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Effects of Cropping Patterns on the Flea Beetles, Podagrica Spp. (Coleoptera: Crysomelidae), In Okra-Kenaf Intercrop System

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Abstract: The pattern of field infestation by the flea beetles, *Podagrica* spp., was assessed in okra-kenaf intercrop system with a view to determining a cropping pattern that would assist in controlling the pest problem. Okra and kenaf were intercropped in row combinations of 1:1, 1:2, 2:1 and 2:2 while sole-cropped okra and kenaf served for comparison. Field sampling for flea beetles commenced three weeks after planting and it lasted till the 12th week, a period that extended to the postharvest stage of okra. There was a significant difference ($P < 0.01$) between the population of the two *Podagrica* spp. (with *P. uniforma* being more abundant than *P. sjostedti*) and among the six planting patterns. The pest population also differed ($P < 0.05$) between the two crops and among ($P < 0.001$) the vegetative, reproductive and postharvest stages of okra. Sole kenaf had a significantly higher level of infestation by the flea beetles followed by sole okra and two rows of okra intercropped with one row of kenaf in descending order. All the other three intercrop patterns had a significantly lower infestation level. Kenaf attracted more flea beetles than okra at the vegetative stage while stumps of okra left in the field after harvesting was over sustained a significantly higher population of flea beetles. Obtained results showed that intercropping could be used, especially by poor rural farmers, as a pest control strategy against *Podagrica* spp. Due to the considerable population of flea beetles sustained by okra stumps, farmers should be encouraged to get rid of leftovers after harvesting as a way of further controlling *Podagrica* spp. The combination of intercropping and farm sanitation would assist in reducing reliance on synthetic chemical insecticides.

Keywords: Intercropping; Kenaf; Okra; *Podagrica sjostedti*; *P. uniforma.*

1. Introduction

The term *cropping system* refers to the crops and crop sequences and the management techniques used on a particular field over a period of years [1]. Cropping systems, such as *intercropping*, are designed to mimic nature and bring diversity into farming [2]. Intercropping is a crop management system that involves two or more crop species grown together for at least a portion of their respective productive cycle and planted sufficiently close to each other so that inter-specific interactions occur [3]. The two or more crops used in an intercrop may be from different species and different plant families or they may be different varieties or cultivars of the same crop species. A critical aspect in developing an effective intercrop system is to select, manage and organize the crops so that they best utilize the available growth resources such as sunlight, soil, nutrient, air and water [4]. Seeds of both crops could be broadcast without any row arrangement to give *mixed intercropping* and seeds could be sown in rows to give *row intercropping*. Though less demanding, the former arrangement makes weeding, fertilization and harvesting difficult whereas the latter makes the operations easier [4].

Intercropping has been seen as a promising technique to develop sustainable farming systems because it often has multifunctional roles and can potentially provide a number of eco-services within the farm system. Examples may include the addition and recycling of organic material, water management, protection of soil from erosion, suppression of weeds, increase in yield and reduced pest and disease incidences. This functional diversity contributes to ecological processes to promote the sustainability of the whole farm system [5]. Intercropping of compatible plants encourages biodiversity, by providing a habitat for a variety of insects and soil organisms that would not be present in a single crop environment. This biodiversity can in turn limit outbreaks of crop pest by increasing the diversity or abundance of natural enemies, such as spiders or parasitic wasps. Available growth resources such as light, water and nutrient are more completely absorbed and converted to crop biomass by intercropping as a result of

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difference in competitive ability for growth factors between intercrop components [6]. The more efficient utilization of growth resources eventually leads to yield advantages and increased stability compared to the sole cropping.

Kenaf (*Hibiscus cannabinus* L.) and okra (*Abelmoschus esculentus* (L.) Moench) belong to the family Malvaceae and they are short-duration crops with similar growth habit and cultivation methods. They also require the same amount of fertilizer and water, and they could be produced on the same piece of land to diversify output [7]. Nigeria produced 1.1 million tonnes of okra (12.7% of World total) in 2013 making her the second largest producer after India. National production of jute and jute-like fibres was however low at 1390 tonnes i.e. 0.04% of the World total [8]. Information abounds in literature on the biology, nutritional, medicinal, and industrial values of the two crops [9-12]. The flea beetle, *Podagrica* spp., is a major insect pest of malvaceous plants and the two common species in West Africa are *Podagrica sjostedti* (Jacoby) and *P. uniforma* (Jacoby); the former has bluish-black elytra while it is shiny brown in the latter. The two insect species can co-exist on the same plant, although they exhibit selective preferences when offered a choice between food-plant species. Severity of defoliation varies with location but it could be as high as 80% [11].

In a pioneering study on the potential of kenaf as an intercrop with okra, Raji and Fadare [7] reported a reduction in yield of kenaf accompanied with a significant increase in yield of okra when the two crops were intercropped. They however concluded that the aggregate yield of the two crops was maximised when they were intercropped. This conclusion was based on the Land Equivalent Ratio (LER) value which was highest when the two crops were planted in alternate rows. The LER value for each planting pattern was calculated using the Relative Yield Estimates (RY) of de Wit and van den Bergh [13] viz:

$$\mathrm{LER} = \mathrm{RYa} + \mathrm{RYb} \;=\; \frac{\mathrm{Oa}}{\mathrm{Ma}} + \frac{\mathrm{Ob}}{\mathrm{Mb}}$$

where RYa is the relative yield of Crop A (Kenaf) in the mixture, RYb is the relative yield of Crop B (Okra) in the mixture; Oa and Ma are the mixture and monoculture yields of kenaf core and fiber while Ob and Mb represent the mixture and monoculture yields of okra fruits.

In Nigeria, use of chemical insecticides is in vogue for the control of insect pests. However, kenaf and okra are usually grown in small scale plots by resource-poor farmers who often do not have enough money to buy the insecticides. Exclusive reliance on insecticides as a control strategy against insect pest has resulted in several undesirable effects, like pesticide pollution, resurgence of secondary pests, insecticide resistance, elimination of beneficial fauna and different human health problems [14]. There is, therefore, a need to explore alternative approaches to reduce the sole dependence on insecticides. The present study focussed on determining a suitable planting arrangement for kenaf-okra intercrop as a tool for controlling the flea beetles in small-scale agriculture with a view to reducing the need for synthetic insecticides.

2. Materials and Methods

Field experiments were conducted at Obafemi Awolowo University Teaching and Research Farm situated at 7˚ 28' N, 4° 33' E and 224 m above the sea level. The experimental field was cleared, ploughed, harrowed and levelled. The experiments consisted of six cropping patterns: sole okra, sole kenaf, 1:1 (one row of okra and one row of kenaf), 1:2 (one row of okra and two rows of kenaf), 2:1 (two rows of okra and one row of kenaf) and 2:2 (two rows of okra and two rows of kenaf) laid out in randomized complete block design and replicated three times. Kenaf seed (*A2-60-2826 variety*) was obtained from the Institute of Agricultural Research and Training, Ibadan while okra seed (*Clemson Spineless*) was obtained from a Premier Seeds retail outlet in Ile-Ife, Nigeria.

The kenaf seeds were planted at the rate of 4 seeds per stand at 50 cm × 10 cm spacing while okra seeds were planted at the rate of 2 seeds per stand at 50 cm × 30 cm space. Plots were separated by 1 m wide border margin and blocks by 3 m. Thinning was done at two weeks after planting to two seedlings per stand to minimize overcrowding and maintain a normal plant population in the experimental field. Fertilizer (NPK 15:15:15) was applied to the crops at 3 weeks after planting at a rate of 181 kg/ha. Weeding was done manually every two weeks.

The number of flea beetles present on 20 randomly-selected plants per plot was counted twice a week beginning at three weeks after planting (WAP) and it lasted till the 12th week. This period of data collection covered the seedling/vegetative (3-4 WAP), reproductive (5-9 WAP) and postharvest (10-12 WAP) stages of okra. Counting was done between 7:00 am – 8:30 am when the flea beetles were less active and the number of each species was recorded separately. The data collected were log transformed before being subjected to analysis of variance (ANOVA) procedures [15] and Tukey's Studentized Range (HSD) Test was used to separate mean values at 5% level of probability. Back-transformed (original) data are presented in the Tables.

3. Results

The mean square values from the analysis of variance are shown in Table 1. The number of flea beetles varied significantly ($P \leq 0.01$) between the two *Podagrica* spp. and among the six planting patterns. The number also varied ($P \leq 0.001$) among the vegetative, reproductive and postharvest stages of okra. The population of *P. uniforma* was higher than that of *P. sjostedti*; the former infesting kenaf and okra equally while the latter attacked kenaf more than okra (Table 2). The flea beetles were more abundant on sole-cropped plots compared to the intercropped. Sole-cropped kenaf was the most infested plot while two rows of okra intercropped with one row of kenaf was the most infested intercrop pattern (Table 3). Kenaf attracted more flea beetles than okra during the vegetative phase but there was no difference in the level of infestation during the reproductive phase. However, the number of flea beetles found on okra stumps after harvesting was over was significantly higher than that on kenaf (Table 4).

4. Discussion

Podagrica sjostedti and *P. uniforma* have similar life-histories and both are usually confined to malvaceous plants [16]. The flea beetles were found on the two experimental crops with *P. sjostedti* showing noticeable preference for kenaf. Generally, *P. uniforma* was more abundant on the crops and the population was eight-fold that of *P. sjostedti*. A similar trend was observed by Agunloye [17], Emosairue and Ukaegbu [18] and Uddin II and Odebiyi [19]. However, a contrary observation was made by Echezona, *et al.* [20] and Ojo, *et al.* [21] where the *P. sjostedti* outnumbered *P. uniforma*. This is an indication that the relative abundance of the two *Podagrica* spp. varies, in Nigeria, with time and location.

Sole-cropped kenaf and okra had the highest flea beetle populations because there was no barrier and life cycle interference against breeding and spread of the flea beetles in sole-cropped plots [22]. One component crop of an intercropping system usually acts as a barrier against the spread of pest [23] and it was obvious that kenaf, being the most infested, offered a level of protection to okra in the current study. The lower populations of *Podagrica* spp. recorded in intercrop okra plants indicate that intercropping kenaf with vegetables not only offers the poor-resource farmers insurance against crop failure but also helps in pest control. Studies on the effect of intercropping on pest attacks are numerous and often contradictory due to the difficulty of teasing out the ecological factors that can affect insect-plant relations. Andow [24] analysed 209 studies involving 287 pest species. Compared to monocultures, the population of pest insects was lower in 52% of the studies (149 species) and higher in 15% (44 species). Of the 149 pest species with lower populations in intercrops, 60% were monophagous and 28% polyphagous. The population of natural enemies of the pests was higher in the intercrop in 53% of the studies and lower in 9%. The results of such studies, therefore, imply a complex situation in which the specific agro-ecological situation is important. Perrin [25] in discussing the effects of intercropping on insect population was of the opinion that visual as well as olfactory effects and diversity of hosts play an important role. A good understanding of this phenomenon in the context of the current study may assist in explaining the reduction in population of *Podagrica* spp. in the intercropped plots.

The greatest reduction in flea beetle population was obtained from all intercrop ratios except where two rows of okra were intercropped with one row of kenaf. This is in agreement with Raji and Fadare [7] who suggested that each row of okra should be intercropped with one row of kenaf to maximize yields of both. Intercropping of okra with kenaf could, therefore, be seen as an option that fits well into the non-pesticide management of flea beetles. This is beneficial, to subsistence farmers who usually practise intercropping, as it would help keep cultivation costs to the barest minimum and avoid excessive dependency on synthetic agrochemicals.

In a *choice* situation, *Podagrica* spp. preferred kenaf to okra during the vegetative phase giving an indication that leaves of kenaf might possess superior nutritional quality needed for growth and development of the flea beetles. Okra is more popular among resource-poor farmers and this preference makes kenaf a good intercrop for protecting okra against the defoliating flea beetles. It is a common practice among small scale farmers to leave plant stumps in the field after harvest till the next planting season. This habit seems to be disadvantageous in the case of okra, especially during the rainy season when the relative humidity is high. It was observed in the present study that okra stumps left in the field, well after harvesting was over, attracted a significantly higher flea beetle population compared to kenaf. The stumps acted as a continuous means of sustaining flea beetles in the field. Local farmers should, therefore, be advised to remove okra stumps immediately harvesting is over.

The current study has added credence to the use of intercropping as a means of controlling crop pests. However, because the underlying mechanism of the multitrophic interactions is a complex one and often not fully understood [6, 24, 26], a synergy between cropping system specialists and entomologists should be pursued with a view to standardizing intercropping protocols for enhanced pest control efficacy.

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Table-1. Mean square values of some experimental factors that affected the population of *Podagrica* spp. in sole and intercropped plots.

Source of Variation	*df*	Mean Square Value
Replication	2	1.06
Planting pattern	5	0.67**
Growth stage of crop	2	72.82***
Podagrica spp.	1	64.16**
Crops	1	3.46*
Planting pattern × *Podagrica* spp.	5	1.70*
Growth stage of crop × *Podagrica* spp.	2	9.02**
Crop × Growth stage of crop	2	43.55**

*, **, *** represent significance at 0.05, 0.01 and 0.001 levels of probability, respectively

Table-2. Relative abundance of *Podagrica uniforma* and *P. sjostedti* in the experimental plots and their presence on each of the two crops

Insect species	† Average number/sampling week	
Podagrica uniforma	453.89[a]	
Podagrica sjostedti	57.11[b]	
LSD (5 %)	28.42	
Crop	**Insect species**	**†† Average number on each crop/sampling week**
Abelmoschus esculentus (Okra)	*Podagrica uniforma*	227.78[a]
Hibiscus cannabinus (Kenaf)		226.11[a]
Abelmoschus esculentus (Okra)	*Podagrica sjostedti*	3.22[c]
Hibiscus cannabinus (Kenaf)		53.89[b]

† Values are significantly different at 0.05 level of probability
†† Populations of each insect species having similar alphabets are not significantly different at 0.05 level of probability.

Table-3. Severity of flea beetle infestation due to each planting pattern

Planting pattern	Average number of flea beetles/sampling week
Kenaf alone	152.44[a]
Okra alone	113.56[b]
2 Okra: 1 kenaf	89.11[c]
1 Okra: 1 kenaf	52.78[d]
2 Okra: 2 kenaf	52.11[d]
1 Okra: 2 kenaf	51.00[d]

Values in the column with similar alphabets are not significantly different at 0.05 level of probability.
The ratios represent the number of intercropped rows.

Table-4. Abundance of flea beetles on the two experimental crops during the vegetative, reproductive and postharvest stages of okra.

Crops	Growth stages	Average number of flea beetles on each crop/growth stage of okra
Abelmoschus esculentus (Okra)	Vegetative	158.50[c]
Hibiscus cannabinus (Kenaf)		958.00[a]
Abelmoschus esculentus (Okra)	Reproductive	75.00[d]
Hibiscus cannabinus (Kenaf)		77.50[d]
Abelmoschus esculentus (Okra)	Postharvest	514.67[b]
Hibiscus cannabinus (Kenaf)		70.67[d]

Populations of flea beetles per growth stages having similar alphabets are not significantly different at 0.05 level of probability.