Insecticide application to reduce pest infestation and damage on cowpea in Uganda

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Field assessments were carried out in seven districts of eastern and northern Uganda to establish pest infestation of cowpea (*Vigna unguiculata*) and the extent of insecticide usage to control these pests. More than 60 % of the farmers in eastern Uganda applied insecticides to control cowpea pests whereas no farmers in the northern region used chemicals for this purpose. The extent of pest infestation at different crop growth stages appeared to influence pesticide application, with most farmers spraying during the vegetative (30 %) and flowering (50 %) stages, and only a few at podding (10 %). There was evidence of ineffective/uneconomical use of insecticides. On-farm trials indicated that insecticide protection at all crop growth stages gave the best control, leading to yield gains of more than 50 %. Spraying during vegetative and flowering stages was also effective, giving yield gains of about 40 %. A three-spray programme (at vegetative growth, flowering and podding) was most profitable in the short rainy season at Serere (marginal return = 6.08) and second best in the long rainy season at Kabanyolo (marginal return = 4.35).

Key words: farmer perception, insecticide sprays, insect pests, plant growth stages, *Vigna unguiculata*.

Cowpea, *Vigna unguiculata* (L.) Walp., is an important food legume in northern and eastern Uganda (Sabiti et al. 1994) where about 90 % of the country's crop is grown (Anonymous 1993). The cowpea contains 23–38 % protein (Bressani 1985) and, as such, provides vegetable protein to a large proportion of the rural and urban poor who cannot afford other sources of protein, especially meat. The crop is also important in other tropical and subtropical areas, particularly Nigeria and the Sahelian region of West Africa (Singh et al. 1997).

Cowpea yield potential in Uganda is high, ranging from 1500 to 3000 kg ha^{-1} (Rusoke & Rubaihayo 1994). At farm level, however, yields are very low, averaging less than 500 kg ha^{-1} (Sabiti et al. 1994). This is attributed to heavy biotic pressure, particularly by insect pests (Rusoke & Rubaihayo 1994; Sabiti et al. 1994). The main approach to control these pests has been by chemicals, for which there are several recommendations (Nyiira 1978; Singh & Jackai 1985; Jackai & Daoust 1986). In the tropics, even varieties with resistance to some pests require a minimum of 2–3 applications of insecticide for optimum performance (Jackai et al. 1985; IITA 1993). However, lack and cost of pesticides have placed them beyond the reach of most cowpea farmers in Uganda. Recently, however, there appears to have been an increase in the use of insecticides to control cowpea pests. For example, in eastern Uganda, where cowpea is grown extensively, a preliminary survey revealed that more than 20 % of the farmers use insecticides to control pests (Omongo 1996). In light of this apparent increased use of insecticides in the country, there was need to establish the types and frequencies of use of insecticides on cowpea, and to ascertain minimum spray schedules for economic management of cowpea pests.

Materials and methods

Pest assessment in farmers' fields

Field surveys were conducted during the first (March–June) and second (September–December) rains of 1994 in the Soroti, Kumi, Pallisa and Tororo districts in eastern Uganda, and Lira, Nebbi and Arua in the northern region. No survey was conducted in Tororo and Lira during the first rains because cowpea is not grown in these districts in this season. One county was chosen per district in Arua, Nebbi, Lira and Tororo; two each in Kumi and Pallisa, and three in Soroti. For each county, 10 farmers from the major cowpea-growing parishes were randomly selected and pesticide usage data obtained from them during cowpea growth. Type of insecticide, dosage and number of times applied per season, and the cowpea varieties grown were recorded. A total of 90 and 110 cowpea fields were assessed during the first and second rains, respectively.

Each field was visited three times during each of the first (March–June) and second rains (September–December) of 1994, the visits

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corresponding to the early vegetative (2–3 weeks after emergence), flowering/podding and pod maturity stages. During each visit, 10 plants in each field spaced about 10 m apart along a transect were inspected for insect infestation. At early vegetative stage, aphid populations were recorded as low (<100 aphids per plant), moderate (100–300 aphids per plant) and high (>300 aphids per plant) based on visual inspection (Ogenga-Latigo et al. 1992). Population densities of thrips and maruca were assessed by counting their numbers on 20 flowers randomly picked per field. At flowering and podding stages, counts were made of different pod-sucking arthropod species on 10 plants per field. Damage by pod-sucking arthropods and maruca was assessed by examining cowpea seeds from dry pods at harvest and expressed as percentage shrivelled seeds and seed eaten, respectively.

On-station assessments

During the short (second) and long (first) rainy seasons of 1994 and 1995, respectively, field experiments were established at Serere Agricultural and Animal Production Research Institute in eastern Uganda, and Makerere University Agricultural Research Institute Kabanyolo in central Uganda. Serere represented the typical drier cowpea-growing areas of Uganda, while Kabanyolo is wetter, more humid and cowpea is grown here only for its leaves that are eaten as a vegetable. Three cowpea varieties were used, namely TVx 3236, IT82D-522-1 and Ebelat. TVx 3236 and IT82D-522-1 are from the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria, while Ebelat is a local cultivar widely grown in eastern Uganda. Variety TVx 3236 is moderately resistant to flower thrips, *Megalurothrips sjostedti* Trybom (Jackai & Singh 1988).

The experiment was a split-plot of randomised complete block design replicated three times. The replicates and main plots were separated by 2 m-wide zones while the sub-plots were 1 m apart. There were five main plots in each block, each with three sub-plots. The main plots, measuring 11 × 1.8 m, comprised insecticide treatments while the sub-plots, measuring 3 × 1.8 m, incorporated the three cowpea cultivars. Crop spacing in each sub-plot was 60 cm between rows and 30 cm within rows. All plots were hand-weeded at 3 and 7 weeks after emergence (WAE).

There were five insecticide application schedules based on plant growth stage;

1-1-1: insecticide applied 5 times viz. at 1, 3 (vegetative), 5, 7 (flowering) and 9 (podding) WAE.

1-1-0: insecticide applied 4 times, viz. at 1, 3 (vegetative) and 5 and 7 (flowering) WAE.

1-0-1: insecticide applied 3 times, viz. at 1, 3 (vegetative) and 9 (podding) WAE.

1-0-0: insecticide applied 2 times, viz. at 1 and 3 WAE (vegetative stage only).

0-0-0: unsprayed (control).

For the spray treatments, Rogor (dimethoate 40 % EC), a systemic insecticide, was applied at a rate of 400 g a.i. ha^{-1} during the vegetative stage, while Dursban (chlorpyrifos 48 % EC), a broad-spectrum non-systemic insecticide, was applied at a rate of 600 g a.i. ha^{-1} during flowering and podding. All plots were sprayed with Dithane M45 (mancozeb 80 % WP) and Benlate (benomyl 50 % WP) at 2, 4 and 6 WAE, to control fungal diseases.

Incidence of *Aphis craccivora* Koch was assessed weekly for 6 weeks starting 2 WAE on 10 plants selected arbitrarily from the middle rows of each plot by recording the number of infested plants. Aphid severity was rated as low (<100 aphids per plant), moderate (100–300) and high (>300) based on visual inspection scores (Ogenga-Latigo et al. 1992). Nymphs and adults of sucking arthropods found on the two middle rows were counted weekly for 3 weeks starting 7 WAE. Abundance of maruca (*Maruca vitrata* Fabricius syn. *Maruca testulalis* Geyer and *M. sjostedti* Trybom) was assessed by counting their numbers on 20 flowers randomly picked from each sub-plot at about 50 % flowering (6–7 WAE). Yield was determined at plant maturity on 10 plants per plot.

Analyses of variance were conducted using an MSTAT-C computer package (R D Freed, Michigan University, USA) and means separated by Fisher's least significant difference (LSD) test at $P = 0.05$. Yield gains and marginal returns were calculated for each spray regime. The marginal returns were estimated as the increase in income for each additional insecticide spray divided by the additional spray cost. Spray costs included the cost of insecticides, hire of sprayer, labour for spraying and depreciation of sprayer. A value of marginal return less than unity indicates that the increase in cowpea yield does not compensate for the additional cost of spraying.

Table 1. Insecticides applied (%) on cowpea by farmers in four districts in Uganda in 1994.

Insecticide	District				Mean
	Soroti	Kumi	Pallisa	Tororo	
Salut (chlorpyrifos + dimethoate)	13.0	50.4	36.1	50.0	37.4
Decis (decamethrin)	13.0	43.6	57.7	25.0	34.8
Ambush (cypermethrin)	47.5	6.0	4.8	0	14.6
Rogor (dimethoate)	19.0	0	0	0	4.8
Karate (lambda-cyhalothrin)	6.5	0	0	0	1.6
% Fields sprayed	37.5	77.5	70	70	63.8

Results

Insecticides were widely used in the Kumi, Pallisa and Tororo (Table 1) districts where cowpea is grown as a cash crop. No chemical control was used in the districts of Lira, Nebbi and Arua, reportedly because of high costs. Farmers who sprayed used more than one type of insecticide, depending on availability and use on other crops. Of the insecticides applied, Salut (chlorpyrifos + dimethoate), Decis (decamethrin) and Ambush (cypermethrin) were the most common (Table 1). However, most farmers were not knowledgeable about the rates to be applied and reported a wide range of dosage in use. For example, Salut was applied at 5–80 ml, Decis at 20–50 ml and Ambush at 10–50 ml per 15 l water and sprayed to cover about 0.2 ha. Most farmers used knapsack sprayers (CP 15) although a few used bundles of grass to sprinkle the chemicals onto the crop.

Most farmers sprayed their cowpea four times, twice at vegetative and flowering stages respectively, although more than one spraying was done at podding stage in Kumi during the long rains (Tables 2, 3). Generally, insecticide application by farmers did not significantly influence pest populations and damage (Table 4). Nevertheless, pest population densities and seed damage levels tended to be lower in sprayed than in unsprayed fields.

In formal field experiments, effective control of pests was achieved with insecticide application. Only one season's data for Serere is presented because of failure of the 1995 experiment. Aphid infestations were more severe in the unsprayed than sprayed plots (Figs 1, 2). Thrips population densities at Serere were also significantly higher in unsprayed plots followed by plots sprayed at vegetative and podding stages only (Table 5). Thrips densities at Kabanyolo were reduced only by four and five applications (Table 6).

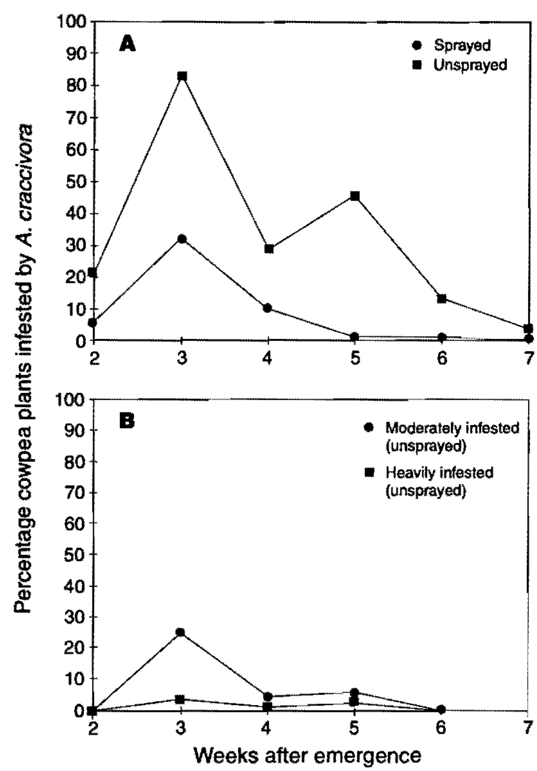

Fig. 1. Incidence (**A**) and abundance (**B**) of *Aphis craccivora* at Serere during the short rainy season of 1994.

Insecticide application did not significantly reduce the population density of maruca during the short (second) rains at Kabanyolo. However, significant reductions were evident during the

Table 2. Schedules of insecticide application (%) on cowpea by farmers during the long rainy season of 1994.

Crop stage	Number of applications	District			Mean
		Soroti	Kumi	Pallisa	
Vegetative	% Fields sprayed	53.6	32.1	48.4	44.7
	1	60	44.0	40	48.0
	2	40	56.0	60	52.0
	3	0	0	0	0
Flowering	% Fields sprayed	42.9	50	48.4	47.1
	1	100	64.3	66.7	77.0
	2	0	35.7	33.3	23.0
	3	0	0	0	0
Podding	% Fields sprayed	3.6	17.9	3.2	8.2
	1	100	60	100	86.7
	2	0	40	0	13.3
	3	0	0	0	0

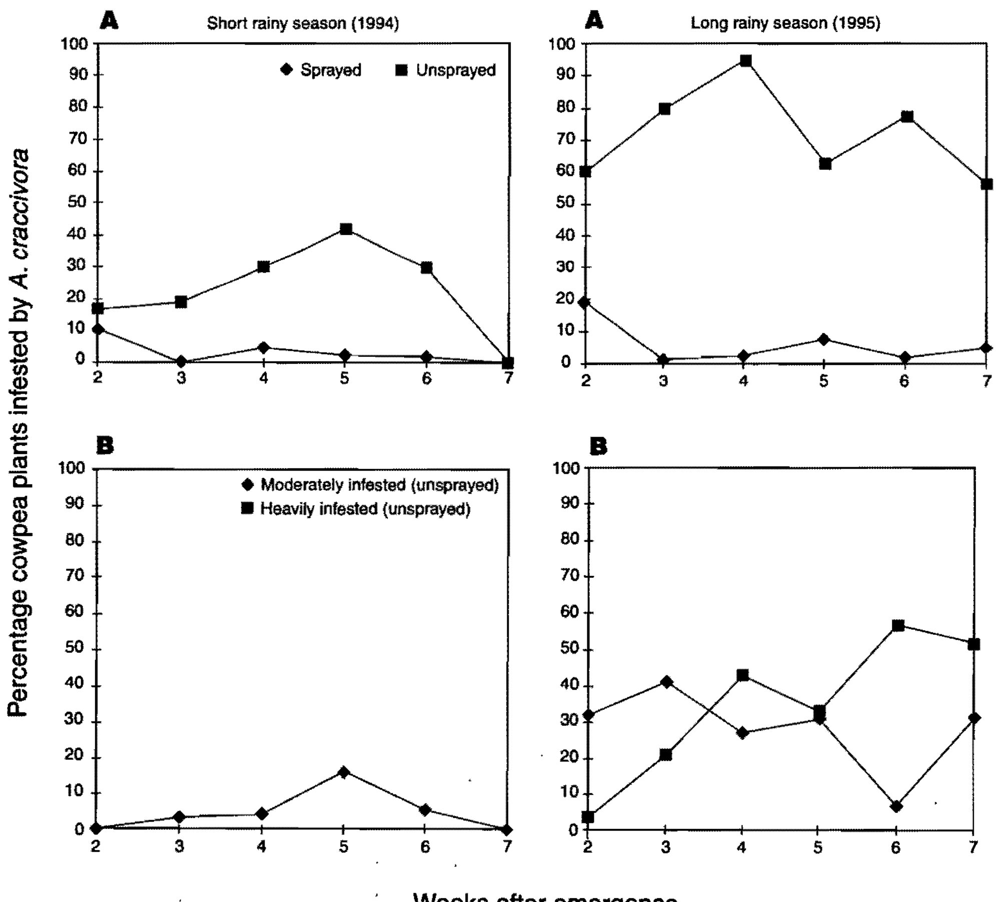

Fig. 2. Incidence (**A**) and abundance (**B**) of *Aphis craccivora* at Kabanyolo during 1994/95.

Table 3. Schedules of insecticide application (%) on cowpea by farmers during the short rainy season of 1994.

Crop stage	Number of applications	District				Mean
		Soroti	Kumi	Pallisa	Tororo	
Vegetative	% Fields sprayed	0	36.2	45.0	20	25.3
	1	0	61.5	75.0	100	59.1
	2	0	38.5	25.0	0	15.9
	3	0	0	0	0	0
Flowering	% Fields sprayed	87.5	38.2	51.7	70	61.9
	1	100	85.7	100	85.7	92.9
	2	0	14.3	0	14.3	7.2
	3	0	0	0	0	0
Podding	% Fields sprayed	12.5	25.2	3.4	10	12.8
	1	100	100	100	100	100
	2	0	0	0	0	0
	3	0	0	0	0	0

Table 4. Effect of insecticides applied by farmers on pest incidence and cowpea seed damage.

Pest counts and damage	Sprayed[a]	Unsprayed[a]	Mean
Long rains (April–July) 1994			
Number of maruca/10 plants	4.4 a	3.8 a	4.1
Number of arthropods/10 plants	2.5 a	2.3 a	2.4
% Shrivelled seeds	10.4 b	18.5 a	14.4
% Seeds eaten	7.2 a	9.1 a	8.2
Short rains (September–December) 1994			
Number of thrips/20 flowers	102.8 b	141.1 a	121.1
Number of maruca/20 plants	2.2 a	2.6 a	2.4
Number of arthropods/10 plants	4.7 a	5.9 a	5.3
% Shrivelled seeds	8.5 a	15.0 a	11.7
% Seeds eaten	5.7 a	4.2 a	4.9

[a]Mean of 20 fields; values in rows followed by the same letter do not differ ($P = 0.05$) according to Fisher's LSD.

Table 5. Mean insect counts and cowpea yields for the different insecticide treatments at Serere during the short rainy season of 1994.

Number of applications[a]	Thrips/20 flowers	Maruca/20 flowers	Athropods/10 plants	Yield (kg ha^{-1})	% Yield gain[b]
1-1-1	41.8 d[c]	0 b	2.0 a	1592.2 a	52.1
1-1-0	32.0 d	0 b	1.3 a	1556.2 a	51.0
1-0-1	149.4 b	0.4 b	1.8 a	1479.6 a	48.4
1-0-0	83.8 c	0.1 b	2.7 a	1259.1 b	39.4
0-0-0	187.4 a	1.8 a	1.0 a	762.8 c	0

[a]1-1-1: insecticide applied 5 times at 1, 3 (vegetative), 5, 7 (flowering) and 9 (podding) weeks after emergence (WAE).
1-1-0: insecticide applied 4 times at 1, 3 (vegetative) and 5 and 7 (flowering) WAE.
1-0-1: insecticide applied 3 times at 1, 3 (vegetative) and 9 (podding) WAE.
1-0-0: insecticide applied 2 times at 1 and 3 WAE, i.e. vegetative stage only.
0-0-0: unsprayed (control).
[b]Compared to unsprayed control.
[c]Values in columns followed by the same letter do not differ ($P = 0.05$) according to Fisher's LSD.

Table 6. Mean insect counts and cowpea yields for the different insecticide treatments at Kabanyolo.

Number of applications[a]	Thrips/20 flowers	Maruca/20 flowers	Arthropods/10 plants	Yield (kg ha^{-1})	% Yield gain[b]
Short rains					
(Sept.–Dec.) 1994					
1-1-1	16.6 b[c]	0.1 c	0.6 a	1402.5 a	15.6
1-1-0	25.4 b	0.8 bc	0.6 a	1314.6 b	9.9
1-0-1	82.2 a	3.0 ab	1.9 a	1302.3 b	9.1
1-0-0	112.8 a	4.4 a	0.6 a	1249.8 c	5.3
0-0-0	77.8 a	3.7 a	0.7 a	1183.9 c	0
Long rains					
(April–July) 1995					
1-1-1	48.2 b	0.5 a	8.9 a	1361.1 a	50.1
1-1-0	58.0 b	1.1 a	8.3 a	1212.6 ab	44.0
1-0-1	120.8 ab	1.7 a	7.3 a	1043.6 bc	35.0
1-0-0	162.8 a	2.0 a	7.6 a	885.8 cd	23.4
0-0-0	123.4 ab	2.1 a	4.2 a	678.7 d	0

[a]1-1-1: insecticide applied 5 times at 1, 3 (vegetative), 5, 7 (flowering) and 9 (podding) weeks after emergence (WAE).
1-1-0: insecticide applied 4 times at 1, 3 (vegetative) and 5 and 7 (flowering) WAE.
1-0-1: insecticide applied 3 times at 1, 3 (vegetative) and 9 (podding) WAE.
1-0-0: insecticide applied 2 times at 1 and 3 WAE, i.e. vegetative stage only.
0-0-0: unsprayed (control).
[b]Compared to unsprayed control.
[c]Values in columns within seasons followed by the same letter do not differ ($p = 0.05$) according to Fisher's LSD.

Table 7. Cowpea yield gains and marginal returns for the different spray programmes.

	Serere, 1994		Kabanyolo, 1994		Kabanyolo, 1995	
Number of applications[a]	Yield gain (kg ha^{-1})	Marginal return	Yield gain (kg ha^{-1})	Marginal return	Yield gain (kg ha^{-1})	Marginal return
2 (1-0-0)	—	—	—	—	—	—
3 (1-0-1)	220.5	6.08	52.5	1.41	157.8	4.35
4 (1-1-0)	76.6	2.11	12.3	0.34	169.0	4.66
5 (1-1-1)	36.0	1.00	87.9	2.42	148.5	4.10

[a]1-1-1: insecticide applied 5 times at 1, 3 (vegetative), 5, 7 (flowering) and 9 (podding) weeks after emergence (WAE).
1-1-0: insecticide applied 4 times at 1, 3 (vegetative) and 5 and 7 (flowering) WAE.
1-0-1: insecticide applied 3 times at 1, 3 (vegetative) and 9 (podding) WAE.
1-0-0: insecticide applied 2 times at 1 and 3 WAE, i.e. vegetative stage only.

short (second) rains at Serere and Kabanyolo where insecticide was applied during the vegetative and flowering stages (Tables 5, 6). None of the pesticide programmes reduced population densities of pod-sucking arthropods at any of the locations. Cowpea yields were, however, significantly influenced by the treatments, with insecticide protection throughout the plant growth stages resulting in the greatest improvement in yield. Except during the short rainy season at Kabanyolo, five sprays resulted in cowpea yield increases of more than 50 % over the untreated control. Spraying during vegetative and flowering stages was also effective, giving a yield increase of more than 40 %. Marginal return values, however, indicated that the three-spray programme was most profitable (MR = 6.08) in the short rainy season at Serere, while the 3, 4 and 5 spray programmes were all profitable in the long rainy season at Kabanyolo (Table 7).

Table 8. Main effect of cowpea genotype on number of thrips, maruca, sucking arthropods and cowpea yield of three cowpea cultivars grown in Uganda, 1994/95.

Cowpea cultivar	Thrips/20 flowers	Maruca/20 flowers	Arthropods/10 plants	Yield (kg ha^{-1})
Serere short rains				
(Sept.–Dec. 1994)				
TVx 3236	88.4 b[a]	0.1 a	1.7 a	1285.5 b
IT82D-522-1	131.7 a	0.6 a	1.5 a	1520.4 a
Ebelat	76.6 b	0.7 a	2.0 a	1184.0 c
Kabanyolo short rains				
(Sept.–Dec.) 1994				
TVx 3236	53.8 a	1.9 a	1.1 a	1298.3 b
IT82D-522-1	70.5 a	2.9 a	0.9 a	1629.4 a
Ebelat	64.5 a	2.4 a	0.5 a	1103.8 c
Kabanyolo long rains				
(April–July) 1995				
TVx 3236	91.7 a	1.5 a	3.9 a	1048.3 a
IT82D-522-1	118.1 a	2.5 a	11.3 a	1109.2 a
Ebelat	98.3 a	0.5 a	6.6 a	959.6 a

[a]Values in columns within seasons followed by the same letter do not differ ($P = 0.05$) according to Fisher's LSD.

Pest infestation in different cowpea cultivars

The only significant difference in pest infestation was the higher number of thrips present on flowers of the cultivar IT82D-522-1 than on TVx 3236 and Ebelat during the short rainy season at Serere (Table 8). IT82D-522-1 produced the highest yield and Ebelat the lowest during the short rainy season at both Serere and Kabanyolo. Cultivar × pesticide programme effects were significant for thrips and maruca infestation at Serere, and for cowpea yield during the short and long rainy seasons at Kabanyolo (Figs 3, 4).

Discussion

The haphazard use of different types of pesticides by farmers and the uncertainty of correct dosages observed in this study indicate a lack of knowledge about the proper use of insecticides in pest control. Farmers seemed to use whatever pesticide was available irrespective of its efficacy but, nevertheless, showed perception of pest problems at different growth stages by timing application of the chemicals accordingly. For example, flower pests were a concern to most commercial farmers, hence they applied pesticides at flowering. However, non-significant differences in pest infestations and seed damage between sprayed and unsprayed fields indicated ineffective use of the chemicals. This appears to have been due to underdosing and incorrect application techniques which, together with deterioration of pesticides due to improper storage, are major causes of ineffectiveness of pesticides (Matthews 1984).

In controlled field experiments, aphid, thrips and maruca infestations were effectively controlled by Rogor and Dursban. Salifu & Hodgson (1987) and Kyamanywa & Tukahirwa (1988) showed thrips populations to increase with growth of cowpea and to reach full infestation at flower opening and fruit maturation. Spraying during the vegetative and flowering stages can thus reduce thrips populations, as was found in this study. Eggs and third instar larvae are the most unprotected stages of maruca (Okeyo-Owuor & Oloo 1991). The eggs are exposed on leaf surfaces and third instar larvae usually move about the plant in search of fresh feeding sites. Commencement of spraying at early stages probably destroyed eggs and early instars of maruca in this study and, consequently, restricted further development of the pest. Pod-sucking arthropods were not significantly affected by the insecticides applied. Similar results have been reported from Nigeria (Alghali 1992), and were attributed to persistent invasion of cowpea fields by adult arthropods from adjacent areas (Singh & Jackai 1985).

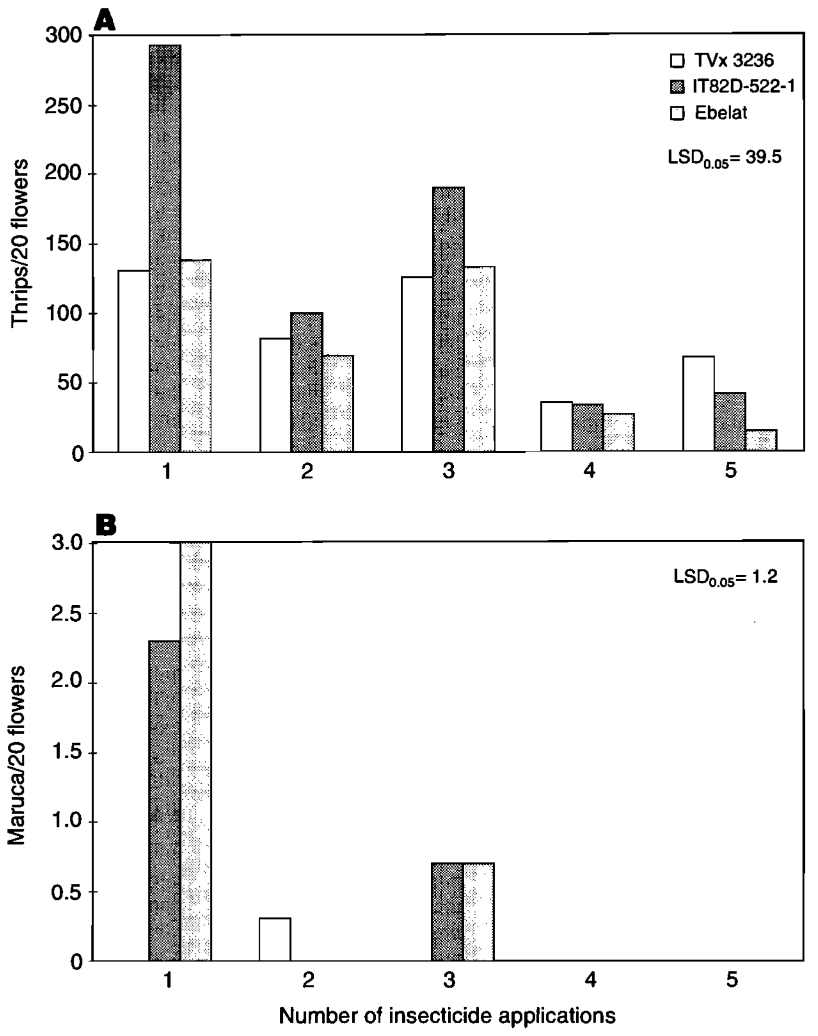

Fig. 3. Interaction of cowpea cultivar and chemical application programme on the number of flower thrips (**A**) and maruca (**B**) at Serere, 1994.

Cowpea yields were substantially increased by some of the treatments, and profit margins were consequently high. Full insecticide protection throughout plant growth gave high yields and high marginal returns, but the three sprays applied at vegetative and early podding stages were equally profitable.

Differential varietal response to pest infestation was revealed in the present study. For example, the number of flower thrips on cultivar TVx 3236 was significantly lower at Serere, and the culivar was also least infested at Kabanyolo during both the short and long rains. The moderate level of resistance of TVx 3236 to flower thrips is consistent with the reports of other workers (Singh & Jackai, 1985). However, resistance/ susceptibility to maruca and sucking arthropods was not apparent amongst cultivars. Nevertheless, the local cultivar (Ebelat) had relatively lower maruca and sucking arthropod infestation levels compared to the elite cultivar IT82D-522-1 throughout the study period at Kabanyolo. This suggests that there are land races of the crop possessing some resistance to the pest. Collection and screening of local germplasm could therefore identify material with sufficient resistance levels.

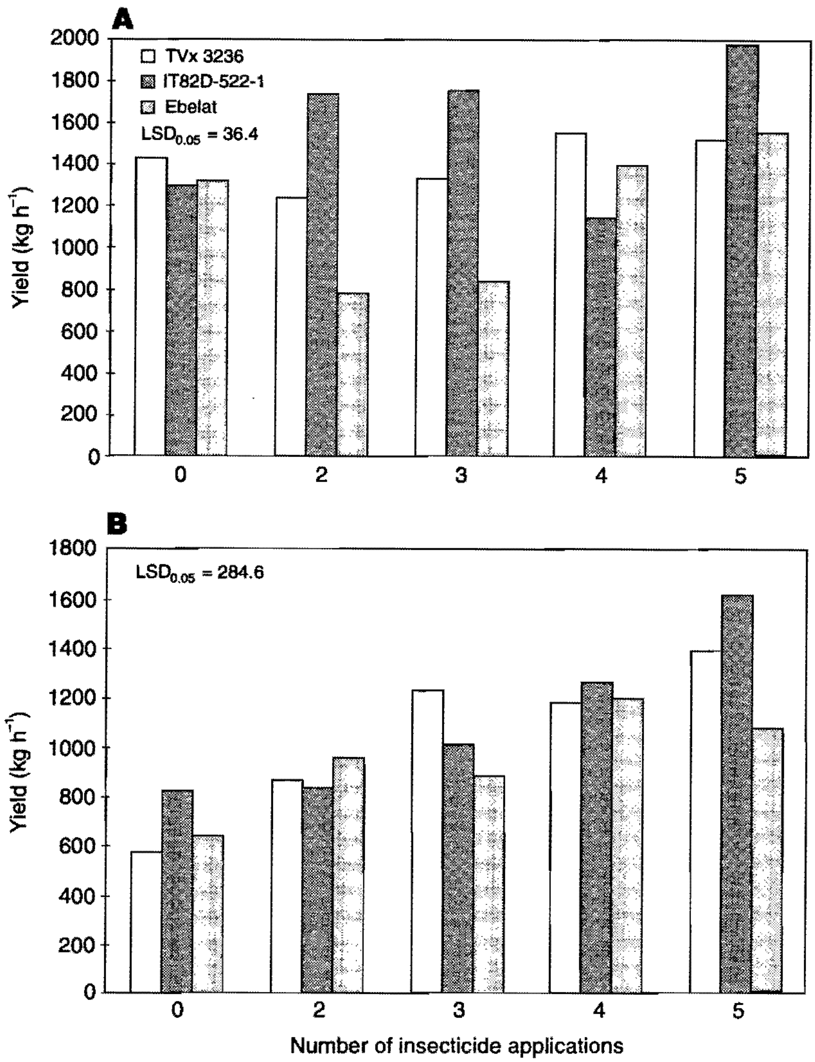

Fig. 4. Interaction of cowpea cultivar and chemical application programme on cowpea yield during the short (**A**) and long (**B**) rainy seasons at Kabanyolo.

Despite the apparent existence of genetic resistance in some genotypes, insect pests still continue to reduce cowpea yields drastically. The significant cultivar × chemical interaction confirmed the need for chemical control of pests in cowpea (generally erect cultivars) to avoid economic losses. As effective control alternatives are still to be developed, insecticide application remains an important management option against pests of cowpea. The increasing but ineffective use of pesticides to control cowpea pests in rural Uganda calls for an aggressive training programme to ensure that compounds are used in an economical and environmentally acceptable manner.

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