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Effects of Timing of Okra Introduction in Okra–Ginger Intercropping System on Insect Pests Population and Yield of Okra for Sustainable Agriculture in Uyo, Nigeria

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Abstract

A field experiment was conducted at the University of Uyo teaching and research farm, Uyo, Nigeria, during the 2020 and 2021 cropping season to evaluate the effect of timing of okra introduction in okra-ginger intercrop systems on the management of insect pests and the yield of okra. The experiment was arranged in a 3 x 2 split plot design arrangement of treatments, fitted in a randomized complete block design (RCBD), replicated three times. The timing of okra introduction (4, 6 & 8 weeks after planting ginger (WAP)) and intercropping systems (sole okra and okra-ginger intercrop) constituted the main plot and sub-plot respectively. Data were subjected to Analysis of Variance (ANOVA) and means were separated using LSD. Results of the study showed that generally, intercrop system of okra-ginger performed better than okra sole crop in suppressing insect pests of okra and enhancing okra yield. Furthermore, introducing okra at 4 WAP ginger significantly ($P \leq 0.05$) recorded highest in pest populations and also produced highest yield (30.01 & 36.01 t/ha for 2020 & 2021, respectively). However, introducing okra at 8 WAP ginger into okra-ginger intercrop system significantly ($P \leq 0.05$) recorded lowest in pest populations and also produced the lowest yield (20.27 & 24.33 t/ha for 2020 & 2021, respectively). Introducing okra 4 WAP ginger in okra-ginger intercropping system combined with targeted pest management strategies is recommended to balance yield and pest control on okra effectively.

Keywords: Okra, Ginger, Intercropping, Time of Planting, Insect Pest Management, Sustainable Agriculture.

Introduction

Okra (*Abelmoschus esculentus*), a member of the mallow (Malvaceae) family, is an annual vegetable plant cultivated for its green seed pods, which can be eaten like a vegetable. It is among the most essential vegetable crops grown extensively by farmers in Akwa Ibom state. Ethiopia is the origin of okra, which is commonly grown in warm temperate to tropical climates. With broad, lobed leaves and yellow blooms, the plant reaches a height of 2 to 6 feet. In Akwa Ibom state, Okra is locally referred to as "Etighi" and it holds a central place in the diet and livelihoods of the people of Akwa Ibom State, the popular okra soup known as "Efere Etighi" is often cooked with fresh seafood (such as fish, prawns and periwinkles), beef, or goat meat. The soup is usually spiced with crayfish, pepper, onions and seasoning cubes. It is also enriched with palm oil giving it a vibrant colour and rich taste. Some variations may include the use of waterleaf or fluted pumpkin leaves for added flavour and nutritional value. Okra is also used in other traditional dishes such as Afang and Editan soup due to its mucilaginous texture providing thickening properties. Nutritionally, it provides essential vitamins and minerals, contributing to the health and well-being of consumers. Economically, okra cultivation supports smallholder farmers, with women playing a significant role in its production and trade. Given the Akwa Ibom state's favourable climate and the crop's short maturity period, okra is a reliable income source and a key component of food systems in the region. This cultural, nutritional, and economic importance necessitates the need for sustainable pest management strategies to improve okra yields and enhance livelihoods in Akwa Ibom State.

A survey conducted across six Agricultural Development Programme (ADP) zones in Akwa Ibom State identified a high diversity and abundance of insect species attacking okra in the state, including flea beetle (*Podagrica uniforma* and *P. jostedti*), whitefly (*Bemisia tabaci*), leafhopper (*Amrasca biguttula*), aphid (*Aphis gossypi*), cotton bug (*Dysdercus superstitiosus*), blister beetles (*Mylabris pustulata*), dusky cotton bug (*Oxycarenus hyalinipennis*), fruit borer (*Helicoverpa armigera*), leaf roller (*Sylepta derogata*), , solenopsis mealy bug (*Phenacoccus solenopsis*), red spider mite (*Tetranychus urticae*), and many others, with the two flea beetle species —*Podagrica uniforma* and *P. sjostedti*—causing the majority of harm to okra through significant defoliations in Akwa Ibom State (Rivers *et al*, 2024). Control of these insect pests problem necessitated the reliance on chemical insecticides by farmers which has many disadvantages such as high cost of procurement especially for small holder farmers, resistance build up, harm on non-target organisms, soil and water pollution, human poisoning etc. hence the need for sustainable, low cost, eco-friendly alternative such as intercropping.

Intercropping is the growing of two or more crops close together for a variety of reasons, such as resource optimization, enhanced yield, and pest control making it a sustainable agricultural technique and practice. It is the most popular cropping system in subsistence tropical Agriculture (Obadoni, 2010). Intercropping fields have diversity of vegetation more than monocropping and this has helped reduce insect pests by increasing the diversity and abundance of predators and parasitoids, (Scherber *et al*., 2010). According to Li *et al* (2021), intercropping rosemary with sweet pepper significantly reduced the population densities of three major pest species on sweet pepper, *Frankliniella intonsa*, *Myzus persicae*, and *Bemisia tabaci*, but did not affect the population densities of their natural enemies, the predatory bug, *Orius sauteri*, or parasitoid, *Encarsia formosa*. Population of *Thrips tabaci* was highly supressed in onion field when intercropped with barley (Sekine *et al.*, 2021). Kumar (2021) recorded lowest population of whitefly, jassids and mites in okra + cowpea intercrop compared to sole crop.

Ginger (*Zingiber officinale*) is an herbaceous perennial plant, indigenous to Southeast Asia and belongs to the Zingiberaceae family. It is extensively grown for its edible rhizome, which is utilized as a flavouring, spice, and traditional medicine. The plant has alternating rows of linear leaves placed on its stem, growing to a height of 2–4 feet. The rhizome is brown, with a core that is pale yellow in color and a corky outer layer. Parts of the rhizome are planted to propagate ginger, which grows best in warm, humid climates with well-draining soil. Ginger is an important plant with several medicinal, ethnomedicinal, and nutritional attributes highly recommended for use as carminative, diaphoretic, expectorant, peripheral circulatory stimulant, astringent, appetite stimulant, and diuretic and digestive aid (Ghosh *et al.*, 2011).

Ginger is selected as a component crop due to its well-documented pest-repellent properties, attributed to bioactive compounds such as zingiberene, which has been demonstrated to have an impact on a variety of insect pests, such as those conducted by Asawalam and Chukwu (2012), who reported significant decrease in the population of flea beetles and whiteflies on okra when intercropped with ginger, Muthomi *et al*. (2017), demonstrated the effectiveness of ginger in significantly reducing populations of whiteflies and thrips, resulting in a 50% increase in bean plant (*Phaseolus vulgaris*) production, Siregar *et al* (2024), utilized ginger as a botanical insecticide to manage Army worm (*Spodoptera frugiperda*) pests in maize crops. In addition, the spatial complementarity of ginger as a root crop, with okra as a surface crop, allows for efficient use of soil nutrients and reduces interspecies competition. This biological advantage is particularly important in Akwa Ibom State, where okra cultivation is often challenged by insect pests that diminish yield. The humid tropical climate of the region favours the growth of both okra and ginger, enhancing the practical feasibility of this intercropping system. Moreover, ginger is a high-value crop with expanding market demand, providing economic incentives for farmers while reducing dependency on chemical inputs. Given the socio-economic conditions and environmental challenges faced by farmers in Akwa Ibom, incorporating ginger into okra cultivation forms a sustainable approach to pest management that aligns with state and national agricultural policies promoting integrated pest management (IPM).

There are scanty research works on how varying okra planting timings affect insect pest dynamics and production performance in the agro-ecological settings of Akwa Ibom State, despite the possible advantages of okra-ginger intercropping. The majority of the material currently available on intercropping systems has concentrated on the overall advantages of crop variety, ignoring the precise effect of planting timing on yield optimization and pest control. This study aims to close that gap which is essential to creating sustainable, location-specific pest management plans that smallholder farmers can use. The results will help Nigeria improve its food security, increase crop output, and lessen its reliance on pesticides.

The objective of this study was to determine the effect of different timings of okra introduction in okra-ginger intercropping system on insect pests and yield of okra in Uyo, Akwa Ibom state.

Materials and Methods

The experiment was conducted at the University of Uyo Teaching and research farm, Uyo, Akwa Ibom State, Nigeria (Latitude 5°03'98.45 and 5°2'23.442' North and Longitude 7°9'83.445 and 7°5'904.02 East of the Greenwich Meridian and Altitude 38m above sea level (Edem *et al.,* 2008) during the 2020 and 2021 cropping seasons.

The okra variety 'Clemson spineless' was obtained from seeds unit of Akwa Ibom state Ministry of Agriculture and Ginger variety (UG) was gotten from National Root Crop Research Institute (NRCRI), Umudike, Abia state. The experiment was laid out in a 3x2 split plot design arrangement fitted in a Randomized Complete Block Design (RCBD), replicated three times. The timings of okra introduction which consisted of 4, 6 and 8 weeks after planting ginger were allocated to the main plot while the intercropping system (Sole okra and Ginger with okra) were assigned to the sub- plot. Each plot measured 4m x 4m with 1m furrow spacing marked out within an area measuring 18m x 15m (270m^2). Ginger rhizome was cut into setts and spread on a jute bag, watered and left for 1 week to sprout before taken to the field for planting in early march 2020 and 2021 at the spacing of 30cm x 30cm. Okra was planted in early April (4 weeks after planting ginger), ending of April (6 weeks after planting ginger), and mid-May (8 weeks after planting ginger) at the spacing of 60cm x 30cm in both sole and intercrop. Poultry manure at the rate of 10t/ha was applied to each plot at two weeks after planting okra. Thinning and hoe weeding was done when necessary with no chemical pest control used in the experimental plot during the period of experiment.

Data Collection

Data were collected on the population of Flea beetles, white fly, leaf hopper and cotton bug through direct visual counting with careful observation of the leaves, pods and stem on five (5) randomly selected plants in each plot, two times a week (7.00am - 8.30am) from 3weeks through 12 weeks after planting okra. Aphids population was assessed by visual scoring system from 0 – 5; where 0 – meant no aphid presence, 1 – few individuals, 2 – few isolated small colonies, 3 – several small colonies, 4 – large isolated colonies, 5 – large continuous colonies (Lumberries *et al,* 2011). This was also done with careful observation of the leaves, pods and stem on five (5) randomly selected plants in each plot, two times a week (7.00am - 8.30am) from 3weeks through 12 weeks after planting okra. Extreme care was taken to ensure minimal disturbance during the counting process and number of insects counted were recorded.

Data collected on the yield of Okra was assessed as mean weight of Okra fruits harvested per treatment from five (5) randomly selected plants in each plot from 10weeks – 12weeks after planting okra. A total 6 harvests were made. Weighing balance of 0.01g sensitivity was used to determine the weight of okra.

Data Analysis

Data collected were subjected to Analysis of Variance (ANOVA) using Xlstat 2018, and means were separated using Least Significant Difference (LSD).

Result

Effect of timing of okra introduction in okra-ginger intercropping system on the population of fleabeetles, whiteflies, leafhoopers, aphids and cotton bugs on okra in 2020 and 2021

Table 2 shows the main effect of timing of okra introduction and okra-ginger intercropping system on the population of fleabeetles, whiteflies, leafhoopers, aphids and cotton bugs on okra. There was no significant (P≤0.05) difference in the timing of okra introduction on flea beetles population as evident in year 2020 with values of 107.07, 111.67 and 115.67 for 4, 6, 8 weeks after planting (wap) ginger respectively while year 2021 also had no significant difference (P≤0.05), thus 108.56, 113.41 and 117.26 for 4, 6, and 8 weeks after planting (wap) ginger respectively. 4 wap ginger significantly (P≤0.05) had the lowest population of whitefly with 51.52 in 2020 and 53.96 in 2021, followed by 6 wap ginger with 53.70 in 2020 and 56.15 in 2021, leaving 8 wap ginger with significantly highest population of whitefly with 61.56 in 2020 and 64.07 in 2021. 4 wap ginger also recorded Leaf hopper population value of 14.41 in 2020 and 16.63 in 2021 which was considered as the most effective period in suppressing population growth of Leaf hopper, closely followed by 6 wap ginger with population values of 14.81 and 16.04 in 2020 and 2021 respectively. 8 wap ginger with 18.63 and 18.74 was considered as the highest populated time. There was no significant (P≤0.05) difference in the effect of the time of introduction of okra on the population of cotton bug. There was a positive influence of intercropping system significantly (P≤0.05) on the population density of flea beetles. Flea beetles population on sole okra was 287.85 and 289.00 in 2020 and 2021 respectively while flea beetles population on intercrop was 46.56 and 50.22 in 2020 and 2021 respectively. Whitefly population was significantly suppressed to 26.33 and 28.37 for intercrop compared to sole okra with population value of 140.44 and 145.81 in both years respectively. Population value of leaf hopper reduced to 4.30 and 3.30 compared to sole okra with value of 43.56 and 48.11 for the two years respectively. Okra-ginger intercrop was highly significant (P≤0.05) in controlling Aphids population (2.67 and 3.89 for 2020 and 2021 respectively) while sole okra recorded 20.96 and 18.78 for 2020 and 2021 respectively. Cotton bug population was not left out in the reduced effect of intercrop system (9.44 and 10.63 in 2020 and 2021 respectively) compared to sole okra population of cotton bug (31.00 and 36.97 in 2020 and 2021 respectively).

Table 3 shows result for interaction effect of timing of okra introduction and okra-ginger intercropping system on the population of insect pests. Significant interactions (P≤0.05) were recorded between times of okra introduction and intercrop system for flea beetles, whitefly, leaf hopper, aphids and cotton bug populations. In comparison, the population of the five insect pests were significantly (P≤0.05) lower in the interaction between okra-ginger intercrop and time of introduction than the interaction between sole okra and time

of introduction. Among the time of okra introduction in the interaction with okra-ginger intercrop, 8 wap ginger recorded the least population of fleabeetle (25.11 & 27.78), whitefly (15.67 & 18.33), leaf hopper (4.89 & 1.00), aphids (2.33 & 2.66) and cotton bug (8.33 & 6.89) in the years 2020 & 2021 respectively.
Generally, among the five insect pests studied, flea beetles recorded the highest population of insect pest attacking okra, followed by whitefly, leaf hopper, cotton bug and the least population was Aphids.

Effect of timing of okra introduction in okra-ginger intercropping on the yield of okra
The main effect of timing of okra introduction in okra-ginger intercropping on the yield of okra is presented in table 4. There was significant difference (P≤0.05) in the time of okra introduction on yield of okra, 4 wap ginger recorded highest yield (15.67 t/ha and 18.80 t/ha in the year 2020 and 2021 respectively), followed by 6 wap ginger, leaving 8 wap ginger with the least yield of 10.96 t/ha and 13.16 t/ha in both years respectively. Intercrop system recorded better yield (24.91 t/ha & 29.90 t/ha) than sole crop (14.59 t/ha & 17.51 t/ha) in the year 2020 & 2021 respectively.
Significant interactions (P≤0.05) were recorded between time of okra introduction and intercropping systems on okra yield (table 5). It was also observed that generally, all the interactions between intercrop x times of introduction produced better yield than interactions between sole crop x times of okra introduction, hence highest okra yield (30.01t/ha & 36.01t/ha in 2020 & 2021 respectively) was produced significantly (P≤0.05) from interaction between intercrop x 4 wap ginger. Okra yield significantly (P≤0.05) declined as time of okra introduction increased, lowest okra yield (12.62 t/ha & 15.15 t/ha in 2020 & 2021 respectively) was recorded in the interaction between sole okra x 8 wap ginger.

Table 1: Rainfall information for Uyo, Nigeria (January – December), 2020 and 2023

Year	Monthly Rainfall accumulation (mm)											
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Ave.
2020	0.00	0.00	80.71	104.33	185.00	211.02	353.11	53.30	265.22	171.00	89.33	3.50	126.38
2021	10.20	7.10	65.82	72.22	163.91	157.21	197.76	300.11	265.32	234.51	195.23	0.00	139.12

Source: Nigerian Meteorological Society (NIMET)

Table 2: Main effect of timing of okra introduction and okra-ginger intercropping system on the population of fleabeetles, whiteflies, leafhoopers, aphids and cotton bugs on okra in 2020 and 2021

Treatment	Fleabeetles (2020)	Fleabeetles (2021)	Whitefly (2020)	Whitefly (2021)	Leaf hooper (2020)	Leaf hooper (2021)	Aphids (2020)	Aphids (2021)	Cotton bug (2020)	Cotton bug (2021)
Okra introduction time										
4 wap ginger	107.07	108.65	51.52	53.96	14.41	16.63	7.00	8.15	14.15	17.59
6 wap ginger	111.67	113.41	53.07	56.15	14.81	16.04	7.52	7.33	12.26	14.96
8 wap ginger	115.67	117.26	61.56	64.70	18.63	18.74	9.11	7.19	14.01	15.04
LSD (P≤0.05)	NS	NS	7.90	6.75	5.30	4.56	1.65	2.80	NS	NS
Cropping system										
Sole okra	287.85	289.00	140.44	145.81	43.56	48.11	20.96	18.87	31.00	36.96
Okra-ginger intercrop	46.56	50.22	26.33	28.37	4.30	3.30	2.67	3.89	9.44	10.63
LSD (P≤0.05)	19.49	18.87	7.90	6.75	5.30	4.56	1.65	2.80	2.60	2.64

- wap = weeks after planting

Table 3: Interaction effect of timing of okra introduction and okra-ginger intercropping system on the population of fleabeetles, whiteflies, leafhoopers, aphids and cotton bugs on okra in 2020 and 2021

Treatment	Fleabeetles (2020)	Fleabeetles (2021)	Whitefly (2020)	Whitefly (2021)	Leaf hooper (2020)	Leaf hooper (2021)	Aphids (2020)	Aphids (2021)	Cotton bug (2020)	Cotton bug (2021)
Sole okra x 4 wap ginger	257.78	258.00	115.00	120.44	38.44	43.78	18.11	19.56	31.78	38.56
Sole okra x 6 wap ginger	283.89	285.00	137.00	143.11	41.22	45.33	19.78	17.89	27.44	34.11
Sole okra x 8 wap ginger	321.89	324.00	169.00	173.89	51.00	55.22	25.00	18.89	33.78	38.22
Okra-ginger intercrop x 4 wap ginger	63.44	67.67	39.56	41.44	4.78	6.11	2.89	4.89	10.67	14.22
Okra-ginger intercrop x 6 wap ginger	51.11	55.22	23.78	25.33	3.22	2.78	2.78	4.11	9.33	10.78
Okra-ginger intercrop x 8 wap ginger	25.11	27.78	15.67	18.33	2.89	1.00	2.33	2.66	8.33	6.89
LSD (P≤0.05)	33.75	32.68	13.68	11.70	9.19	7.90	2.86	4.84	4.51	4.58

- wap = weeks after planting

Table 4: Main effect of timing of okra introduction and okra-ginger intercropping on the yield of okra in 2020 and 2021

Treatment	Yield (t/ha) 2020	Yield (t/ha) 2021	
Time of okra Introduction			
4 wap ginger	15.67	18.80	
6 wap ginger	12.87	15.45	
8 wap ginger	10.96	13.16	
LSD (P≤0.05)	2.48	2.99	
Cropping system			
Sole okra	14.59	17.51	
Okra-ginger intercrop	24.91	29.90	
LSD(P≤0.05)	2.48	2.99	

- wap = weeks after planting

Table 5: Interaction effect of timing of okra introduction and okra-ginger intercropping on the yield of okra in 2020 and 2021

Treatment	Yield (t/ha) 2020	Yield (t/ha) 2021
sole okra x 4 wap ginger	16.99	20.39
Sole okra x 6 wap ginger	14.16	16.99
Sole okra x 8 wap ginger	12.62	15.15
Okra-ginger intercrop x 4 wap ginger	30.01	36.01
Okra-ginger intercrop x 6 wap ginger	24.46	29.35
Okra-ginger intercrop x 8 wap ginger	20.27	24.33
LSD(P≤0.05)	4.30	5.16

Discussion

The observed progressive increase in the population of insect pests (flea beetles, whiteflies, leafhopper, aphids and cotton bug) on okra as time of okra introduction progressed in the main effect result (table 2) could be attributed to the progressive increase in the amount of rainfall during the period (table 1), causing increased relative humidity and availability of food resources that favour insect multiplication. This agrees with the work of Dada *et al* (2022), who reported of increased population of insect pests (*Monolepta thomsoni*, *Nisotra sjostedti* and *Dysdercus volkeri)* on Roselle (*Hibiscus sabdariffa*) with increasing rainfall and relative humidity as weeks after planting increased. The significant (P≤0.05) reduction of the pests' population in the intercrop system of okra-ginger compared to sole okra in both years for all the insect pests (Table 2), could be attributed to the advantage of intercropping such as biodiversity which helps to limit outbreak of insect pests. This agrees with the findings of Rakotomalala *et al* (2023), who reported of reduced arthropods population in intercrop field compared to sole crop through biodiversity effect, promotion of beneficial arthropods and their services etc. Asawalam and Chukwu (2012), had similar view when reporting that intercropping okra and ginger was more effective in supressing the population of flea beetles and whiteflies on okra compared to sole okra. The interaction effect (table2), showed that the interaction significantly (P≤0.05) affected the population of all the insect pests in both years, in a consistent pattern. The interaction of sole okra x time of introduction revealed that 'the higher the time of introduction, the higher the

population' i.e 8 wap ginger had the highest population of insect pests while 4wap ginger had the least pests' population, this pattern was observed for all the insect pests studied, this could be due to population build up over the season, probably due to increasing favourable conditions of temperatures, rainfall and availability of food resources that favour insect multiplication in time, in line with Abudulai *et al*, (2017). For the interaction of okra-ginger intercrop x time of introduction, the reverse was the pattern 'the higher the time of introduction, the lower the population'. i.e 4 wap ginger had the highest pests' population while 8 wap gingers had the least population of pests and this was also observed for all the insect pests studied. This is attributed to the fact that as the time of introduction of okra increased the maturity of ginger crop component increases hence its insecticidal properties became more effective in supressing the pests' population growth. This agrees with work of Asawalam and Chukwu (2012), which planted okra 4 wap ginger and recorded significant ($P \leq 0.05$) population reduction in Flea beetles and whiteflies o okra.
The main and interaction effect on yield showed that 4wap ginger gave best yield in both years and gradually declined with delay in time of introduction evidenced in the yield obtained at 8 wap ginger. This could be attributed to the fact that planting okra 4 WAP ginger allows ginger to establish first, reducing direct competition for nutrients, water, and light. This timing promotes better growth for both crops, enhancing overall yield due to better use of space and resources. This is consistent with Ahmed *et al.* (2024), who reported that early planting of Roselle plant resulted in higher yield due to more favourable soil moisture and temperature conditions. Salau *et al* (2021) reported that early introduction of okra into cassava recorded better yield compared to 2 wap cassava.

Conclusion and Recommendations

The present study evaluated the effect of timing of okra introduction in okra-ginger intercropping system on insect pests' population and yield of okra for sustainable agriculture in Uyo, Akwa Ibom State. From the results obtained, generally, intercropping okra with ginger performs better in management of okra insect pests and enhanced okra yield than sole okra. Furthermore, introducing okra at 4 wap ginger into okra-ginger intercropping system recorded highest in pest populations due to crop tenderness making it more attractive to pests at this stage and the allelopathy pest deterrent effect of ginger component is also low at this stage. However, the early introduction of okra at 4 wap ginger also allows both crops to utilize light, nutrients and water more efficiently resulting in the highest yield. On the other hand, introducing okra at 8 wap ginger reduces pest populations because at this stage, the ginger plants are more established and better at its allelopathy pest deterrent effect. However, this comes at the cost of reduced yields, as the late introduction of okra limits its growth and contribution to the system.
Based on this conclusion, the following recommendations are made for farmers;

i. If the aim is to prioritize yield, introducing okra 4 wap ginger in okra-ginger intercrop system alongside the implementation of Integrated Pest Management

(IPM) strategies such as introduction of natural predators (ladybugs, parasitic wasp etc), regular weeding and maintenance of crop hygiene with pest monitoring, use of botanical pesticides is recommended.

ii. If the main concern and aim is to minimize pest pressure, introducing okra 8 wap ginger in okra-ginger intercrop system alongside proper fertilization and irrigation is recommended.

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