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Research Article

Influence of Variety and NPK Fertilization on Insect Pest Infestation on Cucumber (*Cucumis Sativus* L.)

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Abstract

Background and Objective: Cucumber (*Cucumis sativus* L.) is a widely cultivated vegetable, but insect pest infestations often reduce its yield and quality. The susceptibility of cucumber to pests varies with variety and agronomic practices, including NPK fertilization, which influences plant vigor and resistance. This study aims to assess the impact of variety and NPK fertilization on insect pest incidence, identifying the best combination for minimizing pest damage and improving productivity. **Materials and Methods:** The study was conducted using a factorial experiment arranged in a Randomized Complete Block Design (RCBD) with cucumber varieties and NPK fertilization levels as the main factors. The experiment included selected cucumber varieties grown under different NPK fertilizer treatments, with each treatment replicated across multiple plots. Data on insect pest infestation were recorded at regular intervals, assessing pest incidence and severity. Standard entomological techniques were used for pest identification and population estimation. The effects of variety and fertilization on pest infestation were analyzed using appropriate statistical methods, including One-way Analysis of Variance (ANOVA), followed by mean separation tests to determine significant differences among treatments with a 0.05 significance level. **Results:** The number of leaves produced was significantly affected by variety and jointly by the two factors in the late season, whereas no effect was recorded in the early season. The NPK fertilizer rate significantly positively correlated with numbers of *A. foveicollis*, *A. africana* and *A. hilaris* and leaf and fruit damage, while fruit yield was significantly negatively correlated with leaf and fruit damage. Although there were significant increases in the number of leaves and fruits produced with an increase in NPK fertilization, leaf and fruit damage in the NPK fertilizer-treated plots did not differ significantly from the control. **Conclusion:** The NPK fertilization not only improved cucumber growth and yield parameters, it also encouraged *Aulacophora* genus infestations and leaf and fruit damage. It is therefore recommended that NPK fertilization from 50 kg/ha is sufficient but must be accompanied by adequate insect pest control measures when designing an IPM management.

Key words: NPK fertilizer, NPK 15-15-15, insect pests of cucumber, *Cucumis sativus*, *Epilachna chrysomelina*, *Aulacophora africana*

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Cucumber (*Cucumis sativus* L.) (Cucurbitaceae) is one of the most important cucurbitaceous vegetables grown in Nigeria. It is eaten raw, in salads, or sliced into a stew. It is a rich source of vitamins A, C, K, B_6, potassium, pantothenic acid, magnesium, phosphorus, copper and manganese[1]. Cucumber juice is frequently suggested as a source of silicon to enhance the health and complexion of the skin[2] and the ascorbic and caffeic acids it contains assist to lessen skin irritation and swelling[3].

Its production is, however, limited by various insect pests that attack the crop at different growth stages from seedling to fruiting, resulting in damage to leaves, roots, flowers and fruits[4]. The major insect pests include cucumber beetles (*Aulacophora indica* (Gmelin), melon lady beetle (*Epilachna chrysomelina*), squash beetle, red pumpkin beetle (*Aulacophora foveicollis*)[4]. These insect pests cause defoliations on the leaves, abortion on the flowers and damage to the fruits, thereby causing a reduction in the market value of the cucumber fruits. Apart from insect pest infestation problems, declining soil fertility and nutrient availability due to continuous cropping have also significantly contributed to the reduction in the yield of cucumber[5]. However, incorporating NPK fertilizer helps in creating and maintaining the optimum soil physical conditions for plant vegetative growth and obtainable yield[6]. Adequate fertilizer application rate therefore improves the yield of cucumber[7,8]. However, fertilizers do not only improve crop yield but also influence crop suitability for insect development[9,10], as well as may facilitate plant tolerance against insect pest attacks. The recommended rate of NPK fertilizer is between 100-200 kg/ha for optimal cucumber production, although this is dependent on the soil type[11]. While optimizing fertilizer application is very important, it is vital to investigate the impact of fertilizer rate on the pest population and the damage caused by these insects. This information is useful in developing the integrated pest management of these insect pests. This research therefore focused on investigating the impact of fertilizer rate on the population of insect pests on cucumber.

MATERIALS AND METHODS

Experimental site: The study was carried out during the early cropping season (June-August), 2018 and late cropping season (August-October), 2018 at the Teaching and Research Farm of the Federal University of Agriculture, Abeokuta, Nigeria (7°14'N, 3°26'E, 168 m above the sea level). The study area was characterized by distinct wet and dry seasons with bimodal rainfall patterns and mean annual air of about 30°C.

Experimental layout: The experiment was laid out in a split-plot design fitted into a randomized complete block design with three replicates. The main plots were the three varieties used, while the 11 by 19 m consisted of three varieties, while the sub-plots were the fertilizer rates used. Each sub-plot was 3 by 3 m (9 m^2) and consisted of NPK. The total experimental area was 37 by 19 m (703 m^2). A 1 m border was maintained between each plot and a 2 m border between each replicate to avoid fertilizer interference. A representative soil sample was taken at a depth of 5 cm from each plot in the experimental field before and after fertilizer application. The lumps in the soil samples were broken up, stones and plant debris were removed and the samples were thoroughly mixed and air-dried on a clean piece of paper and later placed in a labeled container. The collected samples were then taken for soil analysis. Three cucumber seeds were planted at a spacing of 0.75 by 0.50 m and were later thinned to two seedlings per hole two weeks after planting (2 WAP). Manual weeding was carried out ten days after planting (10 DAP) and subsequently once every two weeks. There was no herbicide application throughout the experiment. The NPK 15-15-15 fertilizer (granulated) was applied to each cucumber plant at the rates of 0 kg/ha (control), 50, 100, 200 and 400 kg/ha at three weeks after planting using side placement method.

Insect count and data collection: Insects were counted separately on ten randomly selected tagged plants per plot per replicate every week between the hours of 7:30-9:00 am when insects were relatively inactive. Insect count commenced at 3 WAP. The insects collected using a sweep net were preserved with 70% ethanol in a glass jar and mounted in an insect identification box. These were labeled after identification was done at the Museum of the Department of Crop Protection and Environmental Biology, University of Ibadan, Nigeria. Agronomic data viz., number of leaves, number of flowers, number of fruits and leaf area (cm^2, using the graphical method, on the ten randomly selected plants of cucumber from the middle row of each plot. Fruits were picked from each plot at 7 WAP and repeated every 4 days. The undamaged and damaged fruits were counted from each plot and the percentage of fruit damage was calculated. A fruit is considered damaged if it has been characterized by grooves and turns to a brownish color. Marketable fruit yield was taken from each plot separately.

Statistical analysis: All data collected were subjected to One-way Analysis of Variance (ANOVA) at 5% probability. Data on the number of insect pests was transformed using square root ($\sqrt{(X+0.5)}$) before ANOVA and data on percentages were transformed using the logarithm transformation method. Where there were significant differences in the mean values, Least Significant Differences (LSD) were used to separate them at a 5% level of probability.

RESULTS

Physical and chemical properties of the soil of the study area: The soil was described as sandy-clay due to its very high particle size of sand and clay with some deficiency in nitrogen, potassium and phosphorus (Table 1). The soil sample is acidic (pH 5.75) and predominantly sandy (90.80%), with low silt (4.40%) and clay (4.80%) content. The exchangeable base concentrations are relatively low, with calcium (3.10 cmol/kg) being the highest, followed by magnesium (0.67 cmol/kg), potassium (0.02 cmol/kg) and acidity (0.09 cmol/kg). The effective cation exchange capacity (ECEC) is 3.95 cmol/kg and the base saturation is 3.93%. The total available nutrients indicate low nitrogen (0.07%), phosphorus (3.22 mg/kg) and organic carbon (0.55%). Micronutrient levels include iron (1.70 mg/kg), zinc (0.79 mg/kg), copper (0.50 mg/kg) and manganese (3.70 mg/kg).

Insect pests observed on cucumber: Six coleopteran insect pest species were identified. They include *Aulacophora hilaris, Aulacophora foveicollis*, *Aulacophora indica*, *Aulacophora africana*, *Aulacophora nigripennis* in the Family Chrysomelidae and *Epilachna chrysomelina* in the Family Coccinellidae. Their common names are banded pumpkin beetle, red pumpkin beetle, cucurbit beetle, red melon beetle, leaf beetle and melon lady beetle, respectively. The larval and adult stages are the damage-causing stages where leaves and flowers are attacked, except *Epilachna chrysomelina*, which attacks leaves and fruit.

Population densities of some cucumber insect pests about NPK fertilizer application in early and late seasons in 2018: In both seasons, there was no significant interaction between varieties and fertilizer rate on the population of each of the insect pests identified. The application of NPK fertilizer did not significantly ($p<0.05$) influence the population densities of *Epilachna chrysomelina*, *Aulacophora indica* and *Aulacophora nigripennis* (Table 2).

The infestation of *Epilachna chrysomelina*, *Aulacophora indica*, and *Aulacophora nigripennis* varied across cucumber varieties and NPK fertilizer levels in both early and late seasons. In the early season, *Epilachna chrysomelina* showed the highest mean infestation (1.20) at 400 kg/ha NPK, while *Aulacophora indica* and *Aulacophora nigripennis* had lower infestations, with means of 0.94 and 0.82, respectively. In the late season, infestation levels generally increased, with *Aulacophora nigripennis* recording the highest mean infestation (2.29) at 50 kg/ha NPK. However, statistical analysis showed that variety (V), fertilizer (F), and their interaction (V*F) had no significant effects on pest infestation levels ($p>0.05$), indicating that neither fertilizer application nor variety influenced pest abundance significantly.

The numbers of *Aulacophora hilaris, Aulacophora foveicollis* and *Aulacophora africana* were significantly influenced by the application of NPK fertilizer (Table 3). For instance, the highest number of *Aulacophora hilaris* was obtained at 100 kg/ha (1.11) while the lowest was at 200 kg/ha (0.46). For *Aulacophora foveicollis* the highest density was at 200 kg/ha (0.97) and the lowest was at 50 kg/ha (0.50) but was not different from 0 kg/ha (0.11). Similarly, the highest number of *Aulacophora africana* was in 100 kg/ha plots (0.42) and was significantly different from other fertilizer rates.

Table 1: Physico-chemical properties of the soil used for the experiment during early and late 2018 cropping season

C	Value
pH	5.75
Particles size	
Sand (%)	90.80
Silt (%)	4.40
Clay (%)	4.80
Exchangeable bases (cmol/kg)	
Ca	3.10
Mg	0.67
K	0.02
Acidity	0.09
EC	3.95
Base (Sat)	3.93
Total available (mg/kg)	
N (%)	0.07
P	3.22
Organic carbon	0.55
Fe	1.70
Zn	0.79
Cu	0.50
Mn	3.70

Ca: Calcium, Mg: Magnesium, K: Potassium, EC: Electrical conductivity, N (%): Nitrogen (percentage), P: Phosphorus, Fe: Iron, Zn: Zinc, Cu: Copper and Mn: Manganese

Table 2: Population densities of *Epilachna chrysomelina, Aulacophora indica and Aulacophora nigripennis* on three cucumber varieties under varying NPK rates in early and late 2018

		NPK (kg/ha)					
Insect pest species	Variety	0	50	100	200	400	Mean
Early season							
Epilachna chrysomelina	Marketer	0.94	0.33	0.21	0.28	0.94	0.44
	Marketmore	0.81	0.47	0.80	0.94	1.38	0.88
	Poinsett	1.41	1.33	1.14	0.67	1.28	1.17
	Mean	1.05	0.71	0.65	0.54	1.20	
	$LSD_{0.05}$	V = 0.62 (ns), f = 0.63 (ns), V*F = 1.09 (ns)					
Aulacophora indica	Marketer	0.33	0.67	0.24	1.47	1.00	0.69
	Marketmore	0.00	0.47	0.33	0.67	0.33	0.36
	Poinsett	0.33	1.14	0.33	0.67	0.67	0.63
	Mean	0.22	0.76	0.22	0.94	0.67	
	$LSD_{0.05}$	V = 0.86 (ns), f = 0.59 (ns), V*F = 1.01 (ns)					
Aulacophora nigripennis	Marketer	0.33	0.33	0.33	0.91	0.33	0.45
	Marketmore	0.23	0.23	0.47	0.80	0.67	0.39
	Poinsett	0.91	1.28	1.14	0.75	0.67	0.95
	Mean	0.41	0.54	0.65	0.82	0.56	
	$LSD_{0.05}$	V = 0.97(ns), f= 0.54(ns) , V*F = 0.59 (ns)					
Late season							
Epilachna chrysomelina	Marketer	1.22	1.28	1.69	0.94	1.28	1.28
	Marketmore	1.29	1.46	1.00	0.80	1.08	1.13
	Poinsett	1.79	1.62	1.22	1.14	1.28	1.41
	Mean	1.43	1.45	1.30	0.96	1.21	
	$LSD_{0.05}$	V = 1.06 (ns), f = 1.04 (ns), V*F = 1.80 (ns)					
Aulacophora indica	Marketer	0.67	1.52	1.00	0.91	0.67	0.95
	Marketmore	1.28	1.14	1.14	1.24	0.33	1.03
	Poinsett	0.80	0.91	1.05	1.41	1.08	1.05
	Mean	0.92	1.19	1.06	1.19	0.69	
	$LSD_{0.05}$	V = 0.99 (ns), f = 0.99 (ns), V*F = 1.72 (ns)					
Aulacophora nigripennis	Marketer	2.30	1.99	2.38	1.97	1.87	2.10
	Marketmore	2.16	2.70	2.32	1.82	1.63	2.13
	Poinsett	1.72	2.17	1.87	1.52	2.08	1.87
	Mean	2.06	2.29	2.19	1.77	1.86	
	$LSD_{0.05}$	V = 1.31 (ns), f = 1.58 (ns), V*F = 2.73 (ns)					

LSD values are the following comparisons, V: Variety differences, F: Fertilizer rates, V*F: Combination of variety and fertilizer rates, ns: Not significant and *Significant at p<0.05

Insect-induced leaf and fruit damage and cucumber fruit yield (kg/ha) on three varieties of cucumber grown with NPK fertilizer at different rates in the early and late 2018 seasons: In both seasons, there was no significant interaction between varieties and fertilizer rate on the percentage leaf damage, significant interaction effect of varieties and fertilizer rate on percentage fruit damage was observed in the early season while fruit yield per plant was not significantly influenced by NPK rate or cucumber variety, but was influenced jointly by the interaction of the two factors in the early season (Table 4). Leaf and fruit damage varied across cucumber varieties and NPK levels, with significant fertilizer effects ($p<0.05$) but no significant variety or interaction effects ($p>0.05$). In the early season, leaf damage ranged from 43.75 to 69.21%, while in the late season, it was slightly higher (37.71 to 67.49%). Fruit damage followed a similar trend, with higher mean damage observed in the early season (19.41-21.67%) than in the late season (23.87-30.94%). Fruit yield was higher in the late season, with Marketmore (130.08 kg/ha) producing the highest yield. Although variety had a significant effect on late-season yield ($p<0.05$), fertilizer and interaction effects remained non-significant.

The percentage leaf damage in early season was significantly influenced singly by NPK rate with the highest leaf damage ($p<0.05$) recorded at 100 kg/ha relative to other fertilizer-treated plots, while the control recorded the lowest leaf damage. Similarly, in the late season, NPK rate only had a significant effect ($p<0.05$) on percentage leaf damage in all the fertilizer-treated plots, comparable.

The fruit damage on the Poinsett and Marketer varieties was significantly higher at 400 kg/ha fertilizer application rate when compared to other fertilizer levels, however, the variety Marketmore had the highest damage at 200 kg/ha fertilizer application rate. In the late season, however, NPK rate, variety as well as their interaction had no significant impact on fruit damage. The highest yield was produced by Marketmore

Table 3: Population densities of *Aulacophora* species on three cucumber varieties under varying NPK rates in early and late 2018

Insect pest species	Variety	NPK (kg/ha) 0	50	100	200	400	Mean
Early season							
Aulacophora hilaris	Marketer	0.94	0.94	0.94	0.33	0.47	0.72
	Marketmore	1.05	0.80	1.24	0.58	0.47	0.83
	Poinsett	0.80	0.94	1.15	0.47	0.58	0.79
	Mean	0.93	0.89	1.11	0.46	0.51	
	$LSD_{0.05}$	V = 0.22 (ns), f = 0.44*, V*F = 0.75 (ns)					
Aulacophora foveicollis	Marketer	0.23	0.50	0.67	0.58	0.94	0.44
	Marketmore	0.19	0.33	0.33	1.52	0.12	0.37
	Poinsett	0.33	0.32	0.33	0.81	0.33	0.36
	Mean	0.11	0.11	0.33	0.97	0.42	
	$LSD_{0.05}$	V = 0.43 (ns), f = 0.47* , V*F = 0.80 (ns)					
Aulacophora Africana	Marketer	0.21	0.23	0.15	0.15	0.12	0.17
	Marketmore	0.47	0.30	0.47	0.47	0.13	0.19
	Poinsett	0.33	0.22	0.80	0.33	0.11	0.36
	Mean	0.27	0.11	0.42	0.27	0.12	
	$LSD_{0.05}$	V = 0.41 (ns), f= 0.34* , V*F = 0.59 (ns)					
Late season							
Aulacophora hilaris	Marketer	0.18	0.47	0.39	0.47	0.47	0.31
	Marketmore	0.15	0.20	0.40	0.33	0.20	0.25
	Poinsett	0.33	0.47	0.47	0.33	0.47	0.41
	Mean	0.22	0.38	0.42	0.38	0.27	
	$LSD_{0.05}$	V = 0.71 (ns), f = 0.64*, V*F = 1.12 (ns)					
Aulacophora foveicollis	Marketer	0.27	0.30	0.67	0.58	0.94	0.55
	Marketmore	0.11	0.33	0.72	1.52	0.23	0.58
	Poinsett	0.33	0.42	0.33	0.80	0.33	0.44
	Mean	0.24	0.35	0.57	0.97	0.64	
	$LSD_{0.05}$	V = 0.60 (ns), f = 0.46*, V*F = 0.79 (ns)					
Aulacophora Africana	Marketer	0.33	0.33	0.33	0.91	0.33	0.45
	Marketmore	0.12	0.30	0.47	0.80	0.67	0.39
	Poinsett	0.91	1.28	1.14	0.75	0.67	0.95
	Mean	0.41	0.54	0.65	0.82	0.56	
	$LSD_{0.05}$	V=0.97 (ns), f= 0.64 *,V*F = 1.10 (ns)					

LSD values are the following comparisons, V: Variety differences, F: Fertilizer rates, V*F: Combination of variety and fertilizer rates, ns: Not significant and *Significant at p<0.05

variety at 100 kg/ha. However, in the late season, only variety had a significant influence on cucumber fruit yield with significantly higher fruit yield produced by Marketmore when compared to Poinsett and Marketer.

Association between NPK fertilizer application rate and *Aulacophora* spp based on intensity of damage caused by the species: In both seasons, the densities of *A. foveicollis, A. indica* and *A. hilaris* were strongly positively associated with NPK fertilizer application rates. As the fertilizer rate increased, the population densities of the three species of *Aulacophora* increased (Table 5). Similarly, in both seasons, leaf damage had a strong positive relationship with fertilizer application rate (0.83 and 0.77*) at the early and late seasons, respectively. As the fertilizer rate increased, leaf damage also increased. On the other hand, fruit damage, in both seasons, had a non-significant relationship with NPK fertilizer rate. In addition, leaf damage was significantly positively correlated with fruit yield in both seasons (Table 6). The correlation between insect-induced leaf damage and cucumber fruit yield was significant in both seasons, with a stronger negative association in the early season ($R = -0.80$, $p<0.05$) compared to the late season ($R = -0.54$, $p<0.05$). This indicates that increased leaf damage due to insect pests led to a greater reduction in fruit yield, particularly during the early season.

DISCUSSION

Results of this study showed that there was the abundance of *Aulacophora foveicollis*, *Aulacophora indica*, *Aulacophora hilaris*, *Aulacophora nigripennis*, *Aulacophora africana* and *Epilachna chrysomelina* which were the major insect pests of cucumber in the study area. Although Pitan[4] did not report *Aulacophora* spp., in the list of insect pests of cucumber in Southwestern Nigeria, *Aulacophora* appear to be a very important pest species in the study area. This pest damages he fruit by causing grooves n the fruit, thereby

Table 4: Leaf and fruit damage (%) and fruit yield (kg/ha) of three cucumber varieties under varying NPK application rates in early and late 2018 cropping seasons

			NPK (kg/ha)					
Characteristics	Season	Variety	0	50	100	200	400	Mean
Leaf damage (%)	Early	Marketer	48.15	61.44	74.11	62.01	67.86	56.96
		Marketmore	47.75	66.15	66.59	55.36	53.7	61.09
		Poinsett	35.36	64.45	66.92	58.15	55.3	58.41
		Mean	43.75	64.01	69.21	58.51	58.95	
		$LSD_{0.05}$	V = 10.32 (ns), f = 7.48 *,V*F = 12.95 (ns)					
	Late	Marketer	40.45	55.91	59.79	64.87	63.8	56.96
		Marketmore	33.17	62.36	65.69	67.84	76.39	61.09
		Poinsett	39.52	57.91	64.83	67.5	62.29	58.41
		Mean	37.71	58.73	63.44	66.74	67.49	
		$LSD_{0.05}$	V = 5.4 (ns), f= 8.34*, V*F= 14.45 (ns)					
Fruit damage (%)	Early	Marketer	34.43	30.73	34.62	32.78	36.56	56.37
		Marketmore	32.45	32.38	29.54	34.44	29.9	52.90
		Poinsett	30.16	34.52	31.11	38.33	41.85	58.66
		Mean	19.41	19.53	19.05	21.11	21.67	
		$LSD_{0.05}$	V = 11.16 (ns) f = 12.59 (ns) V*F = 21.8* (ns)					
	Late	Marketer	36.11	31.9	31.62	41.34	25.22	55.39
		Marketmore	20.63	20.64	14.43	19.73	19.76	31.73
		Poinsett	22.62	21.57	25.55	31.74	27.14	42.87
		Mean	26.45	24.70	23.87	30.94	24.04	
		$LSD_{0.05}$	V = 10.97 (ns) f = 6.94 (ns) V*F = 12.02 (ns)					
Fruit yield (kg/ha)	Early	Marketer	63.89	47.22	35	31.67	53.18	76.99
		Marketmore	65.56	58.33	61.11	44.44	46.67	92.04
		Poinsett	38.89	44.44	38.89	63.89	61.11	82.41
		Mean	27.00	29.99	33.67	28.00	32.19	
		$LSD_{0.05}$	V = 11.16 (ns) F= 12.59 (ns) V*F = 21.8* (ns)					
	Late	Marketer	68.06	68.1	68.63	58.66	60.21	107.89
		Marketmore	79.37	64.79	85.57	80.27	80.23	130.08
		Poinsett	77.38	78.43	74.45	68.26	72.86	123.79
		Mean	41.44	42.26	45.73	44.96	42.66	
		$LSD_{0.05}$	V = 8.25 * F = 10.25 (ns) V*F = 17.75 (ns)					

LSD values are the following comparisons. V: Variety differences, F: Fertilizer rates, V*F: Combination of variety and fertilizer rates, ns: Not significant and *Significant at p<0.05

Table 5: Correlation coefficient between NPK application rate and *Aulacophora* spp., density and damage in the early and late 2018 cropping seasons

Insect parameter	Early season	Late season
Aulacophora foveicollis	0.90*	0.97*
Aulacophora indica	0.89*	0.98*
Aulacophora hilaris	0.92*	0.97*
Leaf damage	0.83*	0.77*
Fruit damage	0.21	-0.45

*Significant at 5% levels of probability

Table 6: Correlation coefficient of the association between insect-induced leaf damage and cucumber fruit yield

Season	R-value
Early	0.80*
Late	0.54*

*Significant at 5% levels of probability

making the fruit unmarketable. The pest has also been reported on other cucurbits such as watermelon where Pitan[4] noted that this specie only feed mainly on the cucurbitaceae family. *Aulacophora foveicollis*, *A. indica* and *A. hilaris* have been reported as economic insect pests on cucumber and pumpkins, melons, watermelons and squashes especially at the seedling stage[12]. *Aulacophora foveicollis* and *A. hilaris* are most destructive pests of cucumber, especially in the early stage of the crop starting from the foliage stage[13]. Generally, *Aulacophora* spp., was recorded in this study as feeding on the tissues of young and old cucumber leaves in an irregular pattern and sometimes totally defoliated the leaves when the attack was severe. This type of damage causes a reduction in the photosynthetic ability of the plant.

Epilachna chrysomelina was recorded feeding on the leaves of cucumber. Pitan[4] and Akinkunmi[14] have reported this species as one of the most serious insect pests of cucumber in Nigeria, causing severe damage that is direct injury on the cucumber leaves. The adult and larvae of *Epilachna* beetle feed on the epidermal layer of cucumber leaves by forming a net-like appearance and later fall off eventually.

The NPK fertilizer is widely used by smallholder farmers as a soil booster for the development of cucumber plant. This study showed that although in some cases, the population of insect pests were not influenced by NPK fertilization, however, the numbers of *A. hilaris, A. foveicollis* and *A. africana* obtained were significantly higher in the NPK fertilizer-treated plots than the control. Indeed, there was a progressive increase in the density of these three *Aulacophora* species as NPK fertilizer rate was increased. This is also shown in the strong relationship that was recorded between NPK fertilizer levels and their population densities. The reason may be because the nutritional requirement of these three *Aulacophora* species was boosted by cucumber with high NPK fertilizer application, thus positively influencing their reproductive ability. While the development of crops depends on nutrient availability, that of insect pests depends on the quality of food available from their host plants[15]. Shah[9] has reported that the insect-plant relationship may be affected by the application of micro/macro-nutrients to crop plants. Similarly, high levels of fertilization have also been reported to promote increased cotton aphid reproduction and its high build-up in field aphid populations[16].

In the present study, higher *Aulacophora* leaf damage was recorded on cucumber with the following fertilizer application rates 50, 100, 200 and 400 kg/ha plots when compared to the control. In other words, insect pest-induced leaf damage was increased as the NPK fertilizer rate increased from 0 to 400 kg/ha. Also, the relationship between NPK fertilizer rate and leaf damage was high and positive. This implies that *Aulacophora* spp., was attracted into the cucumber ecosystem by more nutritious leaves caused by NPK fertilizer. Therefore, these insects caused more leaf damage through their feeding activities. In a similar study, Feng *et al*.,[17] reported that organic fertilizer application resulted in more insect pest infestations and consequently more leaf damage was recorded. Insect pests and damage to crops have also been demonstrated to increase with the application of NPK fertilizers[18,19].

It is striking that the percentage of fruit damage did not differ from that of the control despite an increase in the number of fruits produced with an increase in NPK fertilization. The implication of this is that the proportion of leaves damaged by the insect pests remained constant, that is, as more leaves were produced, more leaves were also damaged. This is probably the reason for the weak correlation that existed between insect-induced damage and fruit yield. This also indicates that although more fruits were produced with the application of NPK, it did not translate to a yield increase because damage also increased

The highest fruit yield obtained at 100 kg/ha is consistent with earlier findings of Manjy[12] and that is what is usually recommended in Southwestern Nigeria. However, this study revealed that NPK fertilizer application was adequate between 50 and 100 kg/ha for improved yield, but insect infestation and damage also increased with the fertilizer rate. This must be noted when designing an integrated pest management strategy for the pest of the genus *Aulacophora*. The economic implications and justification of the increased cost of controlling the increased insect pests as affected by NPK application would have to be estimated to justify control.

CONCLUSION

The results of this study revealed that *Aulacophora hilaris, A. foveicollis, A. africana, A. indica, A. nigripennis* and *Epilachna chrysomelina* were the major insect pests of cucumber recorded at the study area. However, only *A. indica, A. hilaris* and *A. foveicollis* responded to NPK fertilizer rates and showed numerical increase with increase in NPK fertilization. The NPK fertilizer rate between 50 and 100 kg/ha is sufficient for improved fruit yield, but also led to an increase in *Aulacophora* population, therefore insect control measures must be put in place to diminish the effect of the increased number of insects that will be attracted.

SIGNIFICANCE STATEMENT

This study discovered the impact of NPK fertilization on cucumber yield and its influence on insect pest populations, which can be beneficial for optimizing fertilizer application while managing pest infestations. The findings revealed that *Aulacophora hilaris*, *A. foveicollis* and *A. indica* responded positively to increased NPK rates, highlighting the need for integrated pest management strategies alongside fertilization. This study will help researchers uncover the critical areas of insect-pest interactions with fertilization that many researchers were not able to explore. Thus, a new theory on the ecological balance between fertilization and pest dynamics may be arrived at.

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