Effect of Structural Adjustment Programmes on Pest Control in Tanzania: Case Study of *Helicoverpa armigera* (Hübner) on Cotton

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ABSTRACT

Attack by Helicoverpa armigera remains the major constraint to increased productivity of cotton in Tanzania. For optimal yield, six preventive sprays of chemical insecticides are required during flowering for control of this pest. However, the abolition of subsidies on chemical insecticides/fertilizers and devaluation of the currency (brought about by an on going structural adjustment programme), increased production costs have led to a decline in profitability. VIn light of this new economic environment, on station and on farm trials were carried out between 1994 and 1997, to evaluate the utility of threshold based spraying and plant based insecticides for optimal management of H. armigera. The study showed that spraying on a threshold of 50% damaged buds, reduced spraying frequency from six to three sprays without significantly reducing yield. Similarly, 17% v/v extracts from Tephrosia vogelii, Jatropha curcas, Azadirachta indica and Derris eliptica applied by Micron ULVA + in 10 litres of water/ha, were comparable to either endosulfan applied at 625 or cypermethrin at 45 g a.i ha^{-1} for control of the bollworm. Botanical insecticides gave 17 to 65 % less yield than conventional pesticides but an average of 38% more than the unsprayed control.

Introduction

The American bollworm, *Helicoverpa armigera* (Hübner), is a major world-wide pest of cotton and other crops (Fitt, 1989). In Tanzania, damage by *H. armigera* and other pests is responsible for yield losses of up to 40% (Reed, 1965; Nyambo, 1989; Kabissa, 1989), amounting to approximately 20 million dollars of lost revenue annually (Reed and Pawar, 1982). These losses that exclude expenses on pesticides and their application, are an enormous economic burden to most subsistent growers.

Although *H. armigera* can be controlled by chemical insecticides applied during the flowering period (Reed 1968), productivity of cotton, Tanzania's second most important cash crop after coffee, remains low relative to the area of 0.5 million ha under cultivation (Kabissa, 1995). Thus the 1991/92 crop of 510,000 bales (181 kg each) (Tanzania Cotton Lint and Seed Board, 1997 Unpublished report) constitutes the highest production recorded to date. Among other reasons, low productivity is mainly attributed to low adoption of improved technologies (Cox, 1985; Kabissa *et al.*, 1997).

Recently, cotton marketing in Tanzania was liberalized and ginning privatized to boost production (Mbilinyi, 1996). However, removal of farm subsidies and devaluation of the currency brought about by the structural adjustment programme, has eroded the profitability of cotton through the increased cost of production. For example, the cost of 15 litres of Endosulfan required per ha per season for control of *H. armigera* rose from US$26 in 1992 to US$112 in 1996. However, the price of seed cotton only doubled during the same period (Tanzania Cotton Lint and Seed Board, 1997 Unpublished Report).

In order to cope with the new economic environment, producers need technologies with lower cash input requirements (Tabor, 1995). This has necessitated switching from a prophylactic to a prescriptive mode for control of *H. armigera*, substituting locally available plant based insecticides for synthetic ones and intercropping cotton with other crops. This paper examines the first two options.

Prior to structural adjustment in late 1980s, most growers were spraying their cotton six times or more per season. However, spraying frequency has now declined steadily, resulting in overall reduction in pesticide use in Tanzania (Kabissa, 1995). On the basis of on station trials, Kabissa (1989) and Nyambo (1989) confirmed that *H. armigera* can be managed by a flexible number of sprays triggered by action thresholds based on damage. This strategy offered growers an alternative to calendar spraying but was not tested on farms until 1992. Furthermore, high costs and unavailability of imported pesticides, has stimulated a search for alternative products. Use of extracts from some plants e.g. *Azadirachta indica* and *Derris spp* is reportedly effective against *Heliothis* and *Helicoverpa spp* (Yoshida and Toscano, 1994). Similarly, *Tephrosia vogelii* is reportedly effective against some lepidopterous pests, notably *Busseola fusca* and *Chilo* *partellus* (Ministry of Agriculture; unpublished report). However, little is known of the efficacy of these and other products against *H. armigera* under field conditions (Ahmed, 1995).

This paper describes a participatory process to evaluate threshold spraying on farm, as a strategy for optimizing pesticide use on cotton. The field performance of previously untested botanicals *Tephrosia vogelii* and *Jatropha curcas* L. against *H. armigera* compared to synthetic sprays is reported.

Materials and methods

Threshold based spraying. Between 1993 and 1997, 100 growers from IPM working groups in Shinyanga, Kahama, Meatu and Bariadi districts of Shinyanga region and a Farmer Research Group in Missungwi district of Mwanza region were each asked to allocate two blocks of cotton; 0.4 ha for threshold spraying and 0.4 ha to be sprayed on usual farmer's practice. Before spraying began, growers were instructed on the use of peg boards for spray decision making. The peg boards were a modification of the type described by Matthews and Turnstall (1968) and Nyambo (1989). Sampling for spray decision making was done weekly, starting at flowering and endosulfan was applied at 625 g a.i/ha by Micron Ulva Sprayers whenever 15 or more freshly damaged buds were observed per 30 plants, sampled from the two diagonals of each scouted field. In the case of unscouted cotton, spraying was effected if and when a grower saw fit to do so. Other secondary observations such as sowing date, plant density and weed control were also noted.

After harvest, growers were asked to report on how many times they scouted their field, the number of times the spray threshold was reached, the number of sprays actually applied and seed cotton yield.

Plant Based Insecticides (PBIs). *A. indica*, *J. curcas*, *D. elliptica* and *T. vogelii* were prepared as 16.7 v/v extracts in water before spraying as follows: leaves of *T. vogelli*, roots of *D. elliptica* and seed kernels of *J. curcas* and *A. indica* were pounded separately in a mortar in order to form either a paste in the case of leaves/roots or a powder in the case of kernels. One kg of each product was soaked in 1 litre of distilled water for 24 hours. After sieving, the supernatants were diluted to strengths of 16.7% v/v. These PBIs and checks (endosulfan 25% in 1997, cypermethrin 1.8% ulv in 1996 and 1998 selected on basis of high use patterns), were compared for control of *H. armigera* in trials at Ukiriguru and Ng'hoboko (representing on station and on farm conditions respectively), using randomized complete block designs with four replications. Plot size was 500 m_2. At each site, an unsprayed plot was included but was kept 10 m away from other treatments in order to minimize effects of drift.

In 1996, treatments were applied 6 times at 14 day intervals starting at flowering. In 1997, both PBIs and the check treatment were applied on the basis of a 50% damage threshold only at Ukiriguru. At Ng'hoboko only PBIs were applied on the basis of an action threshold. PBIs were applied by ULVA + sprayer in 10 litres of spray volume/ha using 3.6 m swaths. Ulv insectides were also applied by ULVA + sprayers but at a rate of 2.5 litres of spray volume per ha using 4.5 m swaths. Sampling for damaged buds and infestation by *H. armigera* and indigenous predators was assessed weekly by a sight and count method (Wilson and Room, 1982) on 30 plants randomly selected per plot. Data on seed cotton yield, pest damage and insect numbers were subjected to analysis of variance.

Results

Threshold based spraying. On average, fields were scouted 7.7 times and the action threshold was reached an average of 1.56 times. Most scouted fields were sprayed once or twice. Non scouted fields were sprayed 2 to 3 times. Occasionally, the spray threshold was reached but growers could not spray their fields for lack of pesticides or because pesticides were too expensive. However, in a few cases, farmers sprayed their cotton even when the threshold had not been reached. Seed cotton yields varied between 393 and 1373 kg/ha for scouted fields and between 261 and 1008 kg/ha for unscouted cotton. Spraying on action threshold gave significantly ($P<0.05$) higher yield than spraying intuitively in (Table 1).

Plant Based Insecticides. In 1996 when attack by *H. armigera* was only slight, PBIs and cypermethrin gave similar control of *H. armigera* and seed cotton yield per ha (Table 2). The unsprayed check had more bollworm larvae, more damaged buds and less seed cotton yield than other treatments. In 1997, when attack by *H. armigera* was heavier, *D. elliptica* gave the best formulation control of bollworm larvae at Ng'hoboko. On average, PBIs had 32% fewer larvae and 33% fewer damaged buds than the unsprayed control. At Ukiriguru, endosulfan gave significantly better bollworm control and higher yield than all PBIs. The same was true in 1998 when cypermethrin was used as standard. In general, standards gave over 17% higher yield than PBIs while the latter gave an average of 38% higher yield than the unsprayed check. The effect of PBIs on incidence of coccinellids, syrphids and chrysopids, as assessed in 1997 and 1998, showed variable results (Table 3). In 1997 PBIs were comparable to endosulfan but in 1998, results were less definitive.

Discussion

The high cost and unavailability of inputs in relation to prices offered for cotton is currently the major constraint to increased productivity and hence a disincentive for adoption of improved production technologies in Tanzania.

Apart from the Bariadi district, yields from all over Shinyanga region were generally on the low side. This cannot be attributed to inadequate pest control alone. Rainfall in most of the cotton growing areas of Shinyanga and Mwanza regions is often too erratic to assure optimal yields. In the case of Shinyanga, broadcasting of seed during planting often results in sub-optimal plant population per ha and severe weed problems. These factors also contribute to reduced yields per ha (Meertens *et al.*, 1992).

Thus, in view of low plant densities and generally poorly grown cotton, attack by *H. armigera* on most cotton in western Tanzania, is seldom severe enough to warrant more than just a few sprays (Meertens *et al.*, 1992; Nyambo, 1989). This is confirmed by our study where only up to 2 sprays were needed against *H. armigera* compared to six applications if calendar spraying had been followed (Reed, 1968). If a more intensive pest control programme is envisaged, agronomic practices that assure higher yields will have to be adopted first. However, despite the inherent attractiveness of threshold spraying, continued availability and high cost of imported conventional pesticides remains a bottleneck to profitable cotton production. It is in this regard that locally available PBIs may offer viable alternatives in terms of effectiveness, safety, selectivity, availability, and ease of preparation and application (Casida and Quistad, 1998).

Conclusions

From this study, PBIs averaged over 30% more seed cotton yield than the unsprayed treatment but they gave significantly less yield than conventional pesticides. These results would tend to reinforce the potential of PBIs for use on cotton at field level subject to other considerations, the most critical of which would be labour requirements for frequent processing of PBIs prior to spraying, in view of their shorter shelf life (Ahmed, 1995). Unless this problem is solved, growers may feel reluctant to adopt PBIs in preference to conventional pesticides.

Although PBIs may be used for pest control on cotton in the future, further research is needed regarding their handling to enhance field efficacy. Ultimately, PBIs will have to be used on a need basis, determined through adoption of threshold spraying. These results confirm that action thresholds can reduce overall pesticide use on cotton without sacrificing control of *H. armigera* or seed cotton yield. This has the potential of reducing not only production costs but also adverse environmental effects. It may further facilitate development of IPM for *H. armigera*.

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Table 1. Effect of threshold spraying on seed cotton yield in western Tanzania.

Season	District	Times Scouted	Times Threshold Reached	Number of sprays		Seed cotton Yield (kg ha^{-1})	
				Scouted	Check	Scouted	Check
1992/3	Kahama	8.2	1.8	1.7	2.1	474	433
	Shinyanga	7.0	2.7	2.7	2.3	547	370
	Meatu	9.2	1.8	1.2	1.3	393	261
1993/4	Kahama	8.3	1.0	1.0	1.5	828	715
	Shinyanga	7.7	1.6	1.4	1.3	811	789
	Meatu	8.7	2.3	0.7	0.0	390	391
	Bariadi	8.0	2.0	2.0	3.0	1373	973
1994/5	Kahama	7.5	0.9	0.8	2.0	698	443
	Shinyanga	6.0	0.9	0.8	2.0	678	685
	Meatu	7.4	1.6	1.1	2.0	729	500
	Bariadi	6.7	1.1	0.9	3.0	1351	1008
1996/7	Missungwi	8.2	1.0	0.6	0.0	519	463
Mean		7.7	1.6	1.2	1.7	733	586
SE				0.2	0.3	95.0	70.3

Table 2. Effect of foliar sprays of PBIs on control of *H. armigera* and seed cotton yield.

Treatment	1996			1997						1998		
	Ukiriguru[1]			Ukiriguru[1]			Ng'hoboko[1]			Ukiriguru[1]		
	Lvae	Buds	Yld	Lvae	Buds	Yld	Lvae	Buds	Yld	Lvae	Buds	Yld
A. indica	3.0	3.0	1082	28.0	42.0	651	24.5	112.1	979	19.9	51.7	759
J. curcas	2.0	7.0	1111	30.0	48.1	676	19.0	105.4	827	20.2	49.6	739
D. elliptica	2.0	5.0	975	28.1	46.0	738	9.1	125.1	679	NOT TESTED		
T. vogelii	2.0	5.0	1152	26.3	41.0	620	18.1	110.4	868	22.8	51.7	719
CHECK	2.0	4.0	1300	17.0	37.3	1028	21.1	109.4	1119	15.9	39.6	998
LSD	NS	NS	NS	0.6	NS	NS	0.7	NS	143	0.9	0.7	NS
Unsprayed	8.0	22.0	963	26.1	49.1	358	32.0	128.4	716	24.9	77.8	539

[1] Denotes buds and larvae sampled per 100 plants

Table 3. Effect of PBIs on populations of selected predators 1997(1998).

Treatment	Coccinellid adults		Coccinellid larvae		Chrysopid eggs	
	Ukiriguru	Ng'hoboko	Ukiriguru	Ng'hoboko	Ukiriguru	Ng'hoboko
A. indica	12.2(1.4)	21.1	9.0(0.7)	26.3	2.4(12.4)	16.1
J. curcas	11.1(2.1)	23.1	9.2(1.3)	19.0	2.4(11.2)	16.1
D. elliptica	12.2(_)	23.0	10.3(-)	17.0	2.2(-)	17.0
T. vogelii	9.2(2.9)	20.3	10.0(1.4)	22.4	4.1(9.9)	15.0
Check	12.1(3.7)	20.3	5.2(2.8)	18.3	6.2(8.4)	17.1
LSD	NS(1.5)	NS	NS(0.7)	NS	NS(NS)	NS
Unsprayed	15.0(3.7)	23.0	14.0(4.0)	21.0	3.0(25.6)	21.0

LEGEND: Figures in brackets are data collected in 1998