Gaining confidence in farmer-participatory integrated pest management in Uganda: NARO's experience in improving uptake of crop protection technologies for cotton

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ABSTRACT

The concept of Integrated Pest Management (IPM) was introduced in Uganda merely a decade ago and pioneer work started with cotton. The period 1993 – 96 laid a foundation through the Smallholder Cotton Rehabilitation Project (SCRP) for an IPM research and development process that has progressed through other projects into farmer participatory testing of a wide array of component technologies. The process can be viewed as a confidence gaining process on part of the research team and also as a test of the potency of the developed technologies based on uptake levels by the smallholder cotton farmers. This paper presents the experience of the National Agricultural Research Organisation (NARO) in farmer participatory IPM. The paper highlights aspects of success as well as key issues affecting both research and farmer up-take of new IPM technologies. The Implications of these successes and failures for the government policy to modernize agriculture are also discussed.

Introduction

In recent years we have witnessed an initiative to modernize agriculture in Uganda by converting the peasant-based crop production systems into more economically and environmentally sustainable forms of agriculture. An important thrust has been to embrace the philosophy of integrated pests management (IPM) as the preferred option for suppressing crop pests (Anonymous 1993; Sekamatte and Heneidy, 1996). During the same period, the intensity of crop infestation by insect pests and disease has in many areas shifted from a state of an occasional problem to serious constraints in agricultural production. With the increasing demand for higher agricultural productivity as a result of new market opportunities such as the African Growth Opportunity Act (AGOA), given erratic rains and the prospct of adoption of modern inputs, the need for the IPM approach is felt strongly in Uganda.

The use of chemical insecticides which have, for long dominated pest control programs world-wide has not had wide acceptability amongst the resource-poor farming communities in Uganda, due to unavailability, environmental and public heath risks, and exorbitant costs. The IPM approach in Uganda has emphasized non-chemical control methods, notably biological control, host resistance and cultural practices. The ultimate goal is sustainable, cost-effective crop production, which is within the capabilities of the resource-constrained farmers and is safe for the environment.

Uganda's experience in development and implementation of cotton IPM dates from the early 1990's, when the Government of Uganda through the National Agricultural Research organization (NARO) instituted projects to initiate specific studies. The primary focus was on the management of cotton pests under the World Bank-funded Smallholder Cotton Rehabilitation Project (SCRP). Under this project, the Government of Uganda hired the service of an Egyptian expert for a period of three years (1994-1996) to institute studies pertaining to IPM. Later, a National Biological Control unit was established to strengthen the biocontrol concept as initial studies under the cotton project highlighted the critical need for it. The Uganda projects show that biological control and cultural practices are good strategies for controlling pests of crops under smallholder farming conditions, and that IPM, conceptually and in practice, represents the best option for the majority of cotton farmers in the country.

The current plan for modernization of agriculture inevitably necessitates accelerated use of modern technologies by Ugandan farmers and this is considered by many to be essential in fostering agriculture–led development in the country. Anonymous (1993) however, noted that promoting the use of chemical pesticides, particularly with the small and resource poor farmers in the country, is a very contentious issue. Questions of economic and environmental sustainability and negative impacts on public health have frequently been raised in regard to their use.

Frequent interactions with farmers by the authors have recently revealed the importance of hired labor, full-time commercial farming, crop-suitability, credit use, household incomes, access to infrastructure, gender and level of education as factors useful in assessing potential targets and strategies for developing and disseminating IPM practices.

It appears from these studies that, unlike pesticide use, which has until recently been viewed as a straightforward technology requiring little policy and extension intervention, successful farmer uptake of IPM technologies by smallholder cotton farmers, requires substantial effort involving the whole range of stakeholders.

Until 1992, the Government extension service was the main supplier of subsidized pesticides, the almost sole intervention to address cotton pest problems. Pesticide Act was drafted in 1993 but remained too deficient in many aspects to deal with developments in crop protection. Consequently, in 2001, the Government called for an on-going review of the act. There is a general lack of information regarding pesticide use and crop yields (Anonymous, 1993). In this paper we present some case studies of cotton IPM and highlight progress in both the research and extension of IPM messages focusing on insect pests.

Cotton IPM research in Uganda

Low input cotton production occupies some 500,000 farmers, mostly on areas of one hectare or less. Yields are low and have declined over the last 20 years, possibly due to decline in soil fertility and poor seeds, among other factors. With an average yield of 450 kg seed cotton/ha, cotton is an economically marginal activity for many farmers (Serunjogi *et al*., 2001). Despite this, farmers continue to plant cotton for its relatively guaranteed cash income and its value to succeeding crops in the rotation. The following factors are responsible for the generally very low yields: (1) poor crop husbandry practices (2) many farmers sow late (3) sowing densities frequently too low or too high (4) improper weeding is often associated with lack of labor (5) Poor soil fertility especially in the East and Northeast (6) Losses through ravages of a complex of insect pests. The sixth point is probably the most critical.

Pests, losses and control practices

Uganda's commercial cotton varieties suffer from a range of pests and diseases of economic importance. Although the newer varieties are generally resistant to bacterial blight, the fungal wilts (*Verticillium* and *Fusarium*) are still important, especially when complexed with root-knot nematode. The importance of jassids has been reduced by adoption of hairy leaf varieties. Aphids (*Aphis gossypii* (Glov.)) and whiteflies are significant pests. The key insect pests, however, are the lygus bug, *Taylorilygus vosseleri* (Pop.) and the lepidopterans, pink bollworm (*Pectinophora gossypiella*), spiny bollworm (*Earias* spp.) and American bollworm (*Helicoverpa armigera* Hübner). Cotton staining bugs (*Dysdercus* spp.) are often a problem on open bolls.

Since 1993, the cotton research program has conducted field trials at various locations to compare efficacy of different management options these pests. These included cultural approaches, botanical pesticides and chemical control using conventional pesticides.

Trends in chemical pest control

Until the early 1979 the insecticides used were organochlorines (DDT), endosulfan, and the organphospahtes Methyl Parathion and Fenthoate, with 4-6 insecticide applications per season on average. Throughout the 1980s, after the replacement of organochlorines with more expensive cypermethrin, amidst poor cotton prices, many farmers applied on average four sprays per season. In our experiments we compared the recommended insecticide application scheme of four sprays at two weekly intervals with zero applications, six applications and eight applications per season across various locations in the country.

Highlights of the results

i) Losses by insect pests are high and vary considerably between 63–81% in central and western Uganda and 36–58% in eastern Uganda (Sekamatte and Okoth, unpublished report, 1993).
ii) The three calendar programs prevented 78–83% of anticipated yield losses under research station conditions in both central (Namulonge) and eastern Uganda (Serere) (Sekamatte *et al*., unpublished report).
iii) Similar yield loss levels were obtained under farmers' conditions where cotton was planted as a sole crop. Under intercropping with common beans and a local hibiscus vegetable plant lower yield losses (28-32%) were recorded in farmers fields. This indicated the potential of intercropping for pest suppression in cotton.

Field trials using Ambush CY® (cypermethrin 5%) indicated that four sprays of Ambush following the calendar recommendation yielded almost similar levels of stained cotton (28–37%) as the un-sprayed cotton at Namulonge (Sekamatte, 1994).

Earlier, around 1991, the incidence of the cotton aphid, *Aphis gossyopii* Glov. attained worrying proportions especially in western Uganda, particularly in the Kasese area. Many farmers attempted more sprays (up to eight) but surveys conducted two years latter (Sekamatte and Latigo, 1993) indicated that farmers experienced higher aphid incidences in the heavily sprayed plots. Research trials compared the use of seed dressing using Carbaryl® 35 ST and imidacloprid, and insecticide mixtures notably Salut® (222g/l dimethoate + 278 g/l chlropyrifos). Superior pest control was achieved with the insecticide mixtures compared to cypermethrin when both were applied on a routine basis. Seed dressing did not provide noticeable control of aphids and in addition the plots required foliar sprays using another insecticide against the lygus and bollworms.

The insecticide mixture, Salut® (228g/l chlorpyrifos + 222g/l dimethoate) was however significantly more expensive than the cypermethrin and its adoption by farmers was difficult. Research attempted to minimize application frequencies by developing control action threshold levels for the principal pests, lygus and the bollworms.

Development of control action threshold levels (ATLs)

The concept of control action levels (ATLs) was defined as the pest population size at which management action is required in order to prevent economic loss of yield (Stern *et al*., 1959, Poston *et al*., 1983). The use of appropriate thresholds was viewed by the SCRP project as a requirement for the judicious use of insecticides by the smallholder farmers. This required change of practice from routine insecticide application, to the use of ATLs (El-Heneidy *et al.*, 1995). However difficulties were experienced in making recommendations for controlling the sucking and biting bugs, mainly lygus. A study was instituted to investigate the impact of three provisional action threshold levels for the management of lygus under research station conditions. These were 10 bugs per 50 sweeps of a net (referred to as low threshold =LT), 15 bugs per sweep net catch (medium threshold = MT) and >15 bugs per 50 sweep net catches (high threshold = HT). The decision to spray was taken if the number of bugs caught in the 30 cm diameter sweep net exceeded the above levels. The yield response of cotton was quantified at the two research stations over two growing seasons 1994/95 and 1995/96. The insecticide Sherpa DL® (cypermethrin 50 + dicofol 300g/l) for insect and mite control was used in all the trials.

The mean number of bugs caught exceeded the ATL twice in both the LT and MT and, once in the HT plot (Table 1) and the respective plots sprayed. The seasonal mean number of sprays, granted by the use of three ATLs, is presented in Table 2. The highest yield of seed cotton (887.7 kg/ha) was obtained from the HT plots. The lygus bug to flower bud ratio at eight weeks after germination was significantly (P=0.05, LSD =0.12) higher in the LT than that for MT and HT plots. Overall the lowest mean lygus bugs: flower buds ratio (0.09) occurred in the HT treatment.

The results suggested that a lygus threshold for spraying of 10-15 bugs/50 sweeps corresponds to a lygus: flower bud ration of 1.15 used 7–12 weeks after cotton germination could be economical to use. From the economic point of view, the mean number of insecticide sprays in the two years was lower than the current recommendation and resulted in a significant reduction in the average control costs for lygus. At a cost of UShs 12,500 per liter of insecticide, the lygus control costs estimated for the three ATLs were 31,250, 25,000 and 18,750 UShs respectively.

Similar studies demonstrated the importance of control action thresholds in insecticide applications for bollworm management (Sekamatte and El-Heneidy, 1997). Using the same method as for lygus seed cotton yields, average yields over two years were highest in the MT (5 larvae/100 plants) at 745.3 kg/ha, compared to 714.8kg/ha, 233 kg/ha for LT (3 bollworm larvae/ 100 plants), 534.6 kg/ha for HT (>7 bollworm larvae/100 plants) and for the control plots (Table 3).

Since the development of the provisional control Action Threshold Levels (ATLs) for lygus and bollworms, the cotton research program has undertaken extensive on –farm trials to verify the practicability of the levels and to modify them according to local circumstances. The threshold intervention system however, has been faced with problems related to difficulties in farmers' adoption of the use of sweep nets and in the physical searching for and counting of bollworm larvae. These were additional difficulties for farmers to adopt scouting techniques developed at the research stations.

Assessment of non-chemical approaches

The only non-chemical approaches to cotton pest management studied under the two projects were enhancement of predatory species through intercropping with legumes. In studies at Namulonge and Serere during the 1994/95 and 1995/96 seasons, lygus bugs showed considerable attraction to a local vegetable, Malakwang (*Hibiscus* spp.) compared to cotton. In all cases, significantly higher predator populations were obtained from intercropped cotton than in mono-crop cotton (El-Heneidy and Sekamatte, 1996).

Intercropping of maize with *Phaseolus* beans is part of most Ugandan cropping systems and is widespread in cotton zones, although further research continues to investigate optimum crop population of both beans and cotton. Socio economic studies are also underway:

a) Burning of crop residues for the control of *Pectinophora gossypiella* and *Xanthomonas campestris*. This is a common practice despite the lack of empirical data on its efficacy.
b) Use of bollworm parasitoids. During the two projects, a number of parasitoid species for aphids, *Helicoverpa armigera*, *Pectinophora gossypiella* and *Earias* spp. have been identified. The relative effectiveness of laboratory reared *Aphidius colemani* against *Aphis gossypii* demonstrated its potential for classical biological control of the aphid.

Farmer participatory on-farm research

Since the 1998 cotton season, on-farm trials for pest management have been integrated with agronomic studies principally aimed at improving soil fertility. Farmers are involved in the evaluation of the effect of organic and green manure on yields of cotton. Secondly, farmers participate in the determination of appropriate spacing of cotton grown in intercrops with legumes particularly soybean and common beans. The trials have been conducted in 13 districts covering all the cotton growing zones of the country. The component technologies that were being popularized during the on-farm trials are presented in Table 4.

During the 1999–2000 cotton season, in addition to the on-farm trials, farmer field schools were instituted as way of speeding up the farmers' participation in the ATL verification process. The results obtained through these interactions revealed however, that (1) a large majority of farmers may not sufficiently adopt the scouting technique, (2) virtually no farmers expressed willingness to continue using the sweepnet as tool for scouting lygus and (3), although many farmers were happy with the intercropping recommendations, very few expressed readiness to planting the component cotton-based intercrops in rows (Figure 1).

Discussion

The low levels of adoption of improved IPM techniques in addition to low prices offered to cotton farmers present major constraints to increased productivity and a significant set-back to the agricultural modernization efforts by government. Apart from intercropping, which is to some extent inherent in most cotton-based cropping systems in the country; farmers have not adopted to any appreciable degree any of the other technologies, suggesting that pest control is likely to remain pesticide dominated. Whilst this can be attributed to farmers' passiveness, questions about researcher approaches as well as the appropriateness of the technologies being popularized have repeatedly been asked.

In past studies on factors affecting crop protection packages in Uganda, farmer passiveness came up as a factor explaining as reluctance to take any new recommendations. While it may be true for cotton farmers in the studies reported here, the enthusiasm which the participating farmers expressed during the initial stages of the program suggests that other factors, notably appropriateness of the technologies, probably contributed more to the poor uptake of the research recommendations.

The use of sweepnets and control action thresholds was generally not adopted by large proportions of the farmers, yet they were the principal means to achieving the main goal of introducing IPM in cotton production. Scouting using a sweepnet required that the farmer clearly learnt how to recognize a highly mobile mature bug, he had to count and record the pest levels on each scouting occasion, on top of purchasing the sweepnet itself. This was not a suitable technology for the resource-constrained, largely illiterate/semi-illiterate farming communities that participated in the trials. The same reasoning goes for all the other technologies that require farmers to make additional financial and intellectual inputs. These findings present a major set-back to the process of institutionalizing IPM in the country particularly since attempts to use another alternative options, notably pheromone traps failed owing to (i) the small average size of cotton fields and (ii) the unreliable supply of the pheromones in addition to their cost.

In view of the focus given to the sub-sector by government under the PMA policy, and the strategies designed to tap the advantages of the AGOA agreement, the failure of cotton farmers to embrace improved production technologies (Figure 1) is a big challenge to the researchers. Appropriate research methods must be developed to ensure acceptable levels of farmer adoption of the improved technologies. This requirement has lately been achieved through succeeding projects notably the IDEA/NRI cotton IPM demonstration project (Russel *et al.*, this volume).

By re-modeling the research approach slightly, it has been possible for farmers in the western district of Kasese to adopt the scouting technique and control action thresholds for lygus and bollworms resulting in on average of two instead of four insecticide applications. For the participating researchers, the whole process has been a learning and confidence gaining one.

Conclusions

From this study, it is clear that the initial attempts in extending IPM research to cotton farmers in cotton were frustrated by low adoption levels. Slight adjustments in the technology packaging and transfer methodology by latter projects have generated the possibility of wide-scale adoption. The scenario suggests faults in both researchers' methods and the appropriateness of the technology being presented to farmers. In view of the resource constrained and frequently low literacy status of the target farmers, the researchers need to refine the approach. Unless this problem is critically addressed, investment in IPM research programs may not contribute significantly to the needs for a modernized cotton sub-sector. Nevertheless, the process can be viewed as a significant step in enhancing confidence of the research teams to undertake IPM promotion.

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Table 1. *Mean number of lygus bugs per 50 sweepnet strokes in plots with three trial ATLs (LT = Low Threshold; MT= Medium Threshold; HT= High Threshold).*

Weeks after germination	Location					
	Namulonge (1994/95)			Serere (1994/95)		
	LT	MT	HT	LT	MT	HT
8	5.3	0	0	11.3	8	9.7
9	8.3	0	0	1.5	10.9	11.2
10	13	0	0	4.5	13.2	13.9
11	7	18	9	18.8	12.5	15.3
12	4.8	7.5	14.5	8	9.5	10
13	10.8	5	11.3	11.8	15	18.5
14	9	20.8	16.8	8	11	12
15	6	7	5.5	5.6	5	5.4
16	5.8	6	4.8	6	8	8.3
17	7.5	4.3	5.6	2.7	5.3	5
18	6.3	5.5	6	2.3	3	2.2
19	4.8	6.3	5	0.5	2.8	0.8
20	2.8	2.3	2.8	1.7	1.2	1.3

(Source: Sekamatte and Heneidy, 1998).

Table 2. Mean number of insecticide sprays required in experimental plots at Namulonge and Serere during the 1994/95 and 1995/96 cotton seasons.

ATLs	Number of insecticides sprays		Average
	Namulonge 1994/95)	Serere (1995/96)	
LT	2	3	2.5
MT	2	2	2.0
HT	1	2	1.5
Mean	1.7	2.3	2.0

(Source: Sekamatte and Heneidy 1998).

Table 3. Number of insecticide sprays in the bollworm action threshold experiments at Namulonge (1994/95 and Serere (1995/96).

Action threshold level (ATL)	Number of insecticide sprays		Mean
	Namulonge (1994/95)	Serere (1995/96)	
LT	2	1	1.5
MT	1	0	0.5
HT	1	0	0.5
Control	0	0	0
Current recommendation			4

(Source: Sekamatte and Heneidy, 1997)

Table 4. Component IPM technologies popularized among cotton farmers.

Technology	Description
1. Intercropping	With *Phaseolus* beans, soybean and groundnuts. Intended to augment populations of indigenous natural enemies
2. Scouting for pests	Field scouting to determine whether lygus/bollworm thresholds are exceeded
3. Weeding	Evaluation of weeding frequency
4. Seed dressing	Evaluation of efficacy of fungicides and bactericides against major seed borne diseases of cotton
5. Use of A. T. L's	Used as decision-making tools by farmers to apply insecticides on a need basis
6. Botanical insecticides	Evaluation of alternatives to inorganic insecticides. These are proprietary plant- derived products both imported and locally processed

Figure 1. *Cotton farmers expressing willingness to adopt/not to adopt three IPM techniques in Kasese and Masindi districts in Uganda.*