Calendar and monitored insecticide application for the control of cowpea pests

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Abstract 'Monitored' sprays are applied when the action threshold (AT) has been reached or exceeded, based on monitoring of crop damage or pest infestation, whereas 'calendar' sprays are applied at specific days after planting without taking into account continued presence or absence of the pest. In this study a comparison was made between monitored and calendar spray applications to determine whether monitored spraying would reduce the number of insecticide applications and still produce yields comparable to calendar spraying. The study focused on four insect pests – the cowpea aphid (*Aphis craccivora* Koch), legume bud thrips (*Megalurothrips sjostedti* Tryb.), legume pod borer (*Maruca testulalis* Geyer) and pod-sucking bugs. These pests damage cowpea at various stages of growth. The trials were carried out at three locations in Nigeria – Ibadan (forest transition zone), Mokwa and Bida (in the southern Guinea savanna zone). At all locations the two calendar schedules used were 7- and 10-day spray intervals. Differences in their effect on insect pest numbers were not significant, neither were there differences in grain yield ($p \geq 0.05$). In general, the calendar schedules recorded lower infestation/damage by aphids, flower thrips and pod borers than monitored spraying but grain yields did not differ between them. Monitored spraying required only two sprays at Ibadan and Mokwa and three at Bida. This was half the number used for calendar spraying. Monitored spraying therefore looks quite attractive as a component in the overall management of cowpea pests.

Keywords Application schedules; insecticides; cowpea pests; *Aphis craccivora; Megalurothrips sjostedti; Maruca testulalis*; pod-sucking bugs; monitored spraying

Introduction

Cowpea [*Vigna unguiculata* (L.) Walp.] is attacked and damaged from planting to harvest and also in storage by a wide range of insect pests. However, there are spatial and temporal variations in the incidence and severity of pest attack. Even though some resistance has been reported for a number of the important pests, losses are still high, and good grain yields have been obtained only with the use of insecticides in areas where the crop is intensively cultivated (Matteson, 1982; Jackai and Singh, 1986).

Complete reliance on pesticides for crop protection does not appear to be the answer to increased and sustainable agricultural productivity (Glass and Thurston, 1978). However, Stern (1973) cautioned against the total abandonment of chemical pest control as this would lead only to further decline in food production. Early research workers in the control of cowpea pests recommended six to seven weekly sprays starting a few days after seedling emergence (e.g. Booker, 1965; Raheja, 1976). As well as the adverse effects on non-target beneficial insects and the high cost, the large number of sprays also constitutes a health risk to the user and consumer; any control strategy that reduces the number of sprays to the necessary minimum should, therefore, be readily accepted by growers. The concept of economic thresholds (ET) in integrated pest management (IPM) was introduced to regulate the application of pesticides so that this should be only when necessary (Stern *et al.* 1959; Pedigo, Hutchins and Higley, 1986).

The ET was defined as the pest density at which chemical control should be applied to prevent the pest from reaching the densities that would cause economic damage (the economic injury level, EIL) (Stern *et al.*, 1959). This was redefined by Pedigo *et al.* (1986) with emphasis on the amount of damage suffered by the crop rather than the number of pests in the crop. In this report the term 'action threshold (AT)' (Cancelado and Radcliffe, 1979) is used instead of ET, to mean the infestation and/or damage level at which insecticides are applied to prevent the infestation/damage from reaching the EIL.

A number of workers have proposed action thresholds at which chemical control should be initiated for the different pests of cowpea. For example, in cowpea a score of 3 (on a 10-point scale) corresponding to few isolated aphid colonies in the crop has been used as the AT for aphids (Jackai and Singh, 1988); a score of 3 (on a 1–9 scale) given on the basis of initiation of drying and browning of leaf and floral buds and of stipules (Jackai and Singh, 1988) is the recommended AT for *Megalurothrips sjostedti*. It has been suggested that control of *Maruca testulalis* should start when 40% or more cowpea flowers are infested/damaged (Jackai, 1985; Ke *et al.*, 1985) whereas an infestation level of two insects (third instar or older) of *Clavigralla tomentosicollis* per metre-row of crop

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Table 1. Scale for rating aphid infestation on cowpea[a]

Colony size	Mean score/20 stands
No infestation	0
A few individual aphids	1
Few small scattered colonies	3
Several small scattered colonies	5
Scattered pockets of large colonies	7
Large continuous colonies	9

[a]Litsinger *et al.* (1977)

Table 2. Scale for rating flower thrips damage to cowpea[a]

Score	Symptoms
1	No browning/drying of stipules, leaf buds or flower buds; no bud abscission
3	Initiation of drying of stipules, leaf buds and flower buds not flower bud abscission
5	Distinct browning/drying of stipules, leaf buds and flower buds; start of flower bud abscission
7	Serious flower bud abscission and failure of peduncles to elongate
9	Very severe bud abscission. Most plants carry short barren peduncles

[a]After Jackai and Singh (1988)

represents the AT (Atropo, 1983; Jackai, Atropo and Odebiyi, 1989) for this species. The work reported here used these ATs in a single trial to determine the reduction in pest numbers or damage that would result from monitoring before insecticide application, compared with predetermined calendar spraying.

Materials and methods

The trials were carried out at three locations, all in Nigeria representing two broad ecological zones: Ibadan (forest transition zone) during the second cropping season from September to November, 1987; Mokwa (southern Guinea savanna zone) during the main cropping season from August to November, 1987; Bida (southern Guinea savanna zone) in a rice fallow from December 1987 to March 1988. Each trial was a two-factor factorial arrangement fitted to a randomized block design with four or five replications. The factors were insecticide regimen and cowpea variety.

Insecticide regimens

The four regimens tested were as follows: (1) unsprayed (no insecticide protection); (2) monitored insecticide application, sprayed only when the observed infestation/damage reached or exceeded the recommended AT (monitoring was done at intervals of 5 or 6 days); (3) four calendar sprays applied at intervals of 10 days starting at 25 days after planting (DAP); (4) five calendar sprays at 7-day intervals starting at 25 DAP.

An Electrodyn formulation consisting of a mixture of lambda-cyhalothrin and dimethoate (Karate Super ED) ($17+35$ g.a.i. l^{-1}) was used to investigate the insecticide regimens. The application rate was ~ 0.6 l ha^{-1}, equivalent to ~ 10 g.a.i. cyhalothrin and 21 g.a.i. dimethoate ha^{-1}

Cowpea varieties

Two varieties were used at each site: IT84S-2246 and TVx 3236 were used at Ibadan and Mokwa; at Bida, VITA 7 replaced TVx 3236. IT84S-2246 is erect, determinate and matures in about 65 DAP; it is resistant to aphids and storage bruchids and moderately resistant to flower thrips, *M. sjostedti*. TVx 3236 is semi-erect, determinate, moderately resistant to flower thrips and matures between 70 and 75 DAP; it is widely grown throughout Nigeria. VITA 7 is semi-erect, determinate and matures 75-85 DAP with no known pest resistance; in the African Sahel this variety is known as KN-1. All three varieties were developed at IITA.

Each plot had six rows, 5 m long and spaced 0.75 m apart, with 0.2 m between plant stands. The erect IT84S-2246 was maintained at two plants per stand whereas the semi-erect TVx 3236 and VITA 7 were maintained at one plant per stand. Thinning was done 15 DAP.

The trials were planted on the following dates: Mokwa, 19 August 1987; Ibadan, 16 September 1987 and Bida, 21 December 1987. At Mokwa and Ibadan the trial fields were under conventional tillage but at Bida the crop was planted in a fallowed rice field with the rice stubble *in situ*.

At Bida there was a massive invasion of the crop by the foliage thrips, *Caliothrips impurus* Presner, which destroyed the entire crop 10 DAP. The whole trial was replanted and the protected treatment plots sprayed at 15 DAP to save the crop from further damage by the foliage thrips. This increased the number of calendar sprays originally planned for Bida by one. The crop at Bida was irrigated at 57 DAP due to severe drought conditions.

Monitoring insect infestation/damage

The treatment effects were assessed in relation to the control of four major groups of pests: aphids, *Aphis craccivora*; legume flower bud thrips, *M. sjostedti*; legume pod borer, *M. testulalis*, and pod-sucking bugs.

Aphid. Two observations were made at 15 and 22 DAP in Ibadan and Mokwa, whereas owing to sub-optimal crop development, seven observations were made at Bida between 15 and 60 DAP. Twenty plants were randomly chosen in the two middle rows of each plot and examined for presence of aphids. The colony size on each of the 20 plants was rated using a 10-point scale (*Table 1*) and the mean score calculated. A mean score of 3, corresponding to few isolated colonies in the crop, was the working AT.

Flower thrips damage. Control of flower thrips was based on visual estimation of browning and drying of terminal and floral buds. Damage to 20 randomly selected plant stands was rated using a 1–9 scale, where 1 represents negligible or no damage while 9 denotes intense browning and drying of buds accompanied by severe floral bud abscission resulting in short barren peduncles (*Table 2*). The damage was monitored between 30 and 45 DAP at 6-day intervals using 3 as AT.

Pod borer infestation/damage. *Maruca* infestation/damage was monitored by examining 20 flowers collected at random from each plot between 40 and 55 DAP at 5-day intervals. The flowers were opened and examined in the field to detect larvae or damage. Chemical control started when an average of 40% or more of the flowers were infested and/or damaged.

Numbers of pod-sucking bugs in the crop. Infestations were assessed by counting all bug species and stages (beyond second nymphal instar) on the two central rows of each plot. Hammond (1983), using the direct visual count technique, reported the highest pod-sucking bug counts at ~1500 h. Counting was therefore done between 1430 h and 1630 h from 55 DAP to harvest at 5-day intervals. All species were counted together because their damage to cowpea is similar. Two bugs per metre-row of crop constituted the AT (Jackai *et al.*, 1989).

Seed damage by pod-sucking bugs. One metre of row length (five plants) was staked out on one of the two centre rows of every plot. This was not subjected to any destructive sampling until maturity when all pods on each metre length were harvested individually. A 20-pod sample from each 1 metre-row was hand threshed and the number of seeds damaged by pod-sucking bugs counted. Seed damage was categorized into aborted seeds, wrinkled seeds and seeds that had necrotic spots and/or feeding lesions.

Grain yield. Dry grain yield was assessed from the two middle rows of each plot at the end of the season. This was extrapolated to kg ha^{-1}.

Profit yield. In this study, increased yield (hence profit) was considered as attributable entirely to insecticide application. Partial budgeting was therefore used to estimate profit per hectare for the various spraying regimens and took into account only input costs that were directly or indirectly dependent on insecticide application. The direct costs were insecticide and labour costs for spraying; pest monitoring, harvesting and threshing costs were the indirect costs. Other costs for land preparation, seed, plant and weed control were taken as fixed and, therefore, not considered in the budgeting. Profit was then calculated by deducting total pest control cost from total income derived from the dry grain. The pest monitoring costs were considered only for the guided treatments in the partial budget analysis.

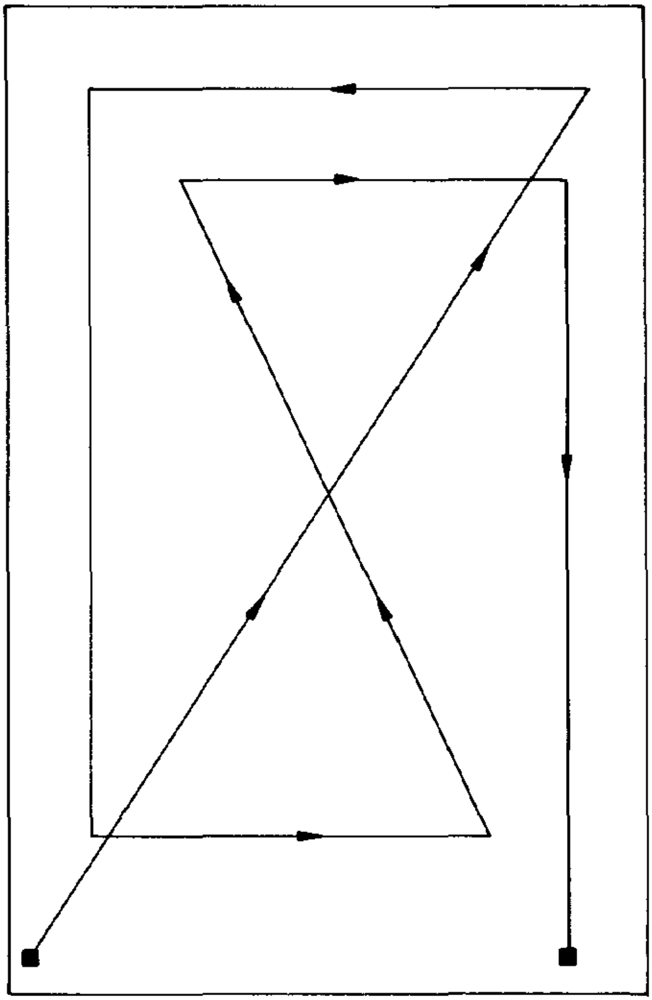

Figure 1. Track for scouting for insect pests in a cowpea field

Pest scouting for monitored spraying. Matthews and Tunstall (1968) developed a scouting method for cotton insect

Table 3. Time in hours and cost of scouting for insect infestation and damage per hectare in cowpea

		Monitoring time (h)					
Location	Cowpea variety	Aphids	Flower thrips	*Maruca* pod borer	Pod-sucking bugs	Total	Total cost(₦)[a]
Ibadan	IT84S-2246	—	2.53(4)	3.75(4)	2.45(3)	8.73	6.55
	TVx 3236	1.26(2)[b]	1.90(3)	3.75(4)	2.45(3)	9.36	7.02
Mokwa	IT84S-2246	—	1.90(3)	2.81(5)	7.60(4)	12.31	9.23
	TVx 3236	1.26(2)	1.27(2)	3.75(4)	8.70(5)	14.98	11.24
Bida	IT84S-2246	—	3.16(5)	3.75(4)	3.90(5)	10.81	8.11
	VITA 7	3.80(6)	2.53(4)	3.75(4)	3.90(5)	13.98	10.49

[a]Naira exchange rate at time of study: official rate, ₦3.5 = US$1; real rate, ₦5.00 = US$1; [b]values in parentheses are the number of observations for which total number of hours is given

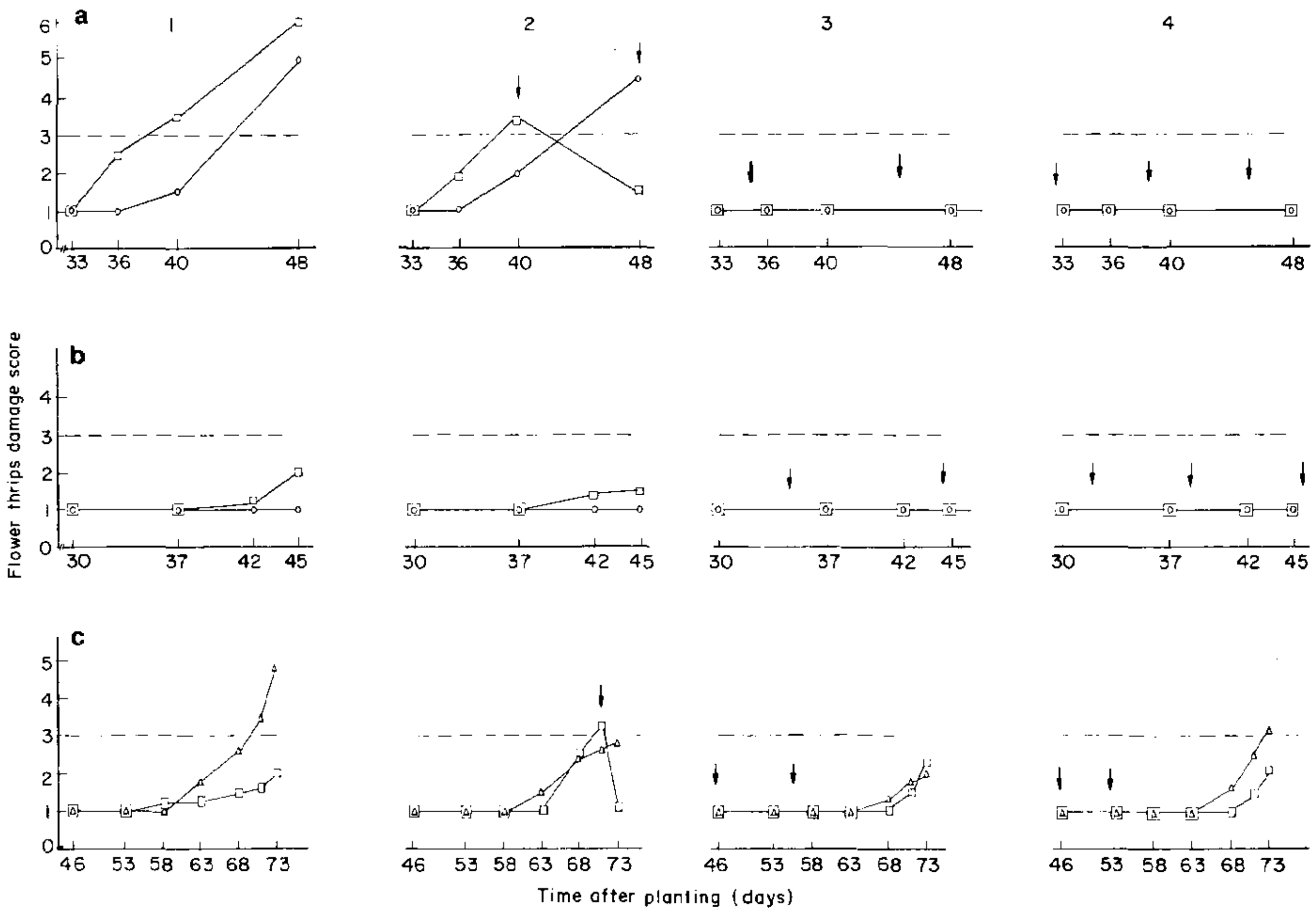

Figure 2. Effect of four insecticide regimens (1, no spray; 2, monitored spray; 3, four calendar sprays at 10-day intervals; 4, five calendar sprays at 7-day intervals) on *Megalurothrips sjostedti* damage to cowpea flower buds (□, IT84S-2246; ○, TVx 3236; △ VITA 7) at three locations (a, Ibadan; b, Mokwa; c, Bida) in Nigeria. ↓, Spray application; ---, action threshold

pests: this method entailed walking in a zig-zag fashion across the field and sampling at pre-determined points. For the present study, the method was modified and adapted for an imaginary sampling on a 0.8 ha field. Sampling techniques were performed after every 10 steps along a track, as shown in *Figure 1*. The mean sampling times were used to estimate the monitoring costs. The mean scouting times and total costs are shown in *Table 3*.

Benefit–cost (B:C) ratio. This was calculated as the value of the increased yield (in Naira) due to insecticide protection, expressed as a ratio of the control cost.

Results and discussion

Aphid infestation and control

The variety IT84S-2246 did not become infested with aphids at any of the sites. This confirms the reported resistance of this variety to the cowpea aphid (IITA, 1987). TVx 3236 and VITA 7 were infested. At Ibadan only the unsprayed and monitored spray plots were infested from 40 DAP. However, the infestation in the monitored treatment did not reach the AT before these were sprayed to control flower thrips 48 DAP; this spray also controlled any aphids that were present on the crop.

No aphids colonized the crop at Mokwa. At Bida, infestation on VITA 7 started from about 20 DAP and needed two sprays (46 and 56 DAP) for control. The two scheduled calendar sprays effectively prevented aphid colonization at Bida.

Flower thrips damage and control

At Ibadan, IT84S-2246 received two sprays at 40 and 48 DAP whereas TVx 3236 had one spray at 48 DAP (*Figure 2*). The higher number of sprays on IT84S-2246, and an earlier attainment of the AT by the same variety at Ibadan, were probably because IT84S-2246 produced flower buds earlier and therefore became infested sooner. TVx 3236 had fewer thrips and a delayed attainment of the AT compared with IT84S-2246 at the same location (*Figure 2*); this could have been attributable in part to differences in the level and/or mechanism of resistance. TVx 3236 and IT84S-2246 have both been reported to be moderately resistant to thrips (IITA, 1987), but the basis of resistance in IT84S-2246-4 has not been fully investigated, while TVx 3236 has been reported to exhibit antibiosis

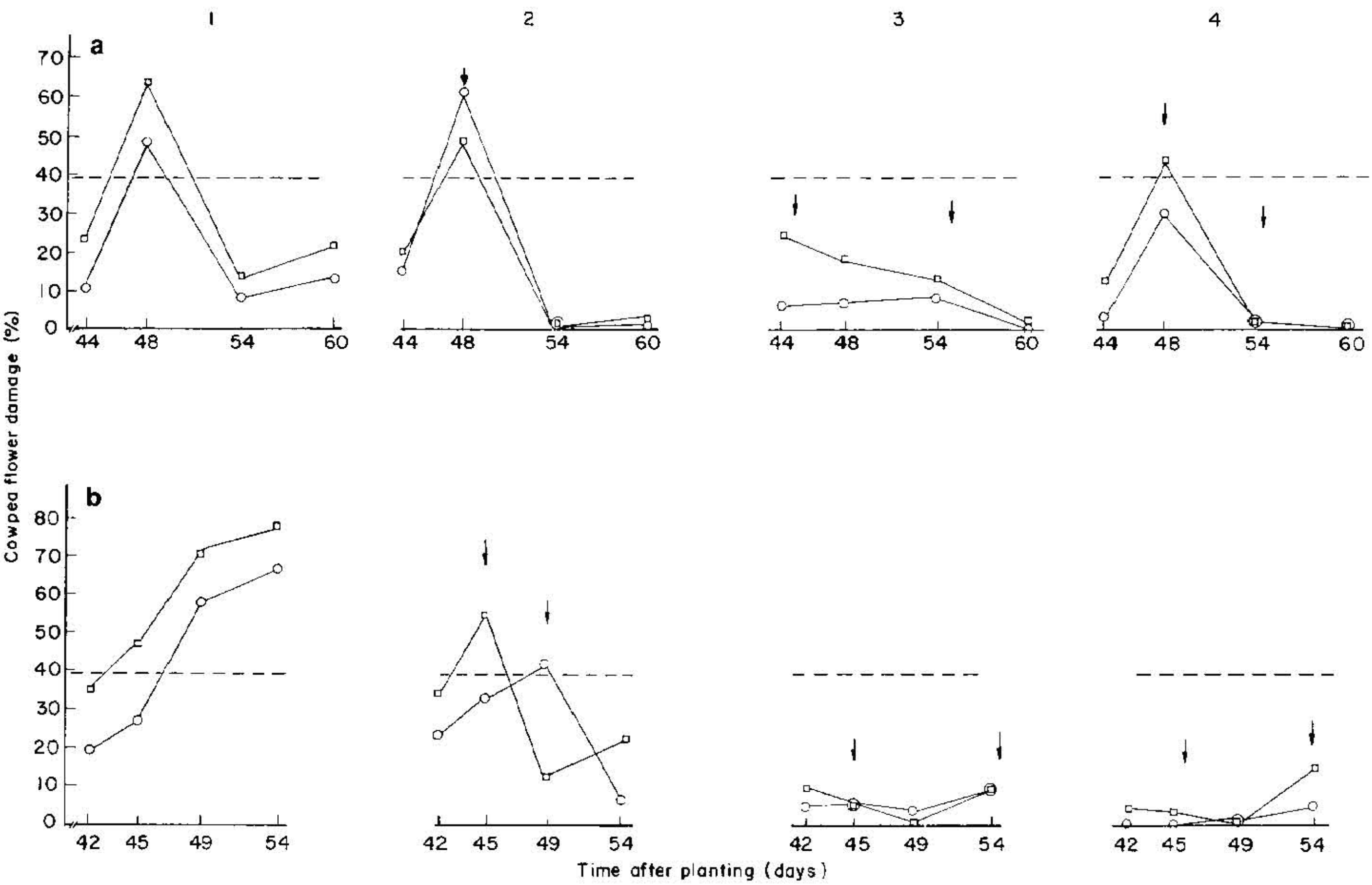

Figure 3. Effect of various insecticide regimens (1–4, as in *Figure 2*) on *Maruca testulalis* damage to cowpea flowers (□, IT84S-2246; ○, TVx 3236) at two locations (a, Ibadan; b, Mokwa) in Nigeria. ↓, Spray application; ---, action threshold

(Salifu, 1986), which retarded development of the flower thrips.

At Ibadan, only the calendar schedules significantly reduced thrips damage when compared with unsprayed treatments (*Figure 2*). Thrips damage at Mokwa did not reach the AT by 42 DAP when monitoring stopped. At Bida, damage by flower thrips was low until 68 DAP when most of the crop was at, or near, 50% flowering. This delayed flowering was traced to soil factors and the slow growth explains why severe damage was recorded so late. Damage to IT84S-2246 reached the AT by 71 DAP and was therefore sprayed. There was no specific spray to control thrips in VITA-7 as the damage did not reach the AT (*Figure 2*). This was possibly caused by the sprays applied at 46 and 56 DAP to control the aphids.

At Bida, only the 10-day-interval calendar treatment recorded a lower mean score for thrips damage than the unsprayed (1.3 and 1.8, respectively). The monitored regimen gave an overall mean thrips damage of 1.7 while the 7-day interval regimen had a score of 1.4, both of which did not differ from the score of the unsprayed treatment. This was probably due to the delayed infestation which built up after the calendar spraying programmes had been completed.

Pod borer infestation/damage control

Infestation by *M. testulalis* did not differ between varieties at any location. MPB infestation in the cowpea varieties did not differ at any of the locations. At Bida where the crop was planted in the dry season, there were no pod borers. Jackai (1983) and Jackai, Ochieng and Raulston (1990) had reported that mating and breeding by this insect were enhanced by moderately low temperature (20–25°C) and high relative humidity (r.h.) (>80%). One would therefore expect high populations of *M. testulalis* during the wet season and relatively lower population densities when there was a drought or during the dry season, as noted here.

At Ibadan, pod-borer flower infestation in the monitored and unsprayed treatments (11.4% and 15.3%, respectively) did not differ significantly, but at Mokwa the guided spray plots had a significantly lower (17.3%) infestation than the unsprayed plots (31.9%). At both sites the calendar regimens recorded significantly lower borer damage than either the monitored or unsprayed regimens (*Figure 3*). Also at Ibadan, the pod-borer population was highest around 48 DAP (the last week of October), but almost disappeared a week later. Similar observations were made by Ke *et al.* (1985) on the yardlong bean *Vigna u. sesquipedalis* in the Hangzhou province of China.

Pod-sucking bug infestation and control

No spray was applied against pod-sucking bugs at Ibadan and Bida in the monitored spray plots, as the population

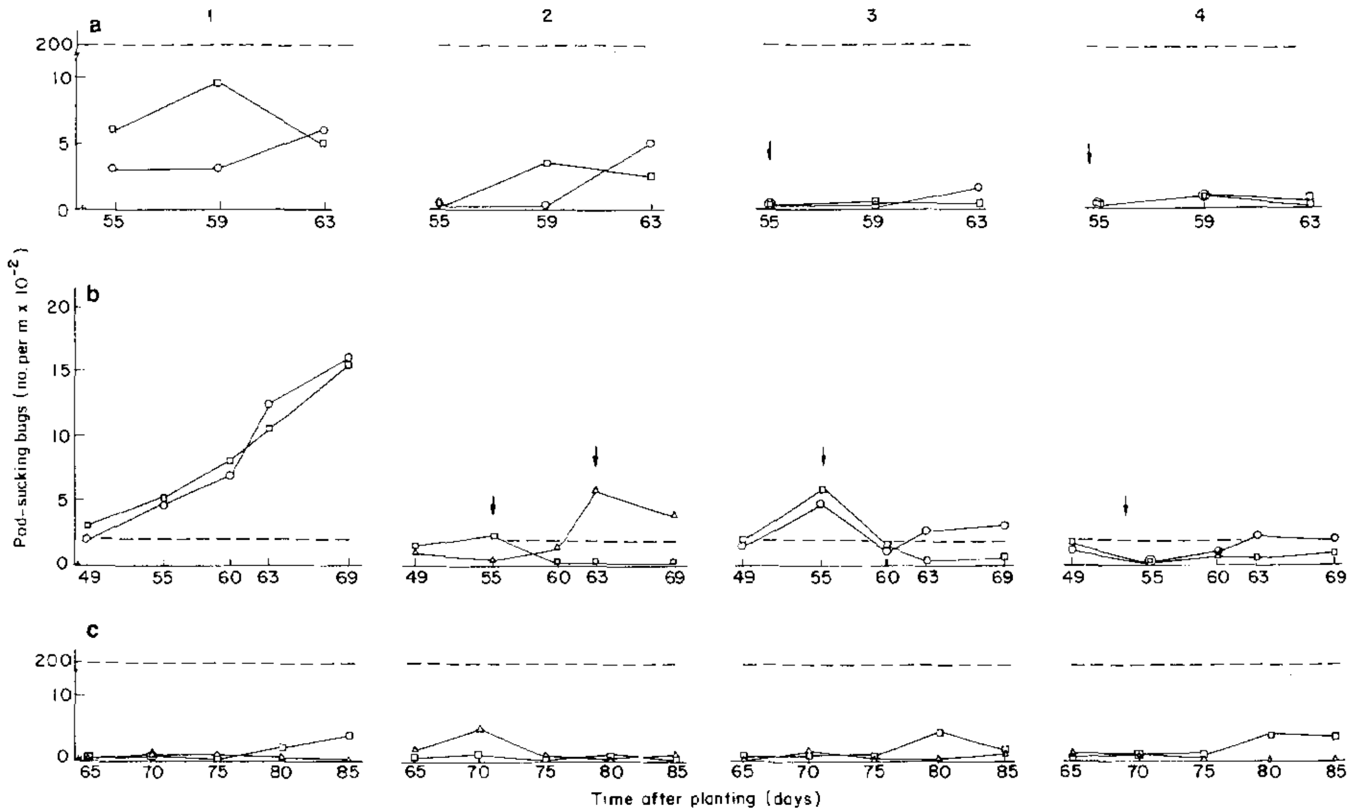

Figure 4. Effect of various insecticide regimens (1–4, as in *Figure 2*) on pod-sucking bug populations in cowpea (□, ○, △, as in *Figure 2*) at three locations (a, Ibadan, b, Mokwa, c, Bida) in Nigeria. ↓, Spray application; ----, action threshold

never exceeded the AT. However, one spray each was applied to both IT84S-2246 and TVx 3236 at Mokwa (*Figure 4*). TVx 3236 should have received a second spray at 69 DAP in the monitored treatment to keep PSB infestation below the AT but it was not applied because the crop was near harvest and was harvested 74 DAP.

The low PSB infestation at Ibadan was unusual, judging from past reports. Consistently high infestations had been recorded at this site (IITA, 1983), especially during the second season when the experiment was conducted. During this period, drought imposed severe stress on the crop, with the last rainfall before harvesting having been recorded at 38 DAP. The mean daily temperatures were >27°C and the mean r.h. fluctuating between 65% and 75%. These ambient conditions may have been unfavourable for pod-sucking bug breeding and survival, thus giving rise to the low population.

At both Ibadan and Mokwa, mean pod-sucking bug numbers in the monitored plots were similar to those in the calendar treatments, all of which were significantly lower than those in the unsprayed plots.

Seed damage due to pod-sucking bugs

Seed damage in IT84S-2246 and TVx 3236 did not differ significantly at both Ibadan and Mokwa. At Ibadan, the monitored and calendar schedules provided equally effective protection against pod-sucking bug seed damage, which was lower than in the unsprayed crop (*Table 4*). A slightly different situation was observed at Mokwa where the two calendar schedules gave significantly lower damage than the monitored treatment (*Table 4*), which also significantly reduced damage when compared with the unsprayed plots. At Bida, IT84S-2246 suffered more seed damage (4.2%) than VITA 7 (3.0%) ($p<0.05$) despite supporting similar numbers of pod-sucking bugs; these levels of seed damage are, nevertheless, low and tolerable. VITA 7 has once been reported to have a low level of pod resistance to pod-sucking bugs (IITA, 1983) but this has never been confirmed. IT84S-2246 is susceptible to these bugs. The lowest seed damage was recorded under the monitored and the 10-day-interval regimens, both of which

Table 4. Pod-sucking bug seed damage (%)[a] under various insecticide regimens at three locations in Nigeria

	Mean seed damage (%)[a]		
Insecticide regimen	Ibadan	Mokwa	Bida
1. Control (no sprays)	46.7 a[b]	74.3 a	4.5 a
2. Monitored sprays[c]	9.1 b	29.8 b	3.0 b
Calendar sprays			
3. 10-day interval[d]	6.0 b	21.6 c	3.4 b
4. 7-day interval[e]	5.0 b	17.8 c	3.5 ab
Mean	16.6	35.9	3.6
s.e. (±)	2.5	2.8	0.4
Coefficient of variation (CV)	47.3	24.3	29.4
n	5	5	4

[a]Percentage data transformed to arcsin values; [b]values followed by the same letter in the same column are not significantly different (Duncan's multiple range test, $p=0.05$); [c]two sprays at Ibadan and Mokwa but three at Bida; [d]four sprays at Ibadan and Mokwa but five at Bida; [e]five sprays at Ibadan and Mokwa but six at Bida

Table 5. Cowpea yield from different locations in Nigeria using various insecticide regimens

Insecticide regimen	Mean grain yield (kg ha^{-1})		
	Ibadan	Mokwa	Bida
1. Control (no spray)	8 b[a]	335 b	166 c
2. Monitored sprays[b]	440 a	1670 a	676 a
Calendar sprays			
3. 10-day interval[c]	397 a	1827 a	480 b
4. 7-day interval[d]	425 a	1834 a	588 ab
Mean	317.5	1416.5	477.6
s.e. (±)	26.8	31.7	58.9
CV (%)	23.9	16.5	39.4
n	4	5	4

[a]Values followed by the same letter in the same column are not significantly different (Duncan's multiple range test; $p=0.05$); [b]two sprays at Ibadan and Mokwa but three at Bida; [c]four sprays at Ibadan and Mokwa but five at Bida; [d]five sprays at Ibadan and Mokwa but six at Bida

Table 6. Crop value (Naira) derived from cowpeas under four protection regimens at three locations in Nigeria

Insecticide regimen	Profit (Naira)[a]		
	Ibadan	Mokwa	Bida
1. Control (no spray)	11 c[b]	611 b	639 c
2. Monitored sprays	528 a	2952 a	2386 a
Calendar sprays			
3. 10-day interval	369 b	3116 a	1501 b
4. 7-day interval	340 b	3060 a	1842 ab
Mean	312	2435	1592
(±) s.e.	55.1	191.9	320.8
CV (%)	35.3	17.6	40.3
n	4	5	4

[a]Exchange rate at time of study: official rate ₦3.5 = US$1; real rate ₦5.00 = US$1; [b]within the same column, values followed by the same letter are not significantly different (Duncan's multiple range test; $p = 0.05$)

Table 7. Benefit: cost ratios for cowpeas under various insecticide regimens at three locations in Nigeria

Insecticide regimen	Benefit: cost ratios		
	Ibadan	Mokwa	Bida
Monitored sprays	3.97 a[a]	6.92 a	6.32 a
Calendar sprays			
10-day interval	2.32 b	5.50 b	2.89 b
7-day interval	1.94 b	4.86 b	3.27 b
Mean	2.79	5.76	4.16
(±) s.e.	0.19	0.5	0.76
CV (%)	14.0	18.2	36.3
n	4	5	4

[a]Within the same column, values followed by the same letter are not significantly different (Duncan's multiple range test; $p=0.05$)

differed significantly from the no-spray regimen. The 7-day-interval regimen was intermediate (*Table 3*). It is obvious from these results that the pod-sucking bug population was very low in Bida, where it may not have been an important constraint to cowpea production during the off-season. This is generally true of most off-season cowpea at other locations as well.

Grain yield

The early-maturing IT84S-2246 gave significantly higher grain yield (376 kg ha^{-1}) than the medium-maturing TVx 3236 (259 kg ha^{-1}) at Ibadan where there was drought. Clearly, this is one advantage of growing early-maturing cowpea varieties. The yield of the same varieties did not differ at Mokwa; yields of IT84S-2246 and VITA 7 at Bida were also similar (494 and 461 kg ha^{-1}, respectively).

At all locations the unsprayed plots gave the lowest yields; this is consistent with what is generally known of cowpea. At Ibadan and Mokwa, yields from the monitored spray treatment (two sprays) and the calendar schedule (four and five sprays) did not differ significantly, whereas at Bida the monitored sprays (three sprays) gave the highest yield, with the calendar schedules (five and six sprays) lying between the monitored and unsprayed treatments (*Table 5*).

The highest yields of between 1200 and 1400 kg ha^{-1} from protected plots were obtained at Mokwa, where the season was considered normal with respect to rainfall. The severe drought at Ibadan probably accounted for the low yields even from the protected plots. The yield difference between the two varieties at Ibadan could be attributed to the drought. Steele, Allen and Summerfield (1985) reported that medium-maturing cowpeas (75–85 days) needed an ample supply of water for at least 55 days for optimum seed production, but such a situation was not present at Ibadan, where the rains ceased 38 DAP.

Profits

The highest profit came from the monitored spray treatments, which differed significantly from the two calendar schedules at Ibadan and from the 10-day-interval programme at Bida (*Table 6*), but at Mokwa there was no significant difference between the profits from the various protective treatments, even though the yields from the calendar treatments were almost 200 kg more than that from the monitored spraying.

Benefit–cost (B:C) ratio

The B:C ratio is the number of times the chemical control cost was recouped from the value of the increased yield. The ratios for the monitored spraying were all significantly higher than those for the calendar schedules at all locations (*Table 7*). This was expected, as the costs for scouting were low and the number of sprays reduced by half.

Conclusions

At all three sites the unsprayed crop suffered the highest insect damage and produced the lowest yield, which underscores the importance of chemical (or other effective) pest control tactics in any cowpea-production enterprise. The two calendar schedules, 7- and 10-day spray intervals (insect infestation/damage and yields) did not differ significantly. However, even though the calendar programmes recorded lower aphid, flower thrips and pod-borer infestation/damage than the monitored programme, the final grain yields between them were similar. Total insect kill is therefore not necessary for optimum cowpea grain yields. In addition, the cowpea variety IT84S-2246 showed a high level of resistance to aphid colonization.

Monitored treatments had only one-half the number of calendar sprays, with the application of two sprays at Ibadan and Mokwa and three at Bida. For a large-scale operation, this represents enormous savings on production and therefore a better cost : benefit option. Profits aside, the reduction in the number of applications is desirable, as this would reduce environmental pollution, health risks and other hazards. Unfavourable conditions such as drought and the dry season suppressed populations of *Maruca* and pod-sucking bugs and consequent damage, and there was no need for any chemical control of these pests under such conditions; calendar spraying in this case would lead only to wastage, avoidable pollution and higher production cost. The insect pests showed spatial and temporal variations in their incidence and status; to prevent unnecessary insecticide application, therefore, and to make chemical control more effective and economical, monitored application should be advocated and encouraged wherever these chemicals must be used.

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