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Farmer-participatory evaluation of cowpea integrated pest management (IPM) technologies in Eastern Uganda

J. Nabirye[a], P. Nampala[a], M.W. Ogenga-Latigo[a], S. Kyamanywa[a], H. Wilson[b,✠], V. Odeke[c], C. Iceduna[d], E. Adipala[a,*]

[a] *Crop Science Department, Makerere University, P.O. Box 7062, Kampala, Uganda*
[b] *Department of Entomology, Ohio State University, Columbus, OH 43210, USA*
[c] *Kumi Agricultural Office, Kumi, Uganda*
[d] *Pallisa, Agricultural Office, Pallisa, Uganda*

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Abstract

A three-season study was conducted with the goal of verifying integrated pest management (IPM) technologies developed at Makerere University for management of cowpea field pests. Ten IPM-field schools with 10–20 farmers were run for three consecutive seasons of 2000 A (first rains), 2000 B (second rains), and 2001 A. Each school evaluated seven treatments that included farmers' practices; cowpea monoculture and cowpea/sorghum intercrop mixtures, and five varying insecticide spray regimes. The key insect pests targeted by the sprays included aphids, *Aphis craccivora* Koch, flower thrips, *Megalurothrips sjostedi* Trybom, the legume pod borer, *Maruca vitrata* Fabricius (formerly *M. testularis* Geyer), and a range of pod sucking bugs (i.e., *Nezera viridula* Linnaeus, *Clavigralla tomentosicollis* Stal., *Riptortus dentipes* Fab.). The experiment was a randomized complete block design with farms (i.e., field schools) as replicates. Results indicated that combining cultural practices and spraying once each at budding, flowering, and podding stages was more effective and profitable than spraying cowpea weekly throughout the growing season. An IPM practice which combined early planting, close spacing cowpea ($30 \times 20\,cm^2$), and three insecticide applications once each at budding, flowering and podding stages, had the highest yields of 791 kg/ha with a 51% yield gain over the farmers' traditional practices. Farmer evaluation over the three seasons revealed that this practice was most preferred by farmers, with a farmer preference of 46.4%, 57.1%, 71.4%, and 89.3% at planting, vegetative, flowering and harvesting evaluation stages, respectively.

Keywords: Cultural practices; Farmer field schools; Spraying; Verifying; *Vigna unguiculata*

1. Introduction

Cowpea (*Vigna unguiculata* L. Walp) is one of the most important food crops in the semi- and tropical regions of Africa (Jackai and Adalla, 1997). It is the main grain legume food crop in parts of eastern and northern regions of Uganda (Sabiti et al., 1994; Adipala et al., 1997). Although potential yields of the crop (3000 kg/ha) have been reported (Rusoke and Rubaihayo, 1994), cowpea grain yields average only 200–400 kg/ha in Uganda (Sabiti et al., 1994; Omongo et al., 1997), and 200–300 kg/ha in Nigeria (Alghali, 1992). In all of the cowpea growing regions, grain yield is seriously curtailed by a multitude of pest problems (Omongo et al., 1997).

In response to these challenges, recent studies within the Makerere University Cowpea Improvement Project focused on development of economically and socially acceptable pest control measures including use of cultural strategies (intercropping, time of planting and plant density), host plant resistance, and minimum insecticide use (Omongo et al., 1997; Nampala et al., 1999; Karungi et al., 2000a, b; Adipala et al., 2000). These research efforts identified three key integrated pest management (IPM) components for management of cowpea field pests, including: close spacing, early planting and three well-timed insecticide applications. We tested these technologies under farmer conditions to determine their effectiveness so that farmers would have a "basket of options" to choose the most preferred and

*Corresponding author. Fax: +256-41-531641.
E-mail address: acss@starcom.co.ug (E. Adipala).
✠ Deceased.

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adopt or modify to suit their needs. We chose a farmer-field school approach (Asby and Sperling, 1992) because it would allow for farmer experimental learning and is significant in influencing adoption behavior (Scarborough et al., 1997).

2. Materials and methods

2.1. Study area and establishment of experiments

On-farm verification trials were conducted in two locations of eastern Uganda: Pallisa (1°13′N; 31°42′E) and Kumi (1°31′N; 33°53′E) districts for three consecutive seasons (i.e., 2000 A, B and 2001A). These districts are located in eastern Uganda where cowpea is a dominant crop (Omongo et al., 1997) and the region experiences bimodal temperature and rainfall patterns; the highest rainfall periods are May and October. The "A" and "B" seasons correspond to the first (March–July) and second (August–November) season, respectively. Thus, the region is characterized by two growing seasons a year.

The study was conducted at 10 IPM-field schools (five in each district), each involving 10–20 farmers. A committee composed of extension staff, local authorities, and research scientists selected the participating farmers. At each site, land was prepared using ox-ploughs. The experimental plots were set up as a randomized complete block design with each field school constituting a replicate. Experimental plots measured $10 \times 5\,m^2$, with 2 m alleys between the plots. Planting was done both early in the season (at the onset of rains) and late in the season (4 weeks after the on-set of rains). For the early plantings, the planting dates were 2 August 2000 and 27 March 2001 for Kumi and 5 August 2000 and 29 March 2001 for Pallisa. Late-planted treatments were sown on 18 May 2000, 1 September 2000, and 30 April for Kumi, and 25 May 2000, 2 September 2000 and 2 May for Pallisa. Three to four seeds were planted per hole but thinned to two plants per hill 2 weeks after germination. A mixture of cypermethrin (25 EC; applied at 200 g ai/ha), a contact insecticide directed at *Aphis craccivora, Megalurothrips sjostedti*, and *Maruca vitrata* and dimethoate (40 EC; applied at 200 g ai/ha), a systemic insecticide directed at the pyrethroid-resistant pod sucking Hemipteran bugs was used in the study (e.g., Alghali, 1992). Cyermethrin was obtained from Twiga Agro-chemical Industries, and Dimethoate from Paz Chemicals Ltd., Nairobi. The spray was applied using a 15 l knapsack sprayer (Cooper Pegler Haid International, Denmark). The sprayer used a hydraulic (cone) nozzle with flow rate of 0.5 l/min. To avoid insecticide drift to other plots, polythene sheets were used to shield off the unsprayed plots. The following treatments were tested and compared:

- FP: Farmers' practice (broadcasted cowpea monoculture planted at the onset of rains sprayed 5–6 times throughout the season),
- IPM 1: closely spaced (30×20 cm) cowpea monoculture planted at the onset of rains sprayed 3 times each once at budding, flowering and podding stages. This corresponded to 30, 45 and 50 d after planting),
- IPM 2: widely spaced ($60 \times 20\,cm^2$) cowpea/sorghum intercrop (based on a replacement 1:1 mixture), planted at the onset of rains, carbofuran (Furadan 5G) seed dressing applied at a rate of 1.5 g per 1 m row as a soil drench, and three insecticide sprays (as in IPM 1),
- IPM 3: widely spaced ($60 \times 20\,cm^2$) cowpea /sorghum intercrop (as in IPM 2), planted at the onset of rains and no insecticide application),
- IPM 4: closely spaced ($30 \times 30\,cm^2$) cowpea monoculture planted at the onset of rains and no insecticide application,
- IPM 5: widely spaced ($60 \times 20\,cm^2$) cowpea monoculture, planted at the onset of rains, and insecticide application at a weekly interval, throughout the crops' growing season, starting at 10 d after cowpea emergence (eight insecticide sprays), and
- IPM 6: closely spaced ($30 \times 20\,cm^2$) cowpea monoculture planted 4 weeks after onset of rains and no insecticide application.

2.2. Assessment of key cowpea field pests infestation and grain yield

Pest infestations were sampled following the procedures of Karungi et al. (2000a) for aphids (*Aphis craccivora* Koch), thrips (*Megalurothrips sjostedti* Trybom), pod borers (*Maruca vitrata* Fab.), and pod sucking bugs (*Clavigarlla tomentoscollis* Stal., *Riptortus dentipes* Fabricius and *Nezara virdula* Linnaeus). Aphid infestations were assessed on 10 plants randomly selected and tagged along a diagonal transect in each plot. Sampling started 10 d after crop emergence (DAE) and continued at 10 d intervals throughout the growing season. On each sampling occasion, all plants with aphids were recorded as infested and the percentage of infested plants determined. Although the percentage aphid infestation gives an overall picture of aphid attack, it does not indicate how severe the infestation is. For this reason, severity of aphids was estimated using a visual rating of 1–6, where: 1 = no aphids; 2 = 1–100 aphids; 3 = 101–300 aphids; 4 = 301–600; 5 = 601–1000 and $6 \geqslant 1000$ aphids. The proportion of plants bearing the different categories of infestation was assessed by counting aphid numbers on 10 plants that were selected for infestation assessment. Population densities of thrips and *Maruca* larvae were sampled every 10 d starting at 30 DAE. Twenty randomly picked flower buds or flowers of cowpea per plot were collected and the number of thrips counted. The number of pod sucking bugs was counted in situ on two middle row plants every 10 d starting at 50 DAE (Olatunde et al., 1991). No attempt was made to separate the different pod sucking bug species. At crop maturity pods from each treatment were harvested and kept separately in labelled polythene bags for determination of grain yields.

2.3. Farmer evaluation

This research was participatory in that farmers were involved in the allocation and sowing of treatments, recording crop agronomic management information, and collection of data on key pests of cowpea and yield. In addition, farmers evaluated general crop performance and yield with a view to selecting the best or preferred IPM package. Farmer preference was calculated as the percentage of the farmers who preferred a particular treatment relative to the total number of participating farmers over different phases of the crop production cycle.

Table 1
Costs of insecticide application used in calculating marginal returns

Pest management system		Cost (1500 UShs = 1 US$)
1	Cost of seed dressing carbofuran	100,500
	Labour for application of seed dressing	20,000
	Total	120,500
2	Insecticide[a]	66,667
	Knapsack sprayer[b]	100,000
	Labour of spraying[c]	92,500
	Labour for harvesting[d], and threshing additional grain[e]	31,111
	Total	290,278
3	Additional insecticide	133,334
	Labour for two more sprays	85,000
	Labour for harvesting and threshing additional grain	62,222
	Total cost for three sprays	570,834
4	Cost for intercropping; Sorghum (20 kg/ha)	24,000
	Labour for planting/ha	60,000
	Labour for harvesting and threshing extra grain	31,111
	Total cost for intercropping	115,111
5	Cost of three foliar sprays only	570,834
6	Cost of seed dressing and three foliar sprays and intercropping	906,445
7	Cost of eight sprays	1,405,280

[a] Calculated/ha.
[b] Cost of sprayer and depreciation of 5 years.
[c] Labour for spraying was calculated at one person-day/ha.
[d] Labour for harvesting and threshing calculated /ha.
[e] Valve of cowpea at the time of the research was 1600 Ushs/kg.

2.4. Data analyses

All data were subjected to analysis of variance (ANOVA), after checking the validity of assumptions underlying this analysis (Steel et al., 1997). Analyses were conducted using the Genstat computer package (Lawes Agricultural Trust Rothamasted Experimental Station, 1993). No transformations were subjected to all data sets since they all conformed to the assumptions of the normal distribution statistics (Steel et al., 1997). For treatments showing significant F-statistics, means were separated using the least significant difference (LSD) method at a probability level of 5%. Comparisons were made among treatments, locations, and seasons. The costs associated with the different spray schedules are shown in Table 1 and were used to calculate the profitability (marginal returns) of each sprayed treatment. The marginal returns indicate the value of the yield gained due to spraying, relative to the cost of the spray schedule. A value of marginal returns less than 1 indicates that the increase in cowpea yield does not compensate for the cost of spraying.

3. Results

Aphid infestations at all locations during the three seasons peaked at 30 DAE (Fig. 1), with the lowest infestations observed during the second season of 2000. The severity of aphids is presented in Table 2. The results indicate that the lowest aphid incidence was observed in the IPM 2 systems (cowpea/sorghum intercrop planted with carbofuran seed dressing, plus three well-timed insecticide sprays each applied once each at budding, flowering and podding). This was closely followed by IPM 5 (plots with cowpea sole crop planted at the onset of rains and sprayed 8 times, once weekly throughout the growing season).

Thrips infestations were lower during the first season of 2001 than during the first and second seasons 2000 (Table 2). During the three seasons, both sprayed and widely spaced treatments significantly ($P < 0.05$) reduced the number of thrips in cowpea flower(s) buds. Thrips infestations were significantly ($P < 0.05$) reduced by IPM 1 treatments that were closely spaced cowpea ($30 \times 20\,cm^2$), planted at onset of rains, and sprayed 3 times, once each at budding, flowering and podding stages), IPM 2 (i.e., cowpea/sorghum intercrop planted with carbofuran seed dressing, and received three well-timed insecticide sprays each applied once at budding, flowering and podding), and IPM 5 (i.e., plots with cowpea monoculture planted at the onset of rains and sprayed 8 times, once weekly throughout the growing season).

Infestation by *Maruca* larvae was highest during the first seasons of 2000 and 2001 and lowest during the second season of 2000 (Table 2). Pesticide application in widely spaced cowpea significantly ($P<0.001$) reduced *Maruca* larvae populations. The lowest densities were recorded in intercropped treatments. Planting date had no effect on *Maruca* larvae densities.

Pod sucking bugs populations were higher during the first and second seasons of 2000 and 2001 than during the second season of 2000 and varied significantly ($P<0.001$) among the different IPM systems (Table 2). Close and irregular spaced plants (FP) had significantly higher pod sucking bug populations during the three seasons. Early plantings did not have an effect on pod sucking bug densities.

Yields were higher during the first seasons of 2000 and 2001 than during the second season of 2000 (Table 3) and varied considerably with the different control options during the three seasons ($P<0.05$). During the first season of 2000, the highest yields were obtained from plots that had a cowpea/sorghum intercrop, planted at a wide spacing early in the season, and received three sprays during the season. Closely spaced cowpea monoculture planted at the onset of rains, receiving three sprays throughout the season (IPM 2), out-yielded all the other treatments during the second season of 2000 and first season of 2001. Generally, spraying significantly ($P<0.05$) increased cowpea grain yields while late planting significantly ($P<0.05$) decreased yields. Yields for IPM treatments that comprised IPM 1 (closely spaced ($30\times20\,\mathrm{cm}^2$) cowpea monocrop planted at the onset of rains and three sprays, once each at budding, flowering and podding), IPM 2 (i.e., cowpea/sorghum intercrop planted with carbofuran seed dressing, and received three well-timed insecticide sprays each applied once at budding, flowering and podding), and IPM 5 system (widely spaced cowpea monoculture planted at the onset of rains and sprayed 8 times, once weekly throughout the growing season), were consistently higher during the three seasons.

Percentage yield gains and marginal returns are presented in Table 3. The highest percentage yield gains,

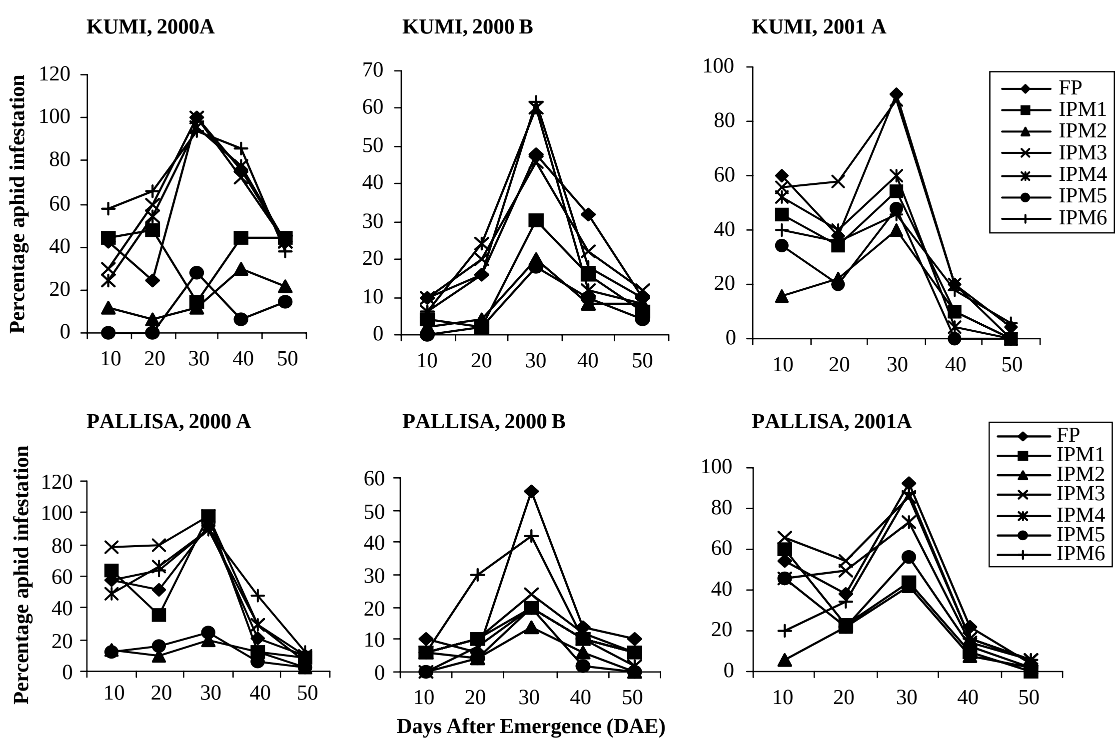

Fig. 1. The mean percentage aphid infestation on cowpea planted during the three seasons of 2000 and 2001 in Kumi and Pallisa districts. FP; Farmers' practice (broadcasted cowpea monoculture planted at the onset of rains sprayed 5-6 times throughout the season) IPM 1; closely spaced ($30\times20\,\mathrm{cm}^2$) cowpea monoculture planted at the onset of rains sprayed 3 times each once at budding, flowering and podding stages. This corresponded to 30, 45 and 50 d after planting). IPM 2; widely spaced ($60\times20\,\mathrm{cm}^2$) cowpea/sorghum intercrop (based on a replacement 1:1 mixture), planted at the onset of rains, carbofuran (Furadan 5G) seed dressing applied at a rate of 1.5 g per 1 m row as a soil drench, and three insecticide sprays (as in IPM 1). IPM 3; widely spaced ($60\times20\,\mathrm{cm}^2$) cowpea /sorghum intercrop (as in IPM 2), planted at the onset of rains and no insecticide application), IPM 4; closely spaced ($30\times30\,\mathrm{cm}^2$) cowpea monoculture planted at the onset of rains and no insecticide application, IPM 5; widely spaced ($60\times20\,\mathrm{cm}^2$) cowpea monoculture, sprayed 8 times, weekly, throughout the crop's growing season, starting at 10 d after cowpea emergence and planted at the onset of rains, IPM 6; closely spaced ($30\times20\,\mathrm{cm}^2$) cowpea monoculture planted 4 week after onset of rains and no insecticide application.

Table 2
Mean field pest population densities on cowpea as influenced by different control options

IPM	Aphids (severity rating/plant)				Thrips /20 flower buds				Maruca /20 flower buds				Pod sucking bugs/ I m row			
System	2000A	2000B	2001A	Mean	2000A	2000B	2001A	Mean	2000A	2000B	2001A	Mean	2000A	2000B	2001A	Mean
FP	1.5b	1.2b	1.6a	1.4	188.4a	99.0a	28.3bc	105.2	1.9bc	2.1a	3.1b	2.3	11.7	7.6a	10.4a	9.8
IPM 1	1.5b	1.1c	1.3ab	1.3	115.9ab	72.3b	26.2c	71.4	2.1b	1.6ab	1.9c	1.8	8.0	5.7b	9.8ab	7.9
IPM 2	1.2c	1.1c	1.2b	1.2	121.4ab	76.6b	16.2c	71.4	1.3cd	1.4b	1.5d	1.4	6.8	5.5b	8.4b	6.9
IPM 3	1.9ab	1.2b	1.6a	1.5	168.6ab	90.3ab	46.1bc	101.6	1.5c	1.7ab	3.6a	2.2	7.9	5.9b	8.3b	7.3
IPM 4	1.5a	1.2b	1.4ab	1.4	147.2ab	79.6b	53.5ab	93.4	2.8a	2.1a	3.1b	2.6	8.4	6.9ab	9.9ab	8.4
IPM 5	1.4bc	1.1c	1.2b	1.3	107.7b	65.1b	14.7c	62.4	0.9d	1.3b	1.8cd	1.3	5.7	5.1b	8.3b	6.4
IPM 6	2.0a	1.4a	1.4ab	1.5	179.1ab	105.5a	70.2a	118.2	2.6a	1.7ab	1.4d	1.8	10.8	6.7ab	9.5ab	9.0
Overall mean	1.6	1.2	1.4		146.9	84.0	36.5		1.9	1.7	2.3		8.5	6.2	9.2	
L.S.D	0.3	0.1	0.4		77.7	17.1	18.2		0.5	0.6	0.4		NS	1.4	1.8	
CV (%)	20.3	9.8	23.2		22.2	33.2	78.9		40.6	57.9	83.1		17.5	29.4	46.5	

Valves within a column followed by the same letter(s) are not different at 5% level of the LSD test and NS = not significant at 5% level of the LSD test.
FP: Farmers' practice (broadcasted cowpea monoculture planted at the onset of rains sprayed 5–6 times throughout the season).
IPM 1: closely spaced (30 × 20 cm^2) cowpea monoculture planted at the onset of rains sprayed 3 times each once at budding, flowering and podding stages. This corresponded to 30, 45, and 50 d after planting).
IPM 2: widely spaced (60 × 20 cm^2) cowpea/sorghum intercrop (based on a replacement 1:1 mixture), planted at the onset of rains, carbofuran (Furadan 5G) seed dressing applied at a rate of 1.5 g per 1 m row as a soil drench, and three insecticide sprays (as in IPM 1).
IPM 3: widely spaced (60 × 20 cm^2) cowpea /sorghum intercrop (as in IPM 2), planted at the onset of rains and no insecticide application).
IPM 4: closely spaced (30 × 30 cm^2) cowpea monoculture planted at the onset of rains and no insecticide application.
IPM 5: widely spaced (60 × 20 cm^2) cowpea monoculture, sprayed 8 times, weekly, throughout the crop's growing season, starting at 10 d after cowpea emergence and planted at the onset of rains.
IPM 6: closely spaced (30 × 20 cm^2) cowpea monoculture planted 4 week after onset of rains and no insecticide application.

Table 3
Mean yield of cowpea as influenced by different pest control options in two districts of eastern Uganda

IPM system	Grain yields (kg/ha)				Yield gain (%)			Marginal returns[a]
	2000 A	2000 B	2001 A	Mean	2000 A	2000 B	2001 A	
FP	422.5b	382.0ab	777.0b	527.0	—	—	—	0.9
IPM 1	766.0a	491.0a	1115.5a	791.0	81.3	28.5	43.6	1.8
IPM 2	856.0a	487.5ab	1041.5ab	786.0	102.7	27.6	34.0	1.3
IPM 3	284.5b	224.5c	496.5b	335.0	−32.5	−41.4	−36.1	—
IPM 4	412.5b	374.5b	749.5b	512.0	−2.4	−1.9	−3.9	—
IPM 5	760.1a	446.0ab	1092.5a	777.0	80.0	16.8	32.2	0.8
IPM 6	308.0b	178.5c	394.5b	294.0	−2.7	−53.4	−49.3	—
Overall mean	544.5	369.0	813.0	575.0				
L.S.D	281.6	145.0	269.0	132.6				
CV (%)	39.7	30.4	25.3	45.1				

[a] Pooled data for three seasons at five locations in Kumi and five in Pallisa, and marginal returns less than 1 are not profitable.
Valves within a column followed by the same letter(s) are not different at 5% level of the LSD test.
FP: Farmers' practice (broadcasted cowpea monoculture planted at the onset of rains sprayed 5-6 times throughout the season).
IPM 1: closely spaced (30 × 20 cm^2) cowpea monoculture planted at the onset of rains sprayed 3 times each once at budding, flowering and podding stages. This corresponded to 30, 45, and 50 d after planting).
IPM 2: widely spaced (60 × 20 cm^2) cowpea/sorghum intercrop (based on a replacement 1:1 mixture), planted at the onset of rains, carbofuran (Furadan 5G) seed dressing applied at a rate of 1.5 g per 1 m row as a soil drench, and three insecticide sprays (as in IPM 1).
IPM 3: widely spaced (60 × 20 cm^2) cowpea /sorghum intercrop (as in IPM 2), planted at the onset of rains and no insecticide application).
IPM 4: closely spaced (30 × 30 cm^2) cowpea monoculture planted at the onset of rains and no insecticide application.
IPM 5: widely spaced (60 × 20 cm^2) cowpea monoculture, sprayed 8 times, weekly, throughout the crop's growing season, starting at 10 d after cowpea emergence and planted at the onset of rains.
IPM 6: closely spaced (30 × 20 cm^2) cowpea monoculture planted 4 week after onset of rains and no insecticide application.

with reference to grain yield from plots with farmer tradition practices, were obtained from plots that received the IPM 1 system (closely spaced cowpea monocrop, planted at the onset of rains receiving three sprays once each at budding, flowering and podding stages). On the contrary, IPM 2 system (closely spaced cowpea monoculture, planted 4 weeks after the onset of rains plus no sprays) had the lowest yield gains.

Marginal returns were higher and profitable for the IPM 1 and 2 treatments that received three insecticide sprays as compared to IPM 5, which received eight sprays throughout the growing season.

Farmers' preferences of the different pest control options varied considerably (Fig. 2). Farmers who preferred IPM 2 and IPM 5 options were of 90% and 69.8%, respectively. During the harvesting of the crop, 89.3% of the farmers preferred IPM 1. Farmers' preference for their own practice (FP), IPM 3 and IPM 6 declined from planting to harvesting. On the converse, preference for IPM 1 increased during this period. Farmers preferred IPM 2 and 5 systems only at planting, but indicated non-preference for these systems at harvesting stage.

4. Discussion

There were higher aphid, pod borer, and pod sucking bug infestations during the first season plantings than during the second season, consistent with the findings of Omongo et al. (1997), Nampala et al. (1999) and Karungi et al. (2000b). However, thrips infestations were highest during both seasons of 2000 than during the first season of 2001. The lower populations in 2001 were perhaps due to high rainfall intensity during this first season of 2001.

Early planting (i.e., on set of rains) greatly reduced aphids and thrips infestations compared with pod borer and pod sucking bug infestations, agreeing with earlier findings of Karungi et al. (2000a). The reduction in aphid populations in early planted treatments is probably due to initial low aphid densities that eventually build-up as the crop develops and as the season progresses. Increased *Maruca* infestation observed in early planted treatments was probably due to the vigorous cowpea growth ascribed to earlier and sufficient rainfall. The plants attained denser canopies earlier and this provided conditions that are more favorable for *Maruca* infestation (Oghiakhe et al., 1991). Early planting also significantly increased yields as opposed to late planting. Karungi et al. (2000b) reported similar findings. However, early planting did not significantly reduce pest densities and this resulted in lower grain yields as compared to treatments that received foliar sprays. This suggests that high pest infestations will require some level of chemical control.

Seed dressing and application of foliar sprays greatly reduced cowpea pest infestations. Carbofuran seed dressing was particularly effective in reducing aphid densities, while foliar sprays effectively controlled thrips, pod borers and pod sucking bugs. This is in collaboration with previous results in Uganda (Nampala et al., 1999; Adipala et al., 2000). However, applying foliar sprays during the vegetative stage resulted in very small grain yield increments and thus, was not profitable. This suggests that cowpea plants can, with regrowth, compensate damage effects of vegetative pests. In this regard, chemical application may not be essential at vegetative stage. Instead, use of close spacing (Karungi et al., 2000a) or intercropping (Nampala et al., 1999) would be used to effectively control early season pests, notably aphids. These cultural practices would allow farmers to eat cowpea leaves during the vegetative growth stage without fear of pesticide poisoning (Adipala et al., 2000).

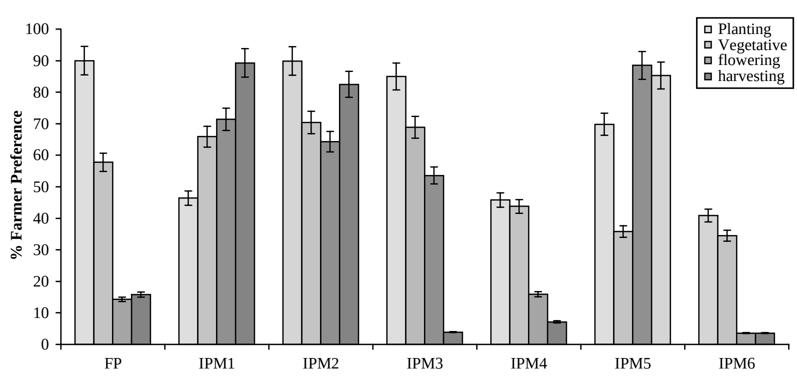

Fig. 2. Percentage farmer (~150 farmers) preference for the different IPM technologies evaluated at different growth stages. FP; Farmers' practice (broadcasted cowpea monoculture planted at the onset of rains sprayed 5–6 times throughout the season) IPM 1; closely spaced ($30 \times 20\,cm^2$) cowpea monoculture planted at the onset of rains sprayed 3 times each once at budding, flowering and podding stages. This corresponded to 30, 45 and 50 d after planting). IPM 2; widely spaced ($60 \times 20\,cm^2$) cowpea/sorghum intercrop (based on a replacement 1:1 mixture), planted at the onset of rains, carbofuran (Furadan 5G) seed dressing applied at a rate of 1.5 g per 1 m row as a soil drench, and three insecticide sprays (as in IPM 1). IPM 3; widely spaced ($60 \times 20\,cm^2$) cowpea /sorghum intercrop (as in IPM 2), planted at the onset of rains and no insecticide application), IPM 4; closely spaced ($30 \times 30\,cm^2$) cowpea monoculture planted at the onset of rains and no insecticide application, IPM 5; widely spaced ($60 \times 20\,cm^2$) cowpea monoculture, sprayed 8 times, weekly, throughout the crop's growing season, starting at 10 d after cowpea emergence and planted at the onset of rains, IPM 6; closely spaced ($30 \times 20\,cm^2$) cowpea monoculture planted 4 week after onset of rains and no insecticide application.

The IPM measures integrating cultural practices with foliar sprays out-yielded sole cultural treatments suggesting that use of cultural control alone is not effective in managing pest infestations. This is in agreement with findings of Nampala et al. (1999), and Karungi et al. (2000b). Other studies elsewhere also suggest that the cowpea production cannot be successful without insecticide application (Jackai et al., 1985; Sabiti et al., 1994). Treatments that comprised of three sprays (IPM 1 and 2) resulted in higher yields as compared to the common practice by commercial farmers of applying six to eight sprays a season. Integration of cultural and insecticide practices resulted in higher returns than the sole use of insecticides, consistent with the findings of Karungi et al. (2000b) and Adipala et al. (2000). Our results suggest the need for only three well-timed insecticide sprays to provide economic pest management for cowpea. Indeed, Bal (1991) working in Nigeria has recommended the use of only two sprays, one at budding and another at flowering. This strategy, as well as the recommendation of three sprays in eastern Africa needs to be explored further.

We observed that farmers had a subjective preference for specific characteristics inherent in the technologies. Lack of access to land and capital were significant constraints to adoption decisions; this is also in agreement with the findings of Havens and Flinn (1976). In addition, IPM components (i.e., crop diversification, alteration of planting dates, seed dressing, spraying and intercropping), and their profitability in terms of marginal returns were major determinants of farmers' preference during the evaluation exercise. Results from this study demonstrated that farmers preferred IPM 1 plots that had closely spaced plants, and planted 4 weeks after the onset of rains. They also preferred IPM 2, the cowpea/sorghum intercrop planted with carbofuran seed dressing, plus three well-timed insecticide sprays, each applied once at budding, flowering and podding. The findings of Adesina and Baidu-Forson (1995), contend that adoption of technologies by farmers reflects decision-making based upon farmers' perceptions of appropriateness of characteristics of the technologies under dissemination. Farmer preference for IPM 1 increased greatly from the time of planting when it was one of the least preferred, until harvest when it was the most preferred. The complexity in the use of these packages played a major role in their adoption. For example, plots with high plant densities controlled aphids and gave higher yields, yet closely spaced plants demand much agronomic labour throughout the season. In addition, seed dressing and spraying were effective in controlling aphids and increasing cowpea yields, but may be expensive components for IPM packages for resource-poor farmers to adopt (Isubikalu et al., 1999, 2000).

Other benefits were observed during this farmer experimental learning approach of the farmer-field schools. For instance, farmer knowledge of pest identification was enhanced. Also, the farmers identified IPM options that best suited their needs, allowing them to be part of the process of technology verification. The next step is to monitor farmer adoption of some of these technologies and dissemination of the economic injury levels concept to further encourage rational use of pesticides.

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