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Impact of Insecticide Spray Regimes on Insect Abundance in Cowpea (*Vigna unguiculata*) in North Eastern Nigeria

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ABSTRACT

Field experiment was carried in Maiduguri during two cropping seasons to assess crop – pest cycle in relation to pest control using insecticides in cowpea [(*Vigna unguiculata* L. (Walp)]. The factional experiment considered two types of insecticides (Decis: deltamethrin and Nogos: dichlorvos) and nine (9) spraying regimes. The four stages in the phenology (pre-flowering (vegetative), flowering, podding & maturation) were monitored closely until harvest. Flower and pod drops were significantly different between control and treated plots and the cost: benefit ratios also followed similar trends. Pest species were more abundant at the pre-flowering and maturation in all the treatments, whether chemically treated or not. A total of 14,400 insect species were counted from the 50 observations in the two seasons and grouped into six orders, listed in order of abundance. Thysanoptera topped the list and diptera was the least in abundance. Insect populations were higher in the untreated (control) plots than in all the two-sprayed fields with 18.3% and 10.3% more between the un-sprayed (control; T_0) and the complete controlled (T_8) for Decis and Nogos treated plots, respectively. A significant interaction existed between insecticides types and spray regimes as there was low insect number per plant in Decis–treated plots than in Nogos treated plots. Flower and flower drops, pods and pods drops and cost: benefit ratios were significantly different with spaying regimes irrespective of the chemicals. Decis treated fields had better protection from Nogos treated fields.

Key Words: Crop phenology; Spraying regimes; Flowering; Podding stages; Insecticides; Crop–pest cycle; Pest abundance; Cost:benefit ratio

INTRODUCTION

Cowpea, [*Vigna unguiculata* L., (Walp)] is the most important legume in the tropics and provides the protein for most people and nitrogen to the soils in the tropical lowlands of Africa in a broad belt along the Southern Sahara. Cowpea contributes immensely to the protein diet of most rural communities in particular Nigeria. Contributing about 24% (Yayock & Asenime, 1977) and effort be made to increase its production and consumption (Duke, 1990).

However, as many as 110 species of insects are associated with cowpea in Maiduguri area of Northeast, Nigeria (Manawadu & Sharah, 1990), many of which cause complete crop failure (Raheja, 1976a). Most serious of which is the pod borer *Etiella zinckenella* (Oladiran & Oso, 1985; Abdalla *et al.*, 1994) and species of Bruchidae, which belong to genus *Collosobruchus* (Lale & Kabeh, 2004). As knowledge of the crop pest cycle is an important tool in the management of these pests (Harcourt, 1970), since the economically important species of these grain legume pest are not crop specific (Taylor, 1971). Further more, the indispensable use of insecticides in cowpea pest control has made it imperative to thrash out alternatives to blanket control in order to satisfy both optimum pest control and environmental concerns.

To achieve this, the life-cycle (Phenology) of cowpea, which comprises four main stages of pre-flowering, flowering, podding and reproductive maturity (Summerfield *et al.*, 1988; Ishiyaku & Singh, 2003) needed careful observations in relation to pest prevalence so as to determine time and stage of intervention during control.

Seriesthrips occipitalis, Taeniothrips sjostdti, Maruca testulalis, Acythomyia horida, Riptortus dentipes, Anoplocnemis curoipes and Cydia ptychora are known to attack cowpea at pre-flowering, flowering and post flowering causing damage from 50%, 20% and 35% (IITA, 1973) i.e., over 90% potential stage (Raheja, 1976a & b). However, cowpea yield in Nigeria can be improved and raised to tenfold, when insects are controlled with insecticides (Booker, 1965). It is for this reason that the objective of this work was designed to review crop- pest cycle of the cowpea plant and subsequently identify appropriate interactive links to reduce adverse effects of pests on cowpea and safe guard the environment from the indiscriminate use of assorted chemicals not specifically meant for the control of cowpea pests in the arid zone of Nigeria.

The specific aims were to identify pest population per

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plant, per growth stage and compare the effects of two insecticides on the pest population in the various stages. The pests were effectively monitored up to harvest (12 weeks after planting (WAP), so as to identify a better choice of the insecticides to be used in control of cowpea pests.

MATERIALS AND METHODS

The experiment was carried out in the field during the rainy season (26^{th} July to 15^{th} October, 2002 & 2003) at the Teaching and Research farm of the Department of Crop Science, Faculty of Agriculture, University of Maiduguri, Nigeria. The soil in the study area was sandy loam.

Semi- erect, early maturing local variety (Borno brown) of cowpea obtained from Borno State Agricultural Development program and deltalmethrin (Decis 500 EC) Roussel Uclaf and dichlorvos (Nogos 50 EC) Ciba Geigy in 2000 and with 5 years shelve life, were obtained from accredited dealers and used for treatments. Doses of 150 g ai ha^{-1} Decis and 7.5 g ai ha^{-1} Nogos were used. These two insecticides were each applied 9 times (subplots) giving a total of 18 treatments. Each treatment was allocated to a plot of 5 × 5 m and replicated (blocks) 3 times. The experiment was laid out as split plot design. Cowpea seeds were dressed in Apron star at 1 sachet to 2 kg of seeds and sown at 50 cm spacing along rows 1 m apart, giving stand density of 16000 plants ha^{-1} and 40 plants $plots^{-1}$.

After establishment, cowpea field was sprayed 9 times as follows: T_0 = No spray; T_1 = Spraying at six weeks after flowering (WAF); T_2 = Spraying once at four WAF; T_3 = Spraying once at two WAF; T_4 = Spraying four and six WAF; T_5 = Spraying at two and six WAF; T_6 = Spraying at two and four WAF; T_7 =Spraying at two, four and six WAF and T_8 = Spraying at two weeks interval i.e., 14 days after germination (DAG) commencing from two weeks after complete emergence of seedlings, five sprays in all (for ten weeks).

Insects were sampled weekly commencing after germination till harvest totaling twenty-five observations in all. Sampling unit was a whole plant and six random samples per plot were collected on each sampling day. Direct counts were done of the conspicuous fairly mobile insects such as grasshopper or slow moving insects as beetles using a tally counter. Small insects like aphids and thrips were dislodged from the plant parts on which they occurred using a fine brush onto a white paper before counting. Flowers and pods were cut open to expose flower thrips and Lepidopterans larvae and pupae and then counted. Roots were examined for insects only when a plant showed signs of wilting. Immature stages of insects were identified at the insect museum, Taxonomy Department of the Institute for Agricultural Research Ahmadu Bello University Zaria, Nigeria.

Crop phenology was monitored by noting the initiation of flowering and podding as well pod maturation. Grain yield of the middle rows of each plot were determined. The data collected on abundance of insects species were statistically analyzed using ANOVA and Duncan Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Insect prevalence. Table I shows the total insect number captured during this study and were grouped under six orders. It clearly indicates that Thysanoptera topped the list with 7005, while Diptera had the list number of only 216. There was significant ($P < 0.01$) difference between chemicals and orders, with nogos- treated having twice (2) than that of decis treated. Aphids (Hemiptera) are phloem-feeding insects that are widely distributed pests of agricultural ecosystems (Gao *et al*., 2007). They feed specifically from the sieve element and cause damage by the direct ingestion of plant nutrients and through aphid-transmitted viruses (Ng & Perry, 2004), which causes losses to crop world wide (Oerke & Dehne, 2004).

Fig. 1 shows the graphical presentation of the three (control, decis & nogos) replicate means, which showed clear indication of the differences. Low insect population at vegetative (pre-flowering), suggest that few insects specialized in leaf consumption, while high at flowering and pod formation suggest that more insect species had predilection for these two phonological stages and very few at pod maturation suggesting that very few insects appeared at this stage. The pattern of build up of insect population followed similar trend irrespective of whether cowpea was treated or not (Fig. 1). On the average peak population was recorded at flowering and podding stage of the cowpea phenology for the control, decis-treated and nogos-treated. The peak population at flowering may be accounted for the abundance of flower thrips, which hibernated inside the flowers and may have likely, escaped immediate effect of the contact pesticides.

Table II shows the mean weekly insect population for each of the three replicates in each field and for the eight treatments and control as observed for twelve weeks. Control which is taken as the index by which chemical control is measured had replicate mean of 40.6 insect per

Table I. Total insect number associate with cowpea in the treated cowpea fields grouped in their respective and descending orders as obtained from total of 25 observations per season

Order	Decis	Nogos	Total	P=0.01
Thysanoptera	2695	4310	7005	*
Hemiptera	2296	2644	4940	*
Coleoptera	946	697	1643	*
Orthoptera	182	185	367	*
lepidoptera	125	104	229	*
Diptera	121	95	216	*
Total	6365	8035	14400	

*significant at 1%. Overall chi-square 249.7
P-value = Significant at 1%

Table II. Mean insect pest abundance plant^{-1} at weekly intervals in years 2002 and 2003

Variables	Wks													
	1	2	3	4	5	6	7	8	9	10	11	12	Total	Mean
Control (T_0) Repl. Mean	1.7	2.1	3.7	6.3	20.1	27.4	105.9	133.1	124.9	43.2	11.8	7.2	487.4	40.6
Decis (deltamethrin) Repl. Mean	1.1	1.1	1.0	3.4	3.8	4.8	40.0	56.0	62.1	22.8	7.0	4.6	207.7	17.3
Nogos (dichlorvos) Repl. Mean	1.1	0.4	0.8	1.5	3.6	20.9	51.6	70.5	64.8	44.8	9.5	5.6	275.1	22.9

Table III. Mean insect abundance plant $^{-1}$and treatments with Decis and Nogos in Maiduguri in 2002 and 2003 cropping seasons of cowpea

	Decis (deltamethrin)		Nogos (dichlovors)		
Treatment	Total	No./plant	Total	No./plant	Spray Regimes
0	1377.30	18.40	1459.00	19.50	T_0 = zero spray
1	992.50	13.30	749.70	10.00	T_1 = 1 spray at 6 WAF
2	809.99	10.80	1055.20	14.10	T_2 = 1 spray at 4 WAF
3	754.10	9.90	885.60	11.80	T_3 = 1 spray at 2 WAF
4	641.00	8.50	870.70	11.60	T_4 = 2 sprays at 4 & 6 WAF
5	590.10	7.90	901.00	12.00	T_5 = 2 sprays at 2 & 6 WAF
6	532.20	7.10	788.80	10.50	T_6 = 2 sprays at 2 & 4 WAF
7	449.10	6.00	712.90	9.50	T_7 = 3 sprays at 2, 4 & 6 WAF
8	219.00	2.90	612.40	8.20	T_8 = 5 sprays at 2 Wk interval (14 DAG)
Total	6365.29	84.78	8035.30	107.20	
Mean	707.25	9.42	892.81	11.91	

DAG = Days after Germination

Table IV. Analysis of variance of the mean number of insects per Decis treated and Nogos treated cowpea fields

Source of Variation	Sum of Squares (SS)	Degree of Freedom (DF)	Means Squares (MS)	Observed F-value
Replicate	0.03	2	0.01	0.34**
Insecticides	15.68	1	15.68	382.49*
Repl. × Insecticides (Error A)	0.08	2	0.04	
Sub-treatment	33.52	8	42.32	156.04*
Insecticides × sub-treatment	468.28	8	58.54	215.84*
Residual (Error B)	8.68	32	0.27	
Total	831.27	53		

* Significant at 1% level
** Significant at 5% level

Table V. Effects of insect abundance on flower and pod numbers in decis-treated and nogos-treated cowpea fields

	Decis(deltamethrin)				Nogos (dichlorvos)			
Treatment	Flower/ Plant	Flower drop plant	Pod/plant	Pod drop/ plant	Flower/ Plant	Flower drop plant	pod/plant	Pod drop/plant
0	269.37	150.10(55.72)	116.84	76.7(65.65)	236.77	149.77(63.25)	87.2	57.07(65.44)
1	272.63	120.13(44.06)	148.80	69.63(46.79)	247.87	149.38(60.27)	105.67	50.06(47.37)
2	302.27	110.77(36.65)	192.16	67.57(35.16)	253.17	147.83(58.39)	100.80	48.43(43.71)
3	305.67	113.23(37.05)	192.05	67.23(35.0)	251.00	126.27(50.31)	128.03	58.53(44.15)
4	313.43	111.73(35.65)	200.83	65.73(32.73)	258.75	121.40(46.92)	136.03	55.57(40.85)
5	310.90	98.67(31.82)	177.73	63.27(35.60)	262.33	103.53(39.47)	102.03	52.60(32.46)
6	323.87	96.90(29.92)	222.30	60.37(27.16)	268.50	89.07(33.17)	170.37	49.43(29.10)
7	371.83	89.47(24.06)	284.56	59.98(21.08)	277.58	91.00(32.78)	188.63	40.63(21.54)
8	389.70	87.93(22.56)	304.60	54.67(17.95)	291.23	86.73(29.78)	200.47	32.63(16.28)

Number in parentheses denotes percentage (%)

Table VI. Analysis of Variance of mean flower and pod number plant^{-1} for Decis- treated and Nogos-treated cowpea fields for Table V

Source of variance	Sum of Square (SS)	Degree of Freedom (DF)	Mean Square (MS)	Observed F-value
Replicate	53.43	2	26.91	6.06
Insecticides	21.35	1	21.35	4.84
Repl. × Insecticide (Error A)	8.82	2	4.41	
Sub-treatment	19792.8	8	2474	288.21*
Insect. × sub-treatment	7327.2	8	915.9	106.7*
Residual (Error B)	274.71	32	8.69	
Total	27278.8	53		

*Significant at 1%

plant while decis had 17.3 and nogos had 22.9 and were significantly ($P<0.05$) different. Table III shows the insect pest abundance per plant and for each treatment and for each chemical. It was observed that total pest population per plant was highest in the zero treatments, 1377.3 or 18.4 for decis – treated fields and 1459.0 or 19.5 for nogos – treated

Table VII. Summary of phenelogy of cowpea growth in Maiduguri during the 2002 and 2003 cropping seasons in relation to the two insecticides and the nine spraying regimes

	Decis-treated plot			Nogos-treated plot		
	Control (T_0)	Control after Flowering (T_1-T_7)	Complete Control (T_8)	Control (T_0)	Control after Flowering (T_1-T_7)	Complete Control (T_8)
Total No. of flowers/plant	269.4 ±3.30	314.36 ±15.57	389.8 ±44.56	236.8 ±7.18	259.9± 14.10	291.23 ±35.60
Total No. pods/plant	116.6 ±4.90	206.36 ±2.30	304.6 ±11.40	86.7 ±5.40	143.9± 2.16	197.9 ±8.10
No. of normal pods/plant at harvest	10.7 ±0.33	90.63 ±0.34	296.1 ±3.46	5.6 ±2.45	65.9 ±1.30	142.5 ±1.47
Yield of seed (kg/ha)	1267 ±94.30	1540± 43.80	1741 ±185.80	960 ±130.60	1287 ±34.70	1493 ±51.10
Av. No. healthy seed/pod	4.2 ±1.08	8.89 ±0.62	11.9 ±2.13	2.9 ±0.82	5.4± 0.29	9.1 ±1.15
Av. No. of damaged seed/pod	7.8 ±3.48	311 ±0.99	0.1 ±0.0	9.1± 6.20	6.6 ±0.64	2.9 ±1.63
Av. Wt per seed/(mg)	166.7 ±11.43	176.47 ±1.63	195.8 ±9.47	159.8 ±8.57	177.8 ±5.50	190.3 ±11.43
Yield /plant (g)	79.2± 7.35	95.89± 3.97	108.8±10.77	60.0 ±12.04	80.4 ±3.06	93.3 ±13.20

All values are expressed as mean ± SE
Figures for partial controlled plots are joint figures ($T_1 – T_7$).
Seeds from completely controlled plots and those from sprayed after flowering were compared with seeds from unsprayed plot

Table VIII. Partial analysis of cost/ benefit ratio of cowpea production using insecticides in Maiduguri in the Arid Northern Nigeria

		Decis (deltamethrin)			
No Spray (Control)	19774	1267.2	50,688	30,914	1:1.56a
Spray at 6WAF	20774	1460.8	58432	37658	1:1.81b
Spray at 4WAF	20774	1476.8	59072	38298	1:1.84c
Spray at 2 WAF	20774	1489.8	59592	38818	1:1.86e
Spray at 4 & 6 WAF	21774	1564.8	62592	40818	1:1.87f
Spray at 2 & 6 WAF	21774	1553.6	62144	40370	1:1.85d
Spray at 2 & 4 WAF	21774	1572.8	62912	41138	1:1.88g
Spray at 2, 4 & 6 WAF	22774	1620.8	64832	42058	1:1.84c
Spray fortnightly (5 sprays)	24774	1740.8	69632	44858	1:1.84c
Mean	21662.8	1527.36	61099.6	39436.7	1:1.85
		Nogos (dichlorvos)			
No Spray (Control)	19774	960.0	38400	18620	1:0.94a
Spray at 6WAF	21474	1064.0	42560	21086	1:0.98b
Spray at 4WAF	21474	1212.8	48512	27038	1:1.25e
Spray at 2 WAF	21474	1307.2	52288	30814	1:1.43h
Spray at 4 & 6 WAF	23174	1332.0	53280	30106	1:1.29f
Spray at 2 & 6 WAF	23174	1292.8	51712	28538	1:1.23d
Spray at 2 & 4 WAF	23174	13720	54880	31706	1:1.36g
Spray at 2, 4 & 6 WAF	24274	1427.2	57088	32214	1:1.29f
Spray fortnightly (5 sprays) 14 DAG = 5 sprays	28274	1492.8	59712	31438	1:1.11c
Mean	22918.4	1273.42	50936.9	27951.1	1:1.24

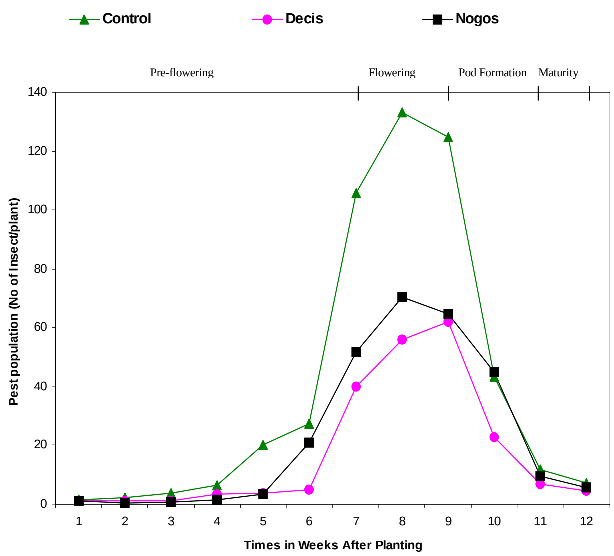
WAF = Weeks After Flowering, DAG = Days after Germination
Cowpea sold at ₦ 40/kg ($0.31 kg^{-1}) in 2002/2003

fields. The number however, reduced drastically to 219 or 2.9 and 612.4 or 8.2 at five sprays for the two chemicals, respectively indicating that the more the number of spray regime, the less the pest prevalence on the crop fields. Another implication is that the cost:benefit ratios for the treatments may be affected by the cost of labor and chemical in addition to drudgery experienced during the spray.

The significant interaction effects between insecticides and the number of sprays suggest that the impact of the insecticides on pest is closely related to application regime. This is significant since is already known that insect species that reduce cowpea yield to zero are those that attack the flowering and the podding stages (Rachie, 1985; Fisher *et al.,* 1987). Significant effects were also detected between the density of insects in the decis- treated and nogos – treated crop (F= 382.49, at p = 0.01). These different sub-treatments also had significantly affected the insect fauna of the plots (F =156. 04. at p = 0.01). However, the main effects were confounded by the significant interactions (F = 215.84, at p = 0.01) between insecticides and sub- treatment, indicating that the two did not operate independently (Table IV).

Effects of insect pests on flowers and pods. Table V shows the effects of insect pest prevalence on flowers and pods formation for each treatment and spray regimes. The control (T_0) produced the least number of flowers, while those sprayed five times (T_8) produced the highest number of flowers. Also observation during this study shows that flowers suffered the highest damage when they were in full bloom. Flower drop range from 22.56% in five spray regime in Decis- treated to 63.25% in zero regimes in Nogos-treated field showing that Decis- treated suffered less flower drop. Pod formation, was indexed by the level of flower drop as Decis- treated field produced 43% more pods per plant than Nogos- treated. Similar trend was observed where

Fig. 1. The crop phenology of cowpea plant and mean insect population for each replication (insecticides) and control in the 2002 and 2003 cropping seasons



pod formation was twice in Decis-treated than Nogos-treated and Decis-treated suffered 35% pod drop and Nogos-treated 37%. The pod drop was significantly (P < 0.05) different (F = 142.05, at P=0.01) between sub-treatments and insecticides, as well as sub-treatment interaction (F = 173.41, at p = 0.01). It could be observed in table 5, the higher the flowers and pods the higher the drops per plant, suggesting numerical reciprocation. In both chemicals, zero treatment suffered as twice as much flower drop than that having five sprays and showed significant (P<0.05) difference (F= 288.21 at P = 0.01) between sub-treatments and between chemicals and sub-treatments (F= 106.7, at p =0.01) (Table VI).

Summary of cowpea phenology. Table VII summarizes the cowpea phenology for 2002 and 2003 cropping seasons as shown by means of observations and results obtained. The table, shows that complete control (T_8) gave better results with higher yields of 1741 ± 185.8 kg ha^{-1} in Decis-treated fields and 1493.0 ± 51.10 kg ha^{-1} in Nogos-treated fields, regardless of cost of production and cost:benefit ratios. Suggesting that the more the spraying regime the higher the yields at harvest.

Cost:benefit ratio. Partial analysis of the yield of cowpea from this study is shown in Table VIII and the cost:benefit ratios per each treatment and spray regimes. The different spraying regimes gave differences in yield and showed significant (P<0.05) difference. The average yield from 5 sprays of decis gave an increase of 473 kg ha^{-1} or 37% increase over that from unsprayed. That from three sprays and control is 353 kg ha^{-1} (28% increase) and between two sprays is 296 kg ha^{-1} (23% increase). The difference between one spray and control is not significant (P >0.05). Similar trend was found in nogos –treated yields e.g., the yield from 5 sprays was 56% higher than those from control plots.

Mean seed yield from decis –treated fields was 1527.38 kg ha^{-1} – yield from Nogos- treated was 1273.42 kg ha^{-1} (Table VIII) giving a sum difference of 253.94 kg ± 3.77, at P = 0.05 and showed significant (P < 0.05) differences by chemicals, suggesting that Decis had offered better protection than Nogos. Dina (1979) also found that decis afforded better control of cowpea pests attacking flower and pods than Nuvacron although the yields were not significantly (P >0.05) different. Cost:benefit ratio was high 1:1.88 in decis treated than 1:1.43 in nogos treated fields being the highest ratios.

The present study have revealed that cowpea is attacked by complex of insect species which can cause complete yield loss (Raheja, 1976a) and therefore recommended pest management as means of achieving the desired goal and safeguard the environment from indiscriminate use of chemicals. Due to short rainy season in the arid part of Nigeria, drought resistant varieties, good cultural practices and insect resistant varieties should be incorporated in the pest control programmes with the least use of pesticides. If inevitable, it is very important to determine which of the available insecticides, the most effective, economical and at which stage of crop phenology, doses and intervals should the spray be done to achieve the best result. The implication of these suggestions is that insecticides that can combine both systematic and contact activities need to be developed for use at both the flowering and podding stages to reduce the heavy losses and impact of flower thrips causing flower drops and pod drops. However there are few species of pests specialized in feeding at flowering and podding stages (Thripidae, Alydidae, Coreidae, Lygacidae, miridae, Pentatomidae & Noctuidae (*Sphingomorpha chlorea*)), plans to target such few specialized groups suggest that the requirements for control can be greatly reduced and still get good results against these few specialized pest species.

CONCLUSION

In conclusion, growing sole cowpea in this part of Nigeria need effective control operations and targeted on the susceptible phenological stages such as the flowering and podding stages. It is less expensive; gives significantly higher yield and had beneficial effect on pod maturation. Mean cost:benefit ratio was higher 1:1.85 for all spray regimes in decis treated as against 1:1.24 for Nogos –treated fields. It is thus recommended that spraying three times at 2, 4 and 6 weeks after flowering (WAF) and two times at 2 and 4 weeks after flowering are the best choices for farmers who cannot afford 5 sprays due to cost and drudgery. To have effective reduction in cowpea pests, it is thus better to intervene at the flowering and podding stages where pest population is very high. In addition, because it is known that systematic pesticides are used in the control of sap sucking pests and most of the cowpea pests, which cause total yield failure in cowpea are the sap sucking insects, bugs and coreids. Therefore, to advocate for two in one insecticides that can combine both systematic and contact actions which may give better control than one of them alone is not asking too much from the chemical manufacturers.

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