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Effects of Different Agroecosystems on Prevalence of Different Species of Pests and Coccinellid Predators

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Abstract: This study was aimed at determining the effects of mixed and single cropping agroecosystems on the prevalence of different species of insect pests and coccinellids. It involved six growing crops: maize *Zea mays* L., beans *Phaseolus vulgaris* L. and cowpeas *Vignaunguiculata* L. Walp in single and mixed stands and sampling throughout the phenology of the crops. Eight insect pest species were recorded on maize grown alone, while thirty seven insect species were endemic on cowpea mono cropped and were of six orders whereas twenty two insect pest species occurred on beans. The predator population was most abundant in the mixed stands of maize and beans (2.33 predators per 30 aphids) as compared to their occurrence in pure stands of cowpeas (0.85 predators per 30 aphids) as there were numerous aphids on beans at pre-flowering phase that supported a higher population level of coccinellids. Also, predator population was at the peak during the tussling stage of maize as they fed on the pollen grains while aphids on cowpeas co-existed mutualistically with black ants that protected them against predation. The genus *Cheilomenes* spp. was the most ubiquitous predator with a mean of 4.00 individuals per 30 aphids while *Hippodamiavariegata* was the least abundant predator species with a mean of 0.92 individuals per 30 aphids in all the agroecosystems as the *Cheilomenes* spp. had a faster discovery rate, range of perception, effective capture efficiency and a shorter handling time of a prey.

Key words: Phenology, stands, *Zea mays* L., *Phaseolus vulgaris* L., *Vignaunguiculata* L. Walp, agroecosystem.

1. Introduction

Damage to the maize crop is as a result of feeding activities of insect pests of which the maize stalk borer *Busseolafusca* is the major pest species [1]. The damage by *Busseolafusca*is vividly described as it has been a pest since 1968 with voracity exhibited throughout the cropping regime of maize [2] Other pests of maize include: the edible grasshopper *Homorocoryphus nitidulisvicinus* Wik, the maize leaf hopper *Cicadulinambila* which causes the maize streak virus disease, the maize aphid *Rhopalosiphummaidis* Fitch, dried fruit beetle *Carpophilusdimidiatus* F. and the maize tassel beetle *Megalognatharufiventris* Bally.

One of the most important production constraints on legumes in tropical and sub-tropical Africa is the wide range of insect pests that attack the crops [3]. Insect pests attack every part of legume plant during pre-flowering, post-flowering and in storage [4]. Species involved comprise of *Ophiomyia*, dipterans, coleopterans, and depidoterans larvae.

Studies have been intensified to develop resistant varieties besides other bio-intensive control strategies, such as biological control and habitat management by the use of mixed cropping or establishment of trap crops [3, 5]. In Kenya, insect pest populations are

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reported to be lower in sorghum/cowpea/maize intercrops than in pure crop stands [6-8]. In another study [9], no significant reduction in the thrips activity and population density was found in cowpeas /maize mixed crops during the colonization phase. Thus, it would appear that cropping regimes will for a long time to come be a feasible method of managing crop pests in developing countries.

Studies have not been conducted on effects of different agroecosystems on prevalence of various species of pests and their coccinellid predators. This study was aimed at determining the endemic field insect pests that naturally infest maize, beans and cowpeas in Busia District, Kenya. This study also quantified the population of different species of pests and coccinellids under different agroecosystems hence enabling us to suggest the best agro-ecosystem suitable in this region.

2. Materials and Methods

2.1 Study Site

These studies were conducted at Nasewa Secondary School (NSS) situated at 20°00′ N of the Equator and 34°10′ E of the Greenwich Meridian and at altitude of 1,231 m. NSS is in Busia District of Western Province of Kenya and is located 7 Km South of Nambale town along Nambale-Matayos road. The rainfall is bimodal occurring in two seasons: March to May and August to November with two distinct peaks in May and September. The range of annual rainfall is 1,000-1,500 mm. Temperatures are high due to the low altitude as well as due to its proximity to Lake Victoria with the average daily temperature being 26.0 °C.

2.2 Study Method

A randomized block design with three replications of six treatments was used. Each plot measuring 5 × 5 m with avenues of between 0.5 m between plots were maintained to ensure accessibility and to facilitate daily operations during the duration of the experiment. The plots were planted at the beginning of the rains with commercial cultivar of hybrid seed maize WS 502 from Western Seed Company Ltd and cowpea, Ken-Kunde variety N.26 and beans, K-22 were obtained from Kenya Agricultural Research Institute (KARI).

The study applied a survey method to investigate the effect of different cropping systems on the population of different species of pests and coccinellids in the ecozone, and the data was accumulated from the treatments described under various experiments as below:

(1) Pure stands / monocropped systems

Three plots of 5 × 5 m of maize with inter-row spacing of 75 cm and inter-plant 30 cm (plants density of 44,000 plants per ha).

Three plots of 5 × 5 m of beans with inter-row spacing of 25 cm and inter-plant 15 cm (plant density of 266,000 per ha).

Three plots of 5 × 5 m of cowpeas with inter-row spacing of 25 cm and inter-plant 15 cm (plant density of 266,000 per ha).

(2) Mixed Stands / intercropped systems

Three replicated plots of 5 × 5 m of maize and beans with inter-row spacing of 75 cm and inter-plant 30 cm (plant density of 44,000 plants per ha) for maize. Inter-row spacing of 25 cm and inter-plant 15 cm (plant density of 266,000 plants per ha) for beans.

Three replicated plots of 5 × 5 m of maize and cowpeas with inter-row spacing of 75 cm and inter-plant 30 cm (plant density of 44,000 plants/ ha) for maize. Inter-row spacing of 25 cm and inter-plant 15 cm (plant density of 266,000 plants per ha) for cowpeas.

Three replicated plots of 5 × 5 m of maize, beans and cowpeas with inter-row spacing of 75 cm and inter-plant 30 cm (plant density of 44,000 plants per ha) for maize. Inter-row spacing of 25 cm and inter-plant 15 cm (plant density of 266,000 plants per ha) for beans and cowpeas.

2.3 Effects of Different Agroecosystems on the Prevalence of Different Species of Pests

The present study also determined field insect pests associated with maize, beans and cowpeas and the complexity of their attack in relation to plant phenology in Busia District, Kenya. The survey was mainly concentrated on experimental plots and was in addition complemented by samples taken from the neighbouring fields of maize, beans and cowpeas. The survey started from the first day after emergence (DAE) and continued until the maize plants tasselled or until pods of beans and cowpeas were harvested.

Sampling was conducted by standard sweep net (38 cm mouth diameter), weekly, for 10 weeks. The collections were temporarily kept in polythene bags for transfer to laboratory examination. Sampling was also conducted by hand picking using forceps, camel brush and plant samples with external symptoms of internal pest infestations were dissected to recover the pests. Individuals of predators were also collected. Representatives of insects collected damaging maize; beans and cowpeas grown in different crop regimes were preserved then identified by use of keys found in standard entomology text books.

The tentative identification was confirmed by comparing with voucher specimens held at the Kenya National Museums, Nairobi. In each plot, twenty plants selected at random were used for pest and predator surveys. Of these, ten plants were dissected to recover internal pests. The data obtained was transformed using the square roots (x + 1) before being subjected to statistical analysis. The Duncan's New Multiple Range test was subsequently applied to separate the means. 7-63 days after planting (DAP); an average of 10 sweeps was taken across plots with different cropping systems using the sweep net. The insects were identified, given a score category and recorded as follows.

2.4 Effect of Different Agroecosystems on the Prevalence of Different Species of Coccinellids

During handpicking, use of forceps, camel brushes and sweep nets, insect pests and their natural enemies (ladybirds) associated with them relative to crop phenology were collected and kept in vials for laboratory identification.

Sampling began seven DAP and subsequently an interval of 7-63 DAP. The number of sampling occasions totalled 10 for all crops. This provided data for ladybirds at pre-tasselling and post-tasselling stages of maize. The operations also yielded data for pre-flowering and post-flowering stages for both beans and cowpeas. Insect occurrence was given a score category and categorized as indicated in Table 1.

3. Results

3.1 Field Insect Pests Associated with Maize in Busia

Data collected during these studies which are presented in Table 2 indicated that the maize stalk borer *Busseolafusca* initiated its attack early on maize crops aged 6 weeks after emergence (WAE), when the plants were at their sixth leaf stage. However, infestation was generally low. At initiation, approximately four borers per 10 plants (0.4 ± 0.2 larvae per plant) were recorded. The population increased

Table 1 Insects score category.

Abundant	Over 15	insects / 10 sweeps
Heavy	11-15	insects / 10 sweeps
Moderate	6-10	insects / 10 sweeps
Light	1-5	insects / 10 sweeps
None	0	insects / 10 sweeps

* An average of less than one was considered as none.

Table 2 Occurrence of stalk borer species according to age of maize plant.

Plant age (WAE)	Mean borers / plant (± SE)	Borer species
1	0.0	-
2	0.6 ± 0.1	*C. Partellus*
3	0.0	-
4	0.4 ± 0.2	*C. Partellus*
5	0.4 ± 0.2	*B. Fusca*
6	2.2 ± 0.8	*C. Partellus*
7	1.0 ± 0.3	*B. Fusca*
8	1.5 ± 0.6	*C. Partellus*
9	0.9 ± 0.5	*B. Fusca*
10	1.5 ± 0.6	*B. Fusca*
12	1.2 ± 0.2	*B. Fusca*
Harvest	1.1 ± 0.3	*C. Partellus*

KEY: WAE—weeks after emergence.
SE—standard error.

four fold at 12 WAE when 15 borers per 10 plants (1.5 ± 0.6 larvae per plant) were recorded. Infestation lasted till harvesting when *Busseolafusca* were recovered from both maize stems and cobs.

Data collected for *C. partellus* showed that the borer was abundant (Table 2). The stalk borer attacked crops from 3 WAE initially with a population of 6 borers per 10 plants (0.6 ± 0.1 larvae per plant). This rose phenomenally by fourfold to 22 borers per 10 plants (2.2 ± 0.8 larvae per plant) at seven WAE. Two species constituted the major pests. Minor pests which were collected during these studies were: the edible grasshoppers in two genera: *Homorocoryphus* and *Ritidulis*, the maize leaf hopper *Cicadulinambila* Naude, the maize aphid *Rhopalosiphummaidis* Bally, the maize tassel *Megalogratharufiventris* and the dried fruit beetle *Carpophilus dimidiatus*.

3.2 Phytophagous Insect Pests of Beans in Busia District, Kenya

A total of 22 insect pest species were recorded feeding on beans as follows: Hemiptera (6), Diptera (3), Coleoptera (6), Thysanoptera (1), Lepidoptera (4) and Orthoptera (2) respectively. The root and stem feeding species comprised of the dusty brown beetle *Gonocephalum simplex*, the bean flies, *Ophiomyiaphaseoli* and *Ophiomyiaspencerella*, the cutworm *Agrotissegetum* and the large brown cricket *Brachytrupes* species. None of the several species of beanflies, previously known to inflict damage to growing beans was identified in this study except for two species: *Ophiomyia spencerella* and *Ophiomyiaphaseoli*. Of these pests, the bean flies appeared to be the most devastating pests of the bean stem in Busia district. Of the two species recorded, *Ophiomyiaphaseoli* was more prevalent. *Agrotissegetum* occurred mainly during the seedling stage 5 to 18 DAE after which its infestation reduced drastically. Most of the pests extended their damage to the podding stage of the bean crop. Leaves and shoots were more susceptible. They were fed upon by the largest group of insect pests observed. The major species was the black bean aphid *Aphis fabae*. Other species that fed on leaves and stems included the cotton lygus *Taylorilygusvosseleri*. Coleopterans observed feeding on bean leaves included the shiny weevil *Nematocerus* spp. the foliage beetle *Ophiomyiabennigseni*, the flea beetle, *Phyllotreta* spp., *Epilachna* spp. and the adult *Gonocephalum simplex*. Among these coleopterans, *Nematocerus* spp. were the most common and abundant. The Golden wing moth *Plusiaorichalcea* and the semi looper *Achaea* spp were the most common lepidopterans. Larvae of leaf miner *Liriomyzatrifolii* damaged leaves by making tunnels while feeding on leaf palisade tissues. The african bollworm *Helicoverpaarmigera* was also observed feeding on leaves. Orthoptera species that fed on foliage included *Zonocerus*spp (Acrididae) and *Branchytrupes* spp. The only bean thrip, namely *Megaloruthripssjostedti* was among the flower feeding species that occurred in large numbers throughout the flowering period. The blister beetles *Myrbis* spp. was also found feeding flowers but were sporadic. The main pod feeding insects were the African bollworm *Helicoverpaarmigera* and legume pod borer *Maruca. testulalis.* The lepidopterans were also found feeding on flowers and flower buds. The pod feeding hemipterans observed on beans consisted of the coreid spiny brown bug *Claviglallashadabi, Claviglallahorrida* and gaintcoreid bug *Anaplocnemis curvipes*.

3.3 Insect Pests Associated with Cowpea Production in Busia, Kenya

The cowpea insect pest complex that attacked cowpeas in Busia is represented in Table 3. A total of 37 species occurring in 6 orders were identified. These orders were: *Coleoptera*, *Hemiptera*, *Thysanoptera*, *Diptera*, *Lepidoptera* and *Orthoptera*. The species identified fed on different parts of the crop from seedling stage to crop maturity.

Table 3 Insect pests associated with cowpea production in Busia, Kenya.

Order	Family	Species	Part of the plant attacked
Coleoptera	Lagridae	*Lagriavilosa* F.	Leaves
	Curculionidae	*Systatescranatipennis* F. *Nematocerusliblomi* *Nematoceruscastnepennis* Hust *Neocleonussania* Abst.	Leaves
	Chrysomelidae	*Oothecamutabilis* S.	Leaves
	Megaloponidae	*Poecilomorphagravestella*	Leaves
	Galerucinae	*Gynandrophthalma* spp. *Raphidopalpaafricana* Ws. *Prosmidiapasseti* *Chrysolina surporba*	Leaves
	Cajoceririae	*Lema fuscitarsis*	Leaves
	Meloidae	*Mylabristristigm* Gerst*Mylabrisamplectenis* Gerst. *Corynaarrusina*	Flowers
	Apionidae	*Apionglobulipene* (Wagner)	Dry pod, seed
	Coccinellidae	*Henosepilachnareticulataswaheliensis*	Leaves
Hemiptera	Pentatomidae	*Nezara viridula* L. *Aspaviaarmigera* *Aspaviahestator*	Green pods
	Coreidae	*Clavigralla horrida* G. *Clavigralla shadabi* S. *Riptortus dentipes* F. *Anaplocnemis curvipes* F. *Mirperus jaculus*	Green pods
	Aphididae	*Aphis craccivora* K.	Leaves, shoots, pod
	Cicadellidae	*Empoascalybica*	Leaves
	Aleyrodidae	*Bemisiatabaci*	Leaves
Thysanoptera	Thripidae	*Megaloruthripssjostedti*	Flowers
	Miridae	*Taylorilygusvosseleri*	Leaves
Diptera	Diopsidae	*Diopsisservillei*	Stem
	Agromyzidae	*Ophiomyia* spp.	Stem
Lepidoptera	Noctuidae	*Helicoverpa armigera* HB.	Flowers, pods
	Pyralidae	*Maruca testulalis*	Flowers, pods
Orthoptera	Gryllidae	*Brachytrupes* spp.	Leaves
	Accrididae	*Acrolylus* spp.	Leaves
	Tettigoniidae	*Phaneroptera* spp.	Leaves

3.4 Pre-flowering Pests Species

Aphis fabae was the most abundant pest that attacked the plant from the early seedling stage and also fed on the leaves, young stems, and shoots and on young developing pods. The pest was noted to cause poor pod formation whenever its heavy infestations were observed. The pests that fed on leaves were largely represented by coleopterans, comprising of 12 species. The most important species which included: *Lagriavillosa*, *Oothecamutabilis*, *Nematocerousliblomi*, and *Nematocerouscastane* were responsible for the major defoliation of the seedling stage. *Raphdopalpaafricana* was responsible for heavy defoliation at the seedling stage, *Lagriavillosa*was prevalent and maintained its prominence throughout the plant growth period. *Henosepilachnareticulataswaheliensis* was observed feeding on leaves at the late seedling stage and because of that, it could be considered a serious pest. Other coleopterans that fed on foliage at relatively low rates were: *Systates cranatipennis*, *Prosmidia passeti*, *Chrysolina surporba, Lema fuscitarsis, Gynandrophthalma gravestella and Neocleonus castane.*

Two dipteran pests mainly, *Diapsisservillei* (Diopsidae) and *Ophiomyia* spp. were observed, with the former more being prevalent than the later. Another important group of pre-flowering pests was the hemipterans represented by three species, namely: *Empoascalybica*, *Bemisia tabaci* and *Taylorilygusvosseri* in the families' cicadelidae, aleyrodidae and miridae respectively. They were found sucking sap from leaves of the developing crop. The *Empoasca lybica* attacked heavily in relation to others.

The important lepidopterous larvae that fed profusely on flowers were *Marucatestitulalis* and *Helicoverpaarmigera*. These pests extended their attack on the developing green pods and fed on seeds. The remaining pre-flowering pests found feeding on leaves consisted of *Brachytrupes* spp. (Glyllidae) which was prominent during the seedling stage and decreased to last observation, while *Acrotylus* spp. (Acrididae) and *Phaneroptera* spp. (Tettigonidae) were noted in varying numbers throughout the plant growth period.

3.5 Post-flowering Pest Species

At the flowering stage, a new group of pests began attacking the crop. The flower feeding beetles were represented by three species, namely: *Mylabristristigma*, *Mylabrisamplectenis* and *Corynaarrusina* which occurred abundantly throughout the flowering period and fed heavily on flower petals. One important thrip species namely, *Megaloruthripssjostedti* showed prominence over the flowering period. At the pod initiation stage, the complex of pod feeding bugs attacked the cowpea crop. They comprised eight species, namely: *Helicoverpaarmigera, Aspaviahestator, Nezaraviridula, Clavigrallahorrida, Clavigrallashadabi*, *Riptortusdentipes*, *Anaplocnemiscurvipes and Mirperusjaculus*. However, *Clavigralla* spp., *Aspavia* spp. and *Nezaraviridula* were prominent in infestion. These pests fed on developing pods causing poor or no pod formation. The weevil *Apionglobulipene* was also common during the seed filling stage (Table 3).

3.6 Effects of Different Agroecosystems on the Prevalence of Coccinellids

Data collected showed that mixed stands had more coccinellids than did the pure stands (Table 4). Mixed stands of maize and beans supported the highest population of 140 coccinellids. Minimum of 51 coccinellids occurred in pure stand of cowpeas. However, the coccinellids *Cheilomenes* spp. was the most abundant while on the other hand *Hippodamiavariegata* was least abundant. Other species recorded were: *Exochomus* spp. and *Henosepichna* spp. all of which appeared largely insignificant.

From the univariate analysis of variance, the effect of different agro ecosystems on the occurrence of coccinellids was significant, this indicated that the interaction of agro systems with the species of coccinellids was significant. This showed that intercropping of different crops had a significant effect on the occurrence of coccinellids.

4. Discussions

The study showed that cereals and legumes in Busia were attacked by different insect species. It was apparent that whereas the pest complexes for the legumes was diversified and extensive comprising of 37 species for cowpeas and 22 species for beans, that of maize was comparatively small and less diversified comprising of only eight species. As expected, there was

Table 4 The abundance of coccinellids in different stands.

Crop agroecosystems	Sum
Maize, Beans & Cowpeas	130
Maize & Beans	140
Maize & Cowpeas	129
Beans	138
Cowpeas	51
Maize	130
Total	718

much similarity between the insect pest complexes for beans and cowpeas since they are both legumes. These crops did not have common insect pest species with maize apparently because they belong to different plant families. This phenomenon is utilized in many cropping systems globally. The pest complex for cereals and legumes in Busia resemble those recorded from other areas of Kenya [1] and Africa at large [2]. This is significant because any new control strategy developed out of these studies could be put to use throughout the continent of Africa.

Cheilomenes spp. was the most abundant predator in all the agroecosystems in these studies while the least abundant predator *Hippodamia variegate*. Others were sparse in population and included: *Exochomus* spp. and *Henosepichna* spp. *Hippodamia variegata*larva was the most efficient predator of *Aphis fabae*in these studies as the larval stage is the most destructive stage of the insect's life cycle. The species was largely polyphagous and fed also on *Aphis caccivora.* The predatory larvae dominated during the rainy season and therefore synchronised with low aphid population levels. Other predatory coccinellids recorded in these studies were: adults of the *Cheilomenes* spp., *Exochomus spp. Hippodamiavariegata and Henosepilachna* spp.. This aspect is expected since pests and their predators synchronise.

Although a total of 22 species in 6 insect orders were recorded, this was proportionally fewer than expected. This was probably because of variations in the density of crop pests which synchronize with areas, seasons and weather as well as other conditions such as mixed and pure stand farming [1]. Current results showed that most of the insect pest species recorded was well known pests of legumes in the tropics, though their occurrence seemed to be of varied magnitudes. The studies showed that the leaf feeders formed the largest group of pests.

It was demonstrated in these studies that the different agroecosystems studied had a significant impact on the abundance of coccinellids. The mixtures of maize and beans supported high population levels of coccinellids apparently because the bean aphid *Aphis fabae*upon which the beetles fed was quite abundant during the pre-flowering stage of beans. On the other hand, the tasselling stage of maize coincided with higher levels of the predators because they fed on pollen grains. However, the pure stand cowpea supported the lowest population of coccinellids due to the mutualistic association of *Aphis fabae* on cowpeas with the black ants ("Attendant ants") such that *Aphis fabae* provided black ants with secretions for nourishment while the ants protected the aphids from predation by coccinellids.

5. Conclusions and Recommendations

Hippodamiavariegata larva was the most bio-efficient agent against aphids in this study and had a tremendous significance. This pointed to the fact that the predator could be put to use in the control of aphids. There is then need to study this predator with a view to understanding its exact ecology and biology. Its predatory potential based on such factors as its discovery rate, speed of movement, range of perception, capture efficiency and handling time ought to be determined. Equally important, was *Cheilomenes* spp., which was relatively bio-efficient as predators of aphids. It should in future be studied as a potential agent for aphid control. This study will improve the quality of maize and beans produced. It will prevent pollution, resistance and resurgence of pests caused by chemical pesticides. Bio magnification of chemical pesticide in food chain to lethal doses will be curtailed. It will also spare the farmers the expenditures on procurement of chemical pesticides hence, utilize the funds on other aspects of economic growth, such as education in Busia District and Kenya at large.

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