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Research Article

Effectiveness of maize as an intercrop in the management of insect pests of okra: Is there a better intercrop pattern than random intercrop practiced by farmers?

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Abstract: A field trial was carried out during the rainy season of 2015 at the Teaching and Research Farm of Faculty of Agriculture, University of Port Harcourt, Nigeria to determine the effectiveness of maize *Zea mays* L. as an intercrop in managing the pests of okra *Abelmoschus esculentum* L. There were five treatments namely 1: 1, 2: 1, 3: 1 (okra to maize intercrop ratios), farmers' practice (random intercrop) and control plot (sole okra). The treatments were assigned one to a plot and arranged in randomized complete block design with four replications. Data were taken on number of days to 50% seedling emergence, 50% flowering and 50% fruiting, number of holes in the leaf damage, number of fruits, weight of undamaged fruits, weight of damaged fruit and population density of insect pests. The sole okra had the highest leaf damage and number of insect pests. *Podagrica uniforma* Jacoby (Coleoptera: Chrysomelidae) was the most important insect pest of okra in terms of population density. Okra intercropped with maize in the ratio of 1:1 was the most effective intercrop system in insect pest management. The intercrop pattern should be promoted while random intercrop pattern practiced by farmers should be discouraged.

Keywords: Intercrop, okra, *Abelmoschus esculentum*, maize, *Podagrica uniforma*

Introduction

Okra, *Abelmoschus esculentum* L. (Malvaceae) is an important vegetable crop grown in the tropics for its immature edible green fruits, young leaves and mature seeds (Ahmed and Abd El-Baky 2004; Christo and Onuh, 2005). It is grown all year round for its nutritional benefits including high level of vitamins A and C, calcium, iron, fiber, ascorbic acid and riboflavin (Ahmed and Abd El-Baky 2004; Christo and Onuh, 2005; Degri and Richard, 2014). In recent times, it has been revealed that regular consumption of raw okra fruits has the potential to remedy diabetes mellitus in human beings (www.healthline.com/health/diabetes/okra). In Nigeria, okra is a good cash crop, improves the palatability of many dishes and builds human blood (NRC, 2006). Okra fruit is used industrially to produce margarine and gum and consumption of the edible parts facilitates food digestion, prevents constipation, and helps to treat peptic ulcer and venereal diseases (Gogus and Maskan, 1999; Sanjeet *et al*., 2010). Okra is an early crop which remains green almost all year, grows well in limited rainfall, under irrigation and in all types of

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soil (Schippers, 2000). It is cultivated singly or intercropped with field crops such as maize, sorghum, yam and cassava (Muoneke *et al*., 1997; Ijoyah and Ozar, 2012).

Insect pest infestation is one of the major challenges in okra production (Hugar and Palled, 2008). Although severe damage is more conspicuous during the vegetative stage, the crop is susceptible to insect pests during all growth stages (Obeng-Ofori and Sankey, 2003; Ahmed *et al*., 2007). Among the insect pests that cause economic damage to the crop, the flea beetle *Podagrica* spp. is the most serious, usually causing heavy defoliation (Ahmed *et al*., 2007). The severity of damage varies with location, however it has been reported that the insect pests of okra possess the ability to cause up to 80% damage (Egwuatu, 1992). The insect pests diminish the photosynthetic capacity of okra leaves culminating in low dry matter production and impoverished yield (Degri and Richard, 2014). The pests could serve as vectors of some mosaic virus diseases causing significant yield losses (NRC, 2006).

Various control measures can be used to tackle the pest infestation in okra cultivation; however there is heavy reliance on conventional synthetic insecticides (Dinham, 2003) that are usually effective, fast in action but with high residual effects (Ahmed *et al*., 2007). However, safety, environmental and economic issues necessitated paying attention to other strategies. The present study was aimed to study intercropping okra with maize *Zea mays* L. and determining the most suitable intercropping.

Materials and Methods

The experiment was carried out at the Teaching and Research Farm of University of Port Harcourt, Rivers State, Nigeria situated at latitude 4º51'N and 4º55'N and longitude 6º54'E and 6º56'E with an elevation of 20 m above sea level. Temperature of the area ranges from 28 to 33 ºC while annual rainfall ranges from 2000 to 2680 mm (GEM, 2012). Land was cleared manually using cutlass, spade and hoe and tilled for easy root penetration. Poultry droppings were obtained from the University of Port Harcourt Demonstration Farm, left to cure for 21 days and sundried before pulverizing to ensure uniform sizes. The poultry manure was applied at the rate of 2.4 kg/bed (Udoh *et al*., 2005) after soil analysis was carried out to ensure the nutrient profile was good for the experiment (Table 1).

Table 1 Physical/chemical properties of soil which was used for the study.

Property	Value
pH (1: 2: 5 in water)	0.15 ± 0.05
Clay (g)	12.60 ± 2.71
Silt (g)	9.00 ± 0.00
Sand (g)	78.40 ± 12.98
Textural class	Sand
Carbon (g/kg)	5.40 ± 0.12
Nitrogen (g/kg)	0.10 ± 0.00
Phosphorus (g/kg)	12.70 ± 0.01
Exchangeable cation (cmol/kg)	5.95 ± 0.11
Calcium (cmol/kg)	5.00 ± 1.00
Magnesium (cmol/kg)	0.50 ± 0.01
Sodium (cmol/kg)	0.26 ± 0.01
Potassium (cmol/kg)	0.19 ± 0.01
Hydrogen ion (mol)	0.12 ± 0.00
Aluminum ion (mol)	0.00 ± 0.00
ECEC (cm/mol)	4.44 ± 1.50

Data are means ± standard error of four replications.

The experiment was conducted in a randomized complete block design with five treatments [1: 1, 2: 1, 3: 1 (okra to maize), farmers' practice (random intercrop) and control (sole okra)] in a row arrangement and replicated four times. This gave a total of twenty plots. Each plot was 1.35m x 3.6 m and there was an alley way of 1m between treatments and 2m between blocks and this gave a total land area of 169.5m^2. The maize variety (Oba 98) used in the experiment was obtained from Rivers State Agricultural Development Programme while okra (Bagarada) seeds were obtained from Lueku village in Khana, Rives State. Three seeds per hole were sown on the 29th of June 2015. Okra to okra was spaced 60cm x 60cm, okra to maize 60cm x 30 cm and maize to maize 60cm x 60cm. The plants were thinned to one per stand 1 week after seedling emergence. The plants were sustained by natural rains and were weeded regularly. Okra fruits were harvested immediately the fruit reached one third full growth and when their skin turned glossy (Udoh *et al*., 2005). Harvesting of fruits was done every 3 days for a period of 3 weeks.

All the okra plants in each plot were examined and data were taken on number of days to 50% seedling emergence, 50% flowering and 50% fruiting and number of holes in leaves (leaf damage), number of fruits, weight of undamaged fruits, weight of damaged fruits and number of insect pests. The insects were collected on weekly basis between 1700 and 1800 hours when the insects were less active. The number of each insect species in each plot was recorded and a representative sample of each insect was collected using sweep nets and or hand picking after enumeration of the insects in a plot and put in a vial containing 70% ethanol preservative. The insects were identified to species at the Entomological Museum of Ahmadu Bellow University, Zaria, Nigeria. Data were subjected to analysis of variance after performing Levene's test for equality of variance. Mean separation was done using LSD.

Results

Table 2 presents the number of days to 50% seedling emergence, 50% flowering and 50% fruiting of okra plants. There was no significant difference ($P > 0.05$) in all the agronomic parameters; however, farmers' practice had the longest days to 50% seedling emergence and also for 50% flowering. The number of holes in the leaves of okra plants produced by insect pests is showed in Table 3. In the first week, the number of holes in okra leaves in the control plot was highest, although it was not significantly different ($P > 0.05$) from farmers' practice. Holes on the okra leaves attributed to flea beetles were lowest in okra intercropped with maize in the ratio of 1: 1 but were not significantly lower ($P > 0.05$) than number of okra leaf holes in the 2: 1 okra-maize row intercropping. Generally it was observed that defoliation by foliage beetles increased with crop maturity.

The number of okra fruits produced, weight of undamaged and damaged fruits caused by insect pests are shown in Table 4. The number of okra fruits and weight of undamaged fruits were significantly higher ($P < 0.01$) in the 1:1 okra to maize ratio. Number of fruits produced by okra planted in the ratio 3:1, random intercrop and sole okra did not vary significantly. Weight of damaged okra fruits was significantly lower in the 1:1 treatment ratio though the damaged fruits were not significantly different from okra planted in 3:1 ratio.

Table 2 Number of days to 50% seedling emergence, 50% flowering and 50% fruiting of okra plants.

Treatment	50% Germination	50% Flowering	50% Fruiting
1. okra:1 maize	7.33 ± 0.30	73.33 ± 2.30	81.33 ± 2.30
2. okra:1 maize	8.00 ± 0.90	71.67 ± 2.90	74.67 ± 2.80
3. okra:1 maize	7.33 ± 0.50	73.67 ± 1.70	77.33 ± 1.60
Farmers' practice (Random intercrop)	9.00 ± 0.30	73.67 ± 0.60	78.00 ± 0.90
Control plot (sole okra)	8.33 ± 0.30	73.33 ± 0.50	81.33 ± 1.40

Data are means ± standard error of four replications.
Means in each column are not significantly different (F-test, $p > 0.05$).

Table 3 Number of holes in okra leaves observed within a period of three weeks (time important for insect-caused defoliation).

Treatment	Week 1	Week 2	Week 3
1. okra:1 maize	1.77 ± 0.10^a	3.07 ± 0.25^a	4.53 ± 0.27^a
2. okra:1 maize	2.40 ± 0.25^a	3.97 ± 0.10^b	5.00 ± 0.21^b
3. okra:1 maize	3.10 ± 0.28^b	4.87 ± 0.10^c	5.00 ± 0.05^b
Farmers' practice (Random intercrop)	4.63 ± 0.25^c	5.00 ± 0.10^c	5.00 ± 0.10^b
Control plot (sole okra)	5.00 ± 0.01^c	5.00 ± 0.02^c	5.00 ± 0.01^b

Data are means ± standard error of four replications.
Means in a column followed by the same letter are not significantly different ($\alpha = 0.05$) by LSD.

Insect pests collected on okra are presented in table 5. The result shows that eight species belonging to two insect orders (Coleoptera and Hemiptera) and four families (Chrysomelidae, Pentatomidae, Coccinelidae and Pyrrhocoridae) were found on okra. The most destructive pest of okra seen was the flea beetle *Podagrica uniforma* Jacoby. Mean population density of insect pests across the treatments is shown in table 6. Okra intercropped with maize in the ratio of 1:1 had the lowest insect population ($P< 0.01$) while the sole okra (control) had the highest population ($P < 0.01$). Insect populations did not differ significantly in treatments 2: 1 and 3: 1 (okra-maize ratios). Weekly occurrences of insect pests across the different treatments are presented in Fig. 1. There were significant variations in the weekly occurrences of insects in the 2: 1 intercropping pattern. The weekly occurrences of insect pests on okra across the different treatments increased with advancing time within the first 3 weeks. The same observation was made in weeks 5 to 8 except that minor fluctuations occurred in treatments 2: 1 and 3: 1.

Table 4 Number of fruits produced by okra plants and weight of damaged and undamaged fruits.

Treatment	Number of fruits per plot	Weight of undamaged fruits (g) per plot	Weight of damaged fruits (g) per plot
1 okra:1 maize	20.00 ± 1.55[a]	77.50 ± 1.22[a]	10.30 ± 2.36[a]
2 okra:1 maize	3.00 ± 0.79[b]	42.40 ± 2.53[b]	19.20 ± 2.48[b]
3 okra:1 maize	11.30 ± 2.33[c]	34.70 ± 6.12[b]	13.90 ± 4.86[ab]
Farmers' practice (Random intercrop)	7.00 ± 1.48[c]	29.00 ± 1.72[b]	17.10 ± 6.71[b]
Control plot (sole okra)	8.70 ± 2.60[c]	44.30 ± 4.25[b]	16.00 ± 7.87[b]

Data are means ± standard error of four replications.
Means in a column followed by the same letter(s) are not significantly different ($\alpha = 0.05$) by LSD.

Table 5 Insects collected on okra during rainy season of 2015 in Port Harcourt, Rivers State, Nigeria.

Scientific name	Common name	Family	Order
Podagrica uniforma	Flea beetle	Chrysomelidae	Coleoptera
Aspavia armigera	Grain-sucking bug	Pentatomidae	Hemiptera
Aulacophora africana	Pumpkin beetle	Chrysomelidae	Coleoptera
Cheilomenes sulphurea	Lady bird	Coccinelidae	Coleoptera
Dysdercus volkeri	Cotton stainer	Pyrrhocoridae	Hemiptera
Chrysolina coerulans	Blue mint beetle	Chrysomelidae	Coleoptera
Nisotradilecta spp.	Leaf beetle	Chrysomelidae	Coleoptera
Epilachna similis	Cereal lady bird	Chrysomelidae	Coleoptera

Table 6 Number of different insect pests (per plot) across the different treatment patterns.

Insect pest	1: 1 (1)	2: 1 (1)	3: 1 (1)	Farmers practice (Random intercrop)	Control plot (Sole okra)
Podagrica uniforma	5.00 ± 1.92[a]	8.30 ± 1.14[a]	7.30 ± 1.39[a]	31.70 ± 1.29[b]	43.30 ± 0.10[b]
Aspavia armigera	3.00 ± 0.01[a]	5.70 ± 1.00[a]	9.70 ± 0.70[ab]	13.30 ± 1.50[bc]	19.70 ± 5.50[cd]
Aulacophora africana	6.00 ± 0.54[a]	10.00 ± 2.34[ab]	13.30 ± 0.82[ab]	16.70 ± 1.50[bc]	28.00 ± 0.01[d]
Cheilomenes sulphurea	5.00 ± 1.20[a]	6.70 ± 0.10[ab]	10.00 ± 1.00[ab]	15.00 ± 2.30[bc]	21.00 ± 0.10[cd]
Dysdercus volkeri	6.70 ± 0.50[a]	8.30 ± 1.00[ab]	13.30 ± 1.50[ab]	16.75 ± 1.50[bc]	23.80 ± 3.45[cd]
Chrysolina coerulans	3.30 ± 0.10[a]	7.00 ± 1.50[ab]	9.00 ± 1.80[ab]	14.00 ± 2.66[bc]	16.70 ± 2.50[cd]
Nisotradilecta spp.	8.30 ± 0.10[a]	10.70 ± 2.50[a]	14.70 ± 1.00[a]	16.70 ± 0.50[a]	26.70 ± 0.01[b]
Epilachna similis	8.30 ± 1.20[a]	14.30 ± 2.00[ab]	17.30 ± 1.50[ab]	23.30 ± 8.50[bc]	1.70 ± 4.00[cd]

(1) Intercrop ratios investigated.
Data are means ± standard error of four replications.
Means in a row followed by the same letter(s) are not significantly different ($\alpha = 0.05$) by LSD test.

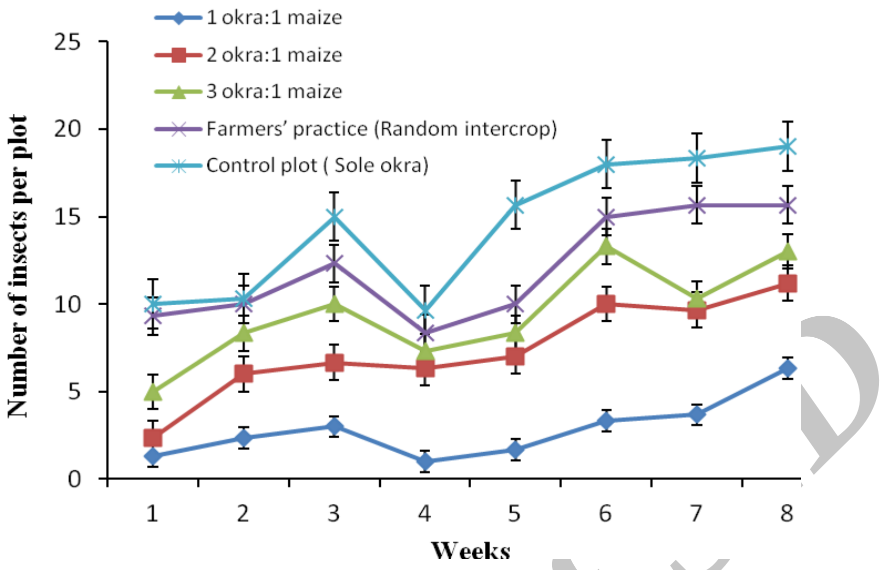

Figure 1 Weekly occurrence of insect pests on okra across the different treatment patterns.

Discussion

In the study, there was no obvious problem with any treatment pattern in terms of number of days to 50% seedling emergence, 50% flowering and 50% fruiting. In other words, spatial arrangement of okra did not pose problem to duration of seedling emergence, plant flowering and fruiting. The significant damage recorded in sole okra compared to okra-maize intercrop patterns suggests that maize has the capacity to reduce pest infestations in okra. This is in agreement with the findings of earlier workers that insect pests prefer to attack monocultures more than mixed crops (Finch and Edmond, 1994; Finch and Collier, 2000). The phenomenon is because insect pests settle on crops only when host factors such as visual stimulus, taste and smell are satisfied and this is more likely in monocultures where the chances of meeting a wrong stimulus is lower (Finch and Collier, 2000). In accordance with the present study Okigbo and Greenland (1992) and Broad (2007) stressed that farmers in Africa practice intercropping for the reasons of better growth, higher yields, insect pest suppression and greater returns than the same crop grown under monoculture conditions. The present study showed that intercropping okra with maize (a compatible crop) increased the barrier against the dispersal of insect pests of okra and this culminated in significantly lower defoliation, lower insect population and higher number of okra fruits in the 1:1 intercrop pattern in particular. This suggests that cultivating equal okra-maize in row spacing is the most suitable agronomic practice in the management of insect pests of okra as well as ensuring higher number of okra fruits in this region. Insect species collected were not only sole pest of okra. The most important pest observed was *P. uniforma*, a notorious defoliator of crops in the family Malvaceae. Earlier, Egwuatu (1992) described this beetle as the most destructive insect pest of okra and that are found in their numbers which commence infestation from germination to maturity (Ahmed *et al*., 2007). Insect pest population density consistently increased with advancing time within the first 3 weeks in all the treatments. This strongly suggests the effect of insect pest response to crop maturity. With advancing age, crops build up canopy and food and this incontrovertibly supports rapid increase in insect population. Conclusively, intercropping okra with maize in the ratio of 1:1 was best at managing the insect pests of okra and at giving higher number of okra fruits. So, random okra-maize intercrop (farmers' practice) should be discouraged.

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کارایی کشت مخلوط ذرت با بامیه در مدیریت حشرات آفت بامیه
آیا الگوی کشت مخلوط بهتری از آن‌چه کشاورزان به‌صورت تصادفی می‌کارند وجود دارد؟

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چکیده: یک آزمایش صحرایی طی فصل بارانی سال ۲۰۱۵ در مزرعه آموزشی – پژوهشی دانشکده کشاورزی دانشگاه پورت هارکوت نیجریه طراحی و کارایی کشت ذرت به‌صورت مخلوط با بامیه بر مدیریت آفات بامیه تعیین شد. در این پژوهش از پنج تیمار ۱:۱ به ۱:۲، ۱:۳ (نسبت بامیه به ذرت)، الگوی کشت رایج کشاورزان (کشت مخلوط به‌صورت تصادفی) و تیمار شاهد (بامیه به‌تنهایی) استفاده شد. آزمایش در قالب طرح بلوک‌های کامل تصادفی با چهار تکرار که در آن هر تیمار در یک کرت قرار داده شده بود انجام شد. در این آزمایش داده‌های مربوط به تعداد روزهای طول کشیده برای ظهور ۵۰ درصد گیاهچه‌ها، ۵۰ درصد گل‌ها و ۵۰ درصد میوه‌ها، تعداد سوراخ‌های روی برگ‌های آسیب دیده، تعداد میوه‌ها، وزن میوه‌های سالم، وزن میوه‌های آسیب دیده و تراکم جمعیت حشرات آفت ثبت شد. در کشت بامیه تنها (بدون کشت ذرت) بیش‌ترین خسارت برگ و بیش‌ترین تعداد حشرات افت را داشت. آفت کک *Podagrica uniforma* (Jacoby) از خانواده Chrycomilidae مهم‌ترین آفت بامیه از لحاظ تراکم جمعیت بود. کشت مخلوط بامیه با ذرت به نسبت ۱:۱ مؤثرترین سامانه کشت مخلوط در مدیریت حشرات آفت بامیه در این پژوهش شناخته شد. نتیجه‌گیری نهایی این که الگوی کشت مخلوط از نوع تصادفی که توسط کشاورزان مورد استفاده قرار می‌گیرد باید تغییر و ارتقاء یابد.

واژگان کلیدی: کشت مخلوط، بامیه، *Abelmoschus esculentus*، ذرت، *Podagrica uniforma*