the 8 plots, was a mix of a split plot and criss-cross layout with the two factors that are crossed being fertiliser use (+/–) and tillage (reduced v conventional) but within the tillage plots there is a further split for weeding (hand weeding v DAP weeding). Although the random effects of district, sub-county location and individual farm could be considered, the treatment comparisons were only made within farms so different possible levels of error term in the analysis of variance did not impinge on these. After initial examination of the raw data it was decided to exclude six farms from the analysis due to a variety of reasons including incomplete data sets and mis-application of treatments on some plots. The use of stand count as a covariate was investigated for the farms where it was present, but there was little consistent evidence of its usefulness across the different strata of the analysis so it was not been used.

*Effect of method of land preparation on weed infestation***:**
A visual estimate of the % weed cover on each plot was made at 15 days after planting, reflecting the situation prior to first weeding. Data were subject to a logit transformation [loge(%/(100-%))] appeared to ensure greater homogeneity of variance across the range of values recorded (1% – 40%). Overall the % ground covered by weeds at first weeding was significantly higher ($p<0.001$) on plots planted following conventional tillage than where reduced tillage and herbicide had been used (Table 10; Figure 1). Basal fertilizer application had a marginal stimulatory effect on weed growth ($p=0.061$) but there was no interaction between tillage method and fertiliser use. Pre-plant application of glyphosate reduces competition from weeds during the critical seedling stage of cotton prior to the time of first weeding.

Table 10. Effect of tillage method and fertiliser use on % weed cover at 15 days after planting cotton at 17 sites in Kumi and Soroti districts in 2005.

Tillage/Fertiliser	Mean (logit)	SED (df)	F-prob	Back-transf. %
Reduced + herbicide	-2.713	0.1598 (16)	<0.001	6.2
Conventional	-1.857			13.5
No Fertiliser	-2.406	0.1199 (16)	0.061	8.3
Fertiliser	-2.165			10.3

As was observed in 2005 of the problem perennial grasses and sedges in the areas where the trials were located *Cynodon dactylon* and *Digitaria abyssinica* were well controlled at the dose used while *Cyperus rotundus* and *Imperata cylindrica* were suppressed so that these did not compete with cotton seedlings. *Commelina benghalensis* formed dense stands at some locations but was not well controlled by glyphosate.

Seed cotton yield:
A $\log_e$ transformation was used prior to undertaking the ANOVA to improve variance homogeneity. Fertiliser application increased mean seed cotton yield significantly (p=0.010). Neither tillage nor in-crop weed control practice (p = 0.161 and p = 0.383 respectively) had any impact on yield (Table 11) and none of the interactions appeared statistically significant. Although the addition of fertiliser increased boll numbers overall this difference was not significant (15.8 bolls per plant with no fertiliser and 18.5 bolls with fertiliser; p = 0.085 for square root transformed data).

Table 11. Effect of tillage, fertiliser use and in-crop weed control practice on seed cotton yield kg ha^{-1} at 18 sites in Kumi and Soroti districts in 2005.

Practice	Mean ($\log_e$)	SED (df)	F-prob	Back-trans. kg ha^{-1}
Fertiliser				
No fertiliser	6.580	0.0592 (17)	0.010	720
Fertiliser	6.750			854
Tillage				
Reduced	6.612	0.0715 (16)	0.161	744
Conventional	6.718			827
Weeding				
Hand	6.649	0.0362 (33)	0.383	772
With Oxen	6.681			797

Economic implications:
Partial budgets covering the variable costs of land preparation and fertiliser use, computed from mean yields are shown in Table 3. At the relatively low cotton price (Sh. 350 kg ha^{-1}) for grade b cotton in 2005 buying season fertiliser use was of marginal economic benefit at best (Table 12). An additional 357 kg ha^{-1} seed cotton was needed to cover the cost of fertiliser. This response was only achieved at three sites under either conventional or reduced tillage. Fertiliser use was economically beneficial in 2005 when greater responses were observed. Output in 2006 was reduced by heavy rains that fell across sites in Kumi and Soroti after the beginning of boll splitting. Ignoring the cost of weeding the profitability of reduced tillage was

higher than that from conventional tillage due to lower ploughing costs. This is the reverse of the situation observed in 2005 when average cotton yields were somewhat higher but returns were better from using conventional tillage.

Table 12. Costs and returns from use of tillage and cotton nutrient management options in 2005.

	Reduced till/herbicide		Conventional tillage	
Costs/returns ha^{-1}	**No fertiliser**	**Fertiliser**	**No fertiliser**	**Fertiliser**
Yield kg	775	934	865	953
Income Sh.[1]	271,250	326,900	302,750	333,550
Ploughing[2]	74,130	74,130	148,260	148,260
Herbicide[3]	20,000	20,000	-	-
Fetiliser[4]	-	125,000	-	125,000
Total cost	94,130	219,130	148,260	273260
Return	177,120	201,900	154,490	60,290

[1] Cotton price in 2005 buying season Sh. 350 per kg;
[2] Sh. 74,130 per ha per plough pass;
[3] Round Up Max Sh. 2000 per sachet; 10 per ha
[4] Basal DAP 62.5 kg ha^{-1} with top dressing of 62.5 kg ha^{-1} urea @ Sh. 1,000 per kg

The farmers who hosted trials estimated the length of time taken to weed with oxen or by hand. Use of the ox-weeder reduced labour costs from a mean of Sh. 79,598 to 44,642 per ha for first weeding. Generally it was necessary to have at least two labourers in the field with the ox-team when weeding. Despite dense trash of fallow vegetation killed by herbicide or conventional tillage it was possible to use the ox-weeder at all sites although weeding busy fields was a slow process due to both trash and large clods of soil. Two passes were possible at 3 and 6 weeks after crop emergence. A three tine weeder attachment for the plough currently sells for Sh. 80,000 and may be used in all row-crops.

Farmer perceptions:
The main advantages of reduced tillage according to farmers is that it allows timely planting and is good for control of a number of perennial grasses and sedges that are difficult to control by mechanical means (Table 13). The cost and limited availability of herbicide, the need for water and a sprayer are constraints to herbicide use. Compared to reduced tillage, conventional ploughing is well known by the farming community and is fast and cheap for those who own oxen. Using a DAP weeder is seen as fast and cheap compared to labour intensive hand weeding (Table 14). Using the weeder will need experience so that farmers know when cotton seedlings become big enough to withstand disturbance by the passage of the weeding tines.

Table 13. Farmer perceptions of reduced and conventional tillage

Reduced tillage with herbicide		Conventional tillage	
Advantage	**Disadvantage**	**Advantage**	**Disadvantage**
Allows timely planting – spray and plant the same day	Herbicide expensive and not readily available	Known to many, no training needed	Needs initial bush clearing
Kills perennial weeds like couch and spear grass.	Sprayers are heavy – spraying is tedious; difficult to ensure all area is covered.	Fast and cheap for those who own oxen	Many farmers have to hire or borrow teams so can not plant on time
Can spray even when ground is dry	Rain directly after spraying may lead to loss of money	Plough repairs easily done at home.	Sickness of animals can delay process
Dead vegetation cover good to protect soil	Water may be unavailable, sprayers unavailable, need to have a separate sprayer for herbicide	Large areas opened in a short time	
	Spraying needs good knowledge		
	Less soil disturbance with less ploughing so less water infiltration.		

Table 14. Farmer perceptions of DAP and hand weeding.

Weeding with DAP		Weeding by hand	
Advantage	**Disadvantage**	**Advantage**	**Disadvantage**
Fast, a large area can be weeded quickly	Leaves weeds in inter-rows	Thorough, removes all weeds	Very slow and hard work
Cheap, fewer people needed. A family alone can weed a whole field in a day	Difficult to use in bushy fields when crop is young	Can be used at all cotton growth stages	Weeding a field not uniform as it takes so long to complete
Brings soil and nutrients nearer to plants; cotton appears less stressed when there are short drought periods	Some cotton seedlings are covered by soil; cotton branches broken off at second weeding		Costly, requires many people
	Not everyone has		

	oxen		

Dap Manual

To date APEP has not discussed DAP operations in cotton in training for the demo programme but agree that this was now appropriate for areas of Uganda were many farmers are once again using DAP. We therefore agreed to prepare a manual, largely based on pictures and diagrams. This, Martin suggested, could be used in 2006 and 2007 by APEP who have two seasons remaining for their current cotton demonstration programme. He is keen to include two days on DAP in the demo training for areas where farmers use animals for ploughing. It is possible that APEP will call upon DAP project staff to assist with the training.

A 17-page manual was drafted. This is in A4 format with colour cover but black and white for the body of text, figures and illustrations. We were able to draw on existing material from earlier DFID (including CPP) funded tillage and cotton projects in Zimbabwe. This was done by extracting graphics from Pagemaker and re-formatting these as a Word file to ensure that the material is accessible in future. New material was prepared to reflect Uganda conditions and appropriate pictures from the field in Uganda were also added. The draft was left at APEP for comment at the end of the visit. Comments will be collated in UK and the final version returned to Uganda for printing. Quotes for printing 500 copies are being sought. The draft manual can be viewed in Appendix II.

Lessons Learned from this project

1. On-farm demonstrations are an effective way to transfer knowledge and are a medium favoured by farmers who prefer direct contact with extension and researchers to written or radio media. However to have a significant impact large numbers of demonstrations are required.

2. Where there is a clear incentive for participation, the private sector can be effective partners in research and are willing to provide extension services.

3. Adoption of promoted technologies through the demonstration process has been widespread but adoption of IPM is more patchy than for some of the less knowledge-intensive aspects, such as correct spacing, timely thinning and weeding.

4. It is often said to the point of becoming a cliché that IPM is a knowledge-intensive technology. However, this is rarely taken into account in considering technology adoption. We have found that only the best educated farmers were using regular scouting to inform their spraying although most understood the use of the peg-board. More widespread adoption requires the message to be frequently repeated. Also, more needs to be done at a higher level in research, extension, NGOs, commodity support organisations and policy makers, to explain the long-term benefits of IPM adoption. Such groundwork needs to be done before trying to promote IPM to farmers.

5. The high labour demand is a disincentive for wider participation in cotton production. Weeding is particularly labour intensive and cotton competes with food security crops at peak times for weeding. The use of ox weeders for inter-row cultivation, greatly reduces labour input and cuts the costs of crop management if labour has to be hired for weeding.

Recommendations

- The APEP programme is essentially a vehicle to support the adoption of existing cotton production practices. Particularly with the loss of Dr Sekamattee to Dunavant, Zambia, APEP has a very real need for continuing technical support in adaptive trails and the validation of components added to the recommended system.

- *Insect control within the IPM demonstration system*: We should seek ways to build on the success of the IPM programme in spreading widespread understanding of insect pests and ability to identify them to strengthen the understanding of the intervention thresholds. However, this has limited usefulness until most farmers have sufficient financial access to inputs to enable flexibility of response (at the moment most demo farmers just spray their allocation of 'free' pesticides). This will come with yield increases. Peg-boards (wood or paper) are helping farmers (particularly lead-farmers) to understand the concepts but trainers seem weakly committed. We need to work with APEP to decide how to take this forward. We need a curriculum re-evaluation session and input into the 2006 pre-season zonal co-ordinator training.

- Building of a national cotton training facility is a long-term project. As national production increases, the prospects for internal support will increase but we need to be building the on-going capacity now. We should try to ensure that Busitmema is built into such a facility, but probably in the first instance in creating a training capacity in APEP which can be exercised at Busitema under a contract basis in 2006 and 2007 (expanding on the experience to date), with the intention of transferring the expertise in 2008, remembering not to focus on only one or two individuals, who, though ideal for the position, may not be available for it in the nature of these things

- *IPM programmes within the region*: The relative success of the demonstration system of cotton extension is based on structural factors provided by government and ginnery companies, operating in their own self interest to increase yields in their own production zones. This model may be replicable in other countries but from the level of interest expressed at international meetings it is clear that it would be valuable to explore this in the region – possibly though SEAC, the South ad East African Cotton group of ICAC. SEAC's next meeting in in S.Africa in March (with a technical focus on whiteflies in cotton). It would be very useful to attend.

- It is clear that Uganda does not have the institutional staff capability to assess properly the impacts and biosafety of biotech cotton to the highest international standards. With both Ugandan cotton and international biotech cotton evaluation experience, the current project team is well placed to assist in the building of such teams. And should actively seek support to continue to provide input to the Ugandan programme in conjunction with that initiative. Collaborative research work on this programme is also possible with Ugandan/Danish partners..

Dissemination Outputs

Peer Reviewed Journal Papers:
HILLOCKS, R. J., RUSSELL, D., SEKAMATTE, B., RICHES, C. R. AND *ORR, A. (2005)* IPM for smallholder cotton in Uganda: An example of successful private sector engagement in service delivery*. Aspects of Applied Biology 75, 1- 9.*

Conference Papers:
RUSSELL, D.A. (2004) Insecticide rationalisation as a driver for the adoption of improved production practices in small-holder cotton: Contrasting cases. Statements to the 63rd Plenary Meeting of the International Cotton Advisory Committee, Mumbai Nov/Dec 2004 pp 56-62. ICAC, Washington, USA.

Internal Reports and Working Papers:
RICHES, C.R. (2005) Report of a visit by the Weed Scientist to Uganda for CPP cotton IPM Project, 6th to 11th June 2005. Natural Resources Institute (NRI), Chatham, UK, 3pp. [BTOR]

HILLOCKS, R.J. (2005) Report of a project management visit to Uganda and Tanzania to review cotton IPM activities, 07 – 13 August 2005. Natural Resources Institute (NRI), Chatham, UK, 7pp. [BTOR]

RUSSELL, D.A. (2005) Report of the visit of the entomologist to support IPM training, act as a technical resource person for the first national Bt cotton workshop 14-21 May 2005 [BTOR]

RUSSELL, D.A. (2005) Report of a visit to Uganda to review capacity building activities for cotton IPM 8-18 Nov 2005 [BTOR]

ORR, A. and KAYOBAYO, G. (2005) Impact of new cotton technology, Palissa district Uganda. Natural Resources Institute (NRI), Chatham, UK, 27pp. [Working Paper A1149/1].

Extension manuals:

SAARI (2005) A guide to using draught animals in cotton production: a manual for training of trainers. Serere Agricultural and Animal Research Institute, Soroti, Uganda, 19 pp.

APEP (2005): Revised: Guide to Pest Management in Ugandan Cotton.25pp APEP 2005

Appendices:

Appendix I: Impact assessment
Appendix II: What's the use of a demonstration plot?
Appendix III: APEP Adoption study
Appendix IV: Report of draught animal power trials
Appendix V: PDF of the DAP Manual
Appendix VI: GM Cotton 1
Appendix VII: GM Cotton 2
Appendix VIII: Capacity Building Needs

Contribution of Outputs to developmental impact

How is the knowledge promoted benefiting the poor?

Cotton offers a source of income to rural households and is especially important to communities far away from markets for food crops.

We have developed and promoted an IPM that can make insecticide use more cost effective and decreases insecticide use in seasons with low pest pressure. IPM was promoted in a total of 12000 on-farm demonstrations during the course of this and the previous project.

The project has contributed to capacity building through our inputs to curriculum development in integrated crop and pest management [ICPM] at Busitema cotton Training College.

The project has contributed to the development of an information system to support improved cotton crop management with the production of a manual on the use of animal draught in cotton.

Field trials with SAARI have shown that animal draught can be used for inter-row weeding, a practice not previously known in Teso. The use of oxen for this task, reduces the time required and saves on labour. This represents a direct cost saving if labour has to be hired and helps to make cotton growing more profitable.

The project has shown that provided the incentives are right the private sector is willing to work with research to deliver improved crop production.

At the end of the project, there is much greater awareness and knowledge has been improved of the benefits of IPM among farmers extensionsists and administrators [CDO]. The 600 trained extensionists will continue to work with the ginning companies to improve smallholder crop production.

What coverage has been achieved (numbers of farmers, institutions and production areas adopting the technology).

Each of the 12,000 farmers who hosted cotton demonstrations were asked to bring at least 15 other farmers to see their demonstrations so that around 180,000 cotton farmers were exposed to the technologies, out of a total number of cotton growers of 250, 000 – 300,000.

Awareness and knowledge of IPM has been raised at research institutes [NARO, SAARI], the Cotton Development Organisation [CDO], Busitema Cotton Training College and the private sector [Uganda Cotton ginners and Exporters Association].

What is the potential for wider scale impact.

There is huge potential for wider impact. Cotton is an important smallholder crop in Tanzania and Zambia and has potential for expansion in Kenya and Malawi. The main constraints to wider adoption of cotton growing are the low returns to labour and the labour demands of the crop, especially for weeding. We have shown that insecticide spraying can be made more cost effective through adoption of IPM and that better use of animal draught can greatly decrease the labour requirement in cotton cultivation. If agriculture is to become the basis for economic growth in SSA, then far more use must be made of draught animals. Lessons learned from Uganda could be used to scale-up the outputs to Tanzania and Zambia where there are a total of almost 1 million cotton smallholders.

What follow up action/research is necessary to promote the findings of the work to achieve their development benefit?

Background surveys would be required in Tanzania and Zambia to take into account local factors in adapting the outputs from Uganda to Tanzania and Zambia and to develop a participatory methodology for training, promotion and adoption of the technologies.

PROJECT LOGFRAME

Narrative Summary	**Objectively Verifiable Indicators**	**Means of Verification**	**Important Assumptions**
Goal			
Benefits for poor people generated by application of new knowledge of crop protection in semi-arid cotton production systems	To be completed by CPP Programme Manager	To be completed by CPP Programme Manager	To be completed by CPP Programme Manager
Purpose			
Strategies promoted to reduce the impact of pests and stabilise yields in smallholder cotton in Uganda.	To be completed by CPP Programme Manager	To be completed by CPP Programme Manager	To be completed by CPP Programme Manager
Outputs			
1. Capacity developed to support scaling-up of IPM system from 600 to 6000 demonstrations. 2. Impact of ICPM demonstrations assessed. 3. Integration of animal draught into cotton weed management systems promoted.	600 supervisors trained in IPM by September 2005 –they in-turn train 6000 farmers Assessment of training needs completed by April 2005 and technical inputs to cotton training centre by December 2005 Impact assessed and recommendations made to APEP by December 2005	Number of demonstrations APEP Reports CDO Reports CPP Progress Reports APEP reports	APEP scaling-up proceeds on schedule That CDO finds financial support for the Cotton Training Centre. APEP support the M & E activities
Activities	**Inputs**	**Means of Verification**	**Important Assumptions**

1.1 Training of APEP trainers in IPM technologies. 1.2 Improve targeting of technical advice on ICPM	Total Budget here £74,562	Supervisors trained CPP progress reports Updated training manual	Ginning companies continue to support APEP and CPP, particularly providing large numbers of demonstration supervisors.
2.1 Conduct impact assessment of the demonstration programme.		Throughput of trainees CPP progress reports	Logistics support from CDO
3.1. Demonstrate benefits of DAP for weed management in cotton.		Socio-economic report	Logistics support available from APEP
3.2. Produce training manual on DAP in cotton			Logistics support available from NARO SAARI Unexpected weather does not adverse affect cotton production