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Effect of cowpea monocultures and polycultures with sorghum and greengram on predatory arthropods

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Summary

Prior to implementing biological control, knowledge on availability of the possible enemies of pest(s) is important. Therefore, as part of a larger on-farm study whose main objective was to develop a farmer-friendly package for the management of cowpea pests, the diversity and abundance of insect predators within cowpea cropping systems (sole crops and intercrops) were monitored at three diverse locations in eastern Uganda. Coccinellids, syrphid larvae, spiders, *Orius* sp. and earwigs were observed at all locations. Abundance of Coccinellids and syrphid larvae were not influenced by the cowpea genotype nor cropping systems. Contrastingly, the abundance of predatory *Orius* sp., spiders and earwigs differed significantly among the cowpea cropping systems, being more common in the cowpea pure stands and cowpea + greengram than in the cowpea + sorghum intercrops.

Key words: Biological control, insect predators, IPM, pests, *Vigna unguiculata*

Introduction

All natural pest populations are regulated to some extent by adverse weather conditions and natural enemies. For example, rain displaces aphids from host plants (Ogenga-Latigo, 1994), so are thrips (Salifu & Hodgson, 1987; Bal, 1991). These then may become prey to predators living on the soil surface, or die in small puddles of water or they dry up easily (Rapport, 1990). Persistent rainfall further increases the relative humidity around the plants thereby promoting the action of entomophagous fungi (Weightman *et al.*, 1990).

Unfortunately, weather conditions can not be manipulated, and rain is a density independent mortality factor that can not be relied upon as a strategy in pest management. Strategic use of natural mortality factors must therefore be based on the manipulation of insect predators and parasitoids, in biological control programmes. From earlier studies conducted in Kenya, a wide range of insect species are known to prey on pests attacking pulse crops (Kyamanywa, Balidawa & Omolo, 1993; Ogenga-Latigo, 1994). For instance a number of coccinellid species, such as *Cheilomones lunata* (F.), *C. aurora* Gerst, *C. lunata* Fab., *C. posticalis* Fairm, *C. sulphurea* Oliv., *C. vicina* Muls., *C. quadrilineatus* Muls., *Chilocorus listigma* Klug., *Dysis quadrilemeata* Sic., *Hippodamia variegata* Goeze, *Hyperaspis* spp. Muls., *Platynaspis capicola* Crotch, *P. sexguttata* Sic., *P. vittigera* Sic., *Scymnus trepidulus* Weise, and *S. Morelleti* Sic. have been recorded on common beans (Ogenga-Latigo, 1994).

Although the efficacy of the range of predatory insect species observed within the cropping systems remains largely unknown, their presence and abundance suggest that they impose some form of regulatory control as has been suggested for other crops (Southwood & Way, 1970). Recommendation for biological control should therefore be based on conservation and augmenting the available natural enemies (Perrin, 1977; Andow, 1983). In this circumstance it is important that detailed studies on the efficacy of biological control agency against pests be carried out.

In Uganda, however, there have been no studies specifically examining the predator species that attack cowpea pests. There is, therefore, a paucity of information on biological control of cowpea pests, and information on the diversity and abundance of insect predators within cowpea cropping systems in Uganda is largely unavailable.

Materials and Methods

On-farm trials were conducted for three consecutive seasons, i.e., during the long (March-July) and short (August-November) rainy seasons of 1997 and the long (March-July) rains of 1998, to monitor the abundance and species diversity of beneficial insect fauna within cowpea cropping systems. The study was conducted in eastern Uganda at sites where cowpea production is high. The sites were Abata (1°31'N; 33°53'E) in Kumi; Katukei (1°13'N; 33°42'E) in Pallisa, and Amuria (2°02'N; 33°39'E) in Katakwi.

Two local cowpea cultivars Ebelat (erect) and

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Icirikukwai (spreading) were grown as sole crops or intercrops with a local variety of greengram (*Vigna radiata*) and sorghum (*Sorghum bicolor* cv. Seredo). The treatment combinations were pure stand Ebelat, pure stand Icirikukwai, Ebelat + sorghum, Ebelat + greengram, Icirikukwai + greengram and Icirikukwai + sorghum. The six treatments were arranged in randomised complete blocks of three replications. Plots and blocks were separated by 1 m and 2 m alleys, respectively. The intercrops were grown in additive mixtures (Osiru & Willey, 1976) and the plant populations for both cowpea and intercrop components were based on a spacing of 60 cm × 20 cm established as the optimum for cowpeas in the region (Obuo, Adipala & Osiru, 1998).

The occurrence and populations of beneficial insects were monitored in the different treatments. The relative abundance of coccinellid and syrphid predators were assessed by randomly selecting two rows from each plot at the time of crop emergence. Plants in these rows were inspected at 15 day intervals and the coccinellids (adults + larvae) and syrphid larvae counted, but thereafter left on the plants.

For *Orius* sp., the predators were counted on 20 flowers selected randomly from each plot. The flowers were picked and placed in glass vials containing 50% ethanol solution, and taken to the laboratory. Subsequently, the flowers were dissected and washed to separate insects from plant parts, and the insects counted.

Activities of earwigs and spiders were monitored using pitfall traps constructed from cylindrical cans 9 cm in diameter and 12 cm deep. Three traps were arranged diagonally across each plot at 1 m intervals. The trap rims were made level with the ground so as not to obstruct insect movement and the area around was kept bare to standardise the catching conditions (Kyamanywa *et al.*, 1993). The traps were half-filled with an aqueous solution of 50% ethanol to preserve the insects, stop predation and increase retaining efficiency. The pitfalls were emptied after 10 days and the earwigs and spiders found counted.

In addition to assessment of predators, microclimatic conditions around the cowpea plants were monitored by taking temperatures and incident light measurements. Three thermometers located at the centre of each plot at about 10 cm from the ground and protected from direct sunlight were used to measure ambient temperature levels at intervals of 20 days starting 20 days after cowpea emergence (DAE). Two sets of readings were taken for each thermometer between 1300 h and 1500 h on bright and rain-free days when maximum variation in microclimatic conditions were expected (Ogenga-Latigo, Baliddawa & Ampofo, 1993).

Photosynthetically active radiation (PAR) reaching the cowpea level was measured at intervals of 20 days, starting 15 DAE, using a quantum radio-meter (LI-1905 Decagon Devices) with a metre long sensor. To obtain a reliable measure of average PAR, the sensor was inserted at three spots within a plot above and below the cowpea canopy. At each sampling occasion the quantum radiometer was configured to take multiple readings for sampling accuracy and also to accommodate changing environments. PAR data were collected manually without the aid of external point sensor, stored and later down loaded for statistical analysis.

All data collected were subjected to analysis of variance (ANOVA) test, after checking the validity of the assumptions underlying this test. Where the F-statistics indicated significant effects, means were separated using Fisher's Protected Least Significant Difference (LSD) test at 5% probability level. All analyses were done using Genstat computer package (Anon., 1993). Data for each season and location were analysed separately before pooling for across season and location analyses.

Results

Five insect predators were commonly encountered. These were the ladybird beetles or coccinellids (Coleoptera: Coccinellidoe), syrphid larvae (Diptera: Syrphidae), spiders (*Oxyopes* sp.), earwigs (Dermaptera: Forficuliidae) and *Orius* sp. (Heteroptera miridae). At all locations, the predators were more abundant during the long (wet) than the short (relatively dry) rains. No significant differences ($P > 0.05$) in abundance of predatory Coccinellids and syrphid larvae were observed between the two cowpea cultivars, or among the cropping systems. Data on the abundance of Coccinellids and syrphid larvae are therefore not presented.

In contrast, the abundance of predatory *Orius* sp., spiders and earwigs differed significantly ($P < 0.05$) among the cowpea cropping system (Tables 1–3). The cowpea + sorghum intercrop had significantly ($P < 0.05$) fewer *Orius* sp. than the cowpea sole crops and cowpea + greengram mixture (Table 1). However, there was no statistical differences between locations. Compared to other predatory insects encountered, the population of predatory *Orius* sp. was low. The cowpea sole crops and cowpea + greengram mixture significantly ($P < 0.05$) supported more spiders (Table 2) and earwigs (Table 3) than the cowpea + sorghum intercrops. Also, the populations of both predators were higher during the long than short rains, with no significant difference between the three locations.

During the initial stages of crop development there was no difference in the intensity of incident light and temperatures at the cowpea canopy (Tables 4 and 5). However, as the sorghum plants grew taller they shaded the intercrop cowpea leading to increased light interception and reduced temperatures.

Discussion

The abundance of different predator species de-

Table 1. *Population density of Orius sp. (per 20 flowers) at peak incidence (60 days after emergence) on cowpea grown as sole crop and intercrops at three sites in eastern Uganda during the first rains of 1997 (1997A), second rains of 1997 (1997B) and first rains of 1998*

Crop combination	Kumi				Pallisa				Katakwi				Overall
	1997A	1997B	1998	Mean	1997A	1997B	1998	Mean	1997A	1997B	1998	Mean	mean
Ebelat	3.0	4.1	3.0	3.4	4.3	3.7	4.0	4.0	4.0	2.7	3.9	3.5	3.6
Icirikukwai	4.1	4.0	3.1	3.7	5.3	3.6	6.0	5.0	3.0	2.2	4.1	3.1	3.9
Ebelat/ Greengrams	6.0	5.0	3.8	4.9	6.0	4.4	5.1	5.2	4.3	2.6	4.0	3.6	4.7
Icirikukwai/ Greengrams	3.0	4.7	3.0	3.6	5.7	4.0	4.9	4.9	4.7	2.5	4.4	3.9	4.1
Ebelat/Sorghum	1.0	1.5	1.0	1.2	1.0	2.0	2.5	1.8	1.2	1.0	2.0	1.4	1.5
Icirikukwai/ Sorghum	1.5	1.3	1.0	1.3	1.0	2.3	2.3	1.9	1.3	0.7	1.8	1.3	1.4
Overall mean	3.1	3.4	2.5	3.0	3.9	3.3	4.1	3.8	3.1	2.0	3.4	2.8	3.2
LSD ($P = 0.05$)	1.8	2.2	1.4	1.6	3.0	1.0	2.2	2.0	1.8	1.0	1.4	1.2	1.0
CV(%)	34.9	10.7	35.4	38.4	46.9	34.2	30.0	27.5	15.1	18.2	19.5	25.3	16.7

Table 2. *Population density of earwigs at peak incidence on cowpea grown as sole crop and intercrops at three sites in eastern Uganda during the first rains of 1997 (1997A), second rains of 1997 (1997B) and first rains of 1998*

Crop combination	Kumi				Pallisa				Katakwi				Overall
	1997A	1997B	1998	Mean	1997A	1997B	1998	Mean	1997A	1997B	1998	Mean	mean
Ebelat	30.0	10.0	30.0	23.3	27.0	16.0	29.0	24.0	21.0	11.0	38.0	23.3	23.5
Icirikukwai	29.6	9.0	28.0	22.2	27.0	12.2	26.2	21.8	19.3	10.1	36.7	22.0	22.0
Ebelat/ Greengrams	37.0	11.0	32.3	26.8	32.0	14.0	33.7	26.6	23.3	12.0	29.5	21.6	25.0
Icirikukwai/ Greengrams	37.0	12.0	34.7	27.9	21.7	11.6	32.6	22.0	21.7	13.2	31.0	22.0	23.9
Ebelat/Sorghum	13.0	5.0	11.3	10.0	10.7	8.1	16.7	11.8	3.0	2.0	5.0	3.3	10.0
Icirikukwai/ Sorghum	16.0	6.2	12.7	11.6	10.3	7.0	12.0	9.8	2.3	2.0	4.8	3.1	8.2
Overall mean	27.1	8.7	24.8	20.3	21.5	11.5	25.0	19.3	15.1	8.4	24.2	15.9	18.8
LSD ($P = 0.05$)	7.0	2.0	14.0	9.0	10.8	3.0	6.6	7.9	8.0	6.0	10.0	11.5	3.0
CV(%)	17.9	21.5	34.8	31.4	30.6	25.5	13.0	26.2	32.0	20.0	22.0	27.1	21.2

Table 3. *Population density of spiders at peak incidence (60 days after emergence) on cowpea grown as sole crops and intercrops at three sites in eastern Uganda during the first rains of 1997 (1997A), second rains of 1997 (1997B) and first rains of 1998*

Crop combination	Kumi				Pallisa				Katakwi				Overall
	1997A	1997B	1998	Mean	1997A	1997B	1998	Mean	1997A	1997B	1998	Mean	mean
Ebelat	31.0	11.0	35.7	25.9	37.6	16.0	30.0	27.9	30.3	19.0	31.0	26.8	26.9
Icirikukwai	34.0	14.5	33.6	27.4	37.0	20.0	38.1	31.7	33.0	16.2	27.0	25.4	28.2
Ebelat/Greengrams	42.0	18.0	46.0	35.3	47.0	14.5	36.7	32.7	35.9	13.4	33.7	27.7	31.9
Icirikukwai/ Greengrams	43.7	15.2	46.4	35.1	45.3	19.0	35.6	33.2	34.0	15.6	29.5	26.4	32.1
Ebelat/Sorghum	15.0	6.4	16.0	12.5	16.0	8.0	11.0	11.7	12.0	6.0	8.0	8.7	10.9
Icirikukwai/ Sorghum	13.5	7.2	18.0	12.9	15.4	7.0	8.7	10.4	10.7	5.5	9.5	8.6	10.6
Overall mean	29.9	12.1	32.6	24.9	33.1	14.1	26.7	24.6	25.9	12.6	37.4	20.6	23.4
LSD ($P = 0.05$)	12.8	3.0	10.0	11.7	9.0	6.0	7.0	10.5	12.0	5.0	12.0	10.2	6.6
CV(%)	25.5	30.0	18.5	20.8	17.0	20.0	14.9	22.9	25.0	32.5	36.0	28.6	33.1

Table 4. *Mean ambient temperature (°C) at cowpea canopy level monitered in different cowpea cropping systems*[1]

Crop combination	Days after emergence			
	20	40	60	80
Ebelat	22.5	27.3	26.0	25.2
Icirikukwai	22.6	26.5	25.4	25.4
Ebelat + Greengram	22.4	25.9	24.9	25.3
Icirikukwai + Greengram	22.3	25.8	25.0	25.1
Ebelat + Sorghum	22.2	21.3	21.0	21.2
Icirikukwai + Sorghum	22.0	21.0	22.0	21.0
LSD ($P = 0.05$)	NS	2.1	1.5	1.8
CV(%)	19.1	25.2	31.2	26.4

[1] Pooled data for three seasons and locations

Table 5. *Mean incident light intensity (micro Einstein s^{-1} cm^{-2}) at cowpea canopy level monitered in different cowpea cropping systems*[1]

Crop combination	Days after emergence			
	15	35	55	75
Ebelat	1000.2	1305.0	1270.0	1300.5
Icirikukwai	1050.1	1300.2	1300.0	1302.1
Ebelat + Greengram	1000.0	1300.0	1350.8	1300.0
Icirikukwai + Greengram	1001.2	1302.1	1325.5	1303.6
Ebelat + Sorghum	1020.3	1001.0	1000.3	900.0
Icirikukwai + Sorghum	1002.1	1012.1	1020.1	915.1
LSD ($P = 0.05$)	NS	121.6	116.9	300.8
CV(%)	25.1	17.8	26.0	30.3

[1] Pooled data for three seasons and locations

pended on cowpea cropping systems, season, and in some cases, location. Populations of the ladybird beetles and syrphid larvae were not significantly affected by cropping systems, although fewer numbers were encountered in the cowpea sole crops and cowpea + greengram mixture than in the cowpea + sorghum mixture (Nampala, 1998). However, there were significantly higher numbers of *Orius* sp. and significantly fewer numbers of earwigs and spiders in the cowpea + greengram and cowpea sole crops than in the cowpea + sorghum mixture. Reasons for the differential abundance of predators within the cropping systems are not very clear. Probably, the varying microclimatic conditions recorded within the different cropping systems affected the survival and activity of the predator species differently. In addition, the differential availability of preferred niches and prey (insect pests) within cowpea cropping systems (Altieri, Francius, Schoonhoven & Doll, 1978; Andow, 1983; Letourneau & Altieri, 1983; Ogenga-Latigo, 1988; Nampala, 1998) were probably the main factors accounting for variation in predator abundance.

The activities of beneficial fauna against aphids and thrips have been reported. For example, Andow & Risch (1985) observed that predacious coccinellids beetle, *Coleomegilla maculata* (Dey) and its prey (aphids) were both more abundant on sole crops than on mixed maize and beans. In Kenya, Kyamanywa *et al.* (1993) evaluated the influence of cowpea + maize intercropping on generalists predators and population density of flower thrips, *Megalurothrips sjostedti* Trybom. Interestingly, abundance of the *Orius* sp., ladybird beetles, earwigs and spiders were not enhanced by planting cowpea as a mixed crop with maize. Contrastingly, Ogenga-Latigo *et al.* (1993) found *A. fabae* and coccinellid beetles at higher densities on sole cropped *Phaseolus* beans than in a mixture with maize.

Knowledge that such levels of nature enemy activity exist for cowpea pests probably implies that pest control plans should include strategies that will preserve non-target organisms so that the trophic linkages in the system will not be upset. However, knowledge on the abundance and species profile of natural enemies alone says little about their direct (control of pests on the cultivated plants) or indirect (control in the wild habitat to prevent outbreaks on cultivated plants) impact on the pests (Ogenga-Latigo, 1988). Thus, we do not interpret these results as indicative of effective biological control, and there is need to evaluate the effectiveness of the predator species observed in this study. Such an evaluation requires studies on multi-trophic level interactions in the wild and cultivated habitats at selected sites over several seasons.

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