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The influence of nutrient application on the pests and natural enemies of pests of okra *Abelmoschus esculentus* (L.)(Moench.)

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ABSTRACT
Objective: Increased nutrient application to the soil enhances plant growth and thus improves the yield of crops. However, improved vegetative growth can make the plant more attractive to pests attack and destruction. The study was therefore conducted to assess the effects of artificial fertilizer and poultry manure on the pests and the natural enemies of the pests of okra.
Methodology and Results: The experiment was conducted in a randomized complete block design with three treatments which were replicated three times. The effects of NPK and poultry manure were studied on parameters such as insect pests' numbers and their natural enemies. The numbers of infested leaves, numbers of holes, leaf area, percentage defoliation, fruit damage, plant height and number of fruits were determined. Pest numbers on the various treatments did not differ significantly ($P > 0.05$). Numbers of infested leaves and holes and percentage defoliation did not differ significantly ($P > 0.05$). Mean leaf area was however significantly larger on NPK-treated plots than on poultry-manured plots.
Conclusions and application of findings: Management of insect pest by the average resource-poor farmer using chemical insecticides may not be a viable option. Application of poultry manure as soil amendments may be a viable alternative to artificial fertilizer. Its use does not only enhance the growth of the plant but also improve yield. The use of animal manure in Africa will be particularly beneficial to the small-scale farmers many of whom cannot afford artificial fertilizers. The continuous and indiscriminate use of chemical fertilizers has some negative effects on the environment. These include run-off and leaching into water bodies thereby polluting them. Thus the use of organic manure will help address some of these environmental challenges.

INTRODUCTION
Okra, *Abelmoschus esculentus* (L.) (Syn. *Hibiscus esculentus*) is an important vegetable crop cultivated in the tropics and subtropics for its immature edible green fruits (George, 1999). It has moderate levels of Vitamins A and C, some minerals such as phosphorus, calcium and potassium and has larger concentration of thiamine, riboflavin and niacin than many vegetables (Ranganna, 1979). It is a source of carbohydrate, dietary fibre, fat and protein (Asawalam *et al*., 2007). As a traditional food in Africa, okra has the potential to improve nutrition and food security. The mucilaginous juice is an excellent thickener for stews and soups (Dupriez and Deleener, 1989). Okra grows best on loams and sandy loams, but will produce good yields on

heavier soils. However, incorporating organic matter and balanced fertilizer before planting will produce good yields. One of the limiting factors to the profitable production of okra is damage by insect pests (Praveen and Dhandapani, 2002). In order to improve yield and maintain good quality, the pests and diseases of okra must be managed. The application of artificial fertilizer and organic manure as soil amendments will improve the yield of okra. One of the effects of applying soil amendments, especially nitrates to the soil is an increase in leaf area. This is agronomically the most important result of fertilizer application because an increase in leaf area results in improved radiation intercepted by the crop and therefore higher rate of photosynthesis (Varela and Seif, 2004).

One of the major insect pests of okra is *Aphis gossypii*. Crop plants attacked by this pest include cotton, citrus, coffee, egg plant, pepper and tomato (Blackman and Eastop, 1984). They infest seedlings of susceptible plants, but may also infest older plants and pods. The nymphs remove plant sap causing stunted growth, curling of leaves or may even kill young plants (Davidson and William, 1987). *A. gossypii* is also a vector of over 50 plant viruses (Saskia *et al*., 2004). The cotton looper (*Anomis flava*) is a polyphagous insect whose main host plants are *Hibiscus* sp*, Sida* sp and *Althaea rosae*. The caterpillar eats the leaves of host plants and when attack is heavy may lead to complete defoliation (Hill, 1983). Other important pests of okra include the flea beetle, *Podagrica uniformis*, whose activities reduce drastically the photosynthetic capacity of the leaf, resulting in low dry matter production and consequently the yield (Davidson and William, 1987) and the bollworm, *Earias* sp (Hill, 1983). Other insects that can be considered as minor or occasional pests include *Nezera viridula* (L.), *Bemisia tabaci* (Genn.) and *Spodoptera litoralis* (Boisd.) (Hill, 1983).

The control of insect pests by natural enemies presents an environmentally friendly method of controlling pests. This involves the activities of predators, parasitoids and pathogens as well as climatic factors in maintaining the population of insect pests below the economic injury level (Metcalf and Luckman, 1975). Ladybird beetle, *Cheilomenes* sp for example is used in controlling aphid population, while the larvae of *Chrysopera carnea* feed on all soft-bodied insects like aphids and the white fly *B. tabaci* (Webb, 2004). Farmers can manipulate some production practices to minimize insect damage to plants. This is done by ensuring that plants have favourable growing conditions such as sufficient water and fertilizer. Higher doses of nitrogen fertilizer increases pest attack while pottasic fertilizer makes plants more resistant. Plants suffering from mineral nutrient deficiency have lower tolerance to pathogens and pests (Huber, 1980, 1989).

Surekha and Rao (2001) and Prakash *et al*. (2002) explored the utilization of organic manure for managing the pests of okra. However the interactions between fertilizer application and insect pest infestation in okra production have not been adequately addressed. The study therefore assessed the influence of artificial fertilizer and poultry manure on the pests of okra and their effects on the natural enemies of pests of okra.

MATERIALS AND METHODS

The study was conducted on an experimental farm at the Department of Theoretical and Applied Biology, Kwame Nkrumah University of Science and Technology, Kumasi Ghana. The experimental plot was divided into 3 blocks, each of which was divided into 3 plots, each measuring 3.5 m x 3.5 m, with an alley of 0.5 m between them. The experiment was conducted in a randomized complete block design (RCBD), with 3 treatments, NPK, poultry manure and control, each of which was replicated 3 times. Okra seeds (var. Kpando Torkor) were obtained from the Horticultural Department of Crop Research Institute (CRI), Kwadaso, Kumasi. The seeds were soaked in water for 24 hrs to facilitate germination. Two seeds were sown per hole. Each plot had 5 rows and 5 columns; thus there were 25 plant stands per plot. Between row and within column spacing was 0.7 m. Eight days after germination; the seedlings were thinned to one per hole.

Application of soil amendments: Artificial fertilizer (NPK) was applied at a rate of 5 g/plant, whilst 12.5g/plant of poultry manure were applied to the soil at the base of the stem in the form of a ring. This was done 3 weeks after germination. A second application was done 2 weeks later using the same rate.

Weed control: Weed control was done by hand using a hoe 14 days after germination (DAG) and at 42 DAG. Subsequently weeds found growing were uprooted by hand.

Data collection: Scouting for the presence of insect pests and their natural enemies started 1 week after germination and sampling was done weekly between 6.00 am and 8.00 am when the insects were less active and easier to spot. Different insect species were sampled into sealed labelled bottles and taken into the laboratory, counted and their numbers recorded. *Aphis gossypii* and *Bemisia tabaci* were scored on a scale of 0 -1.0 depending on the area of leaf surface covered. Two growth parameters, plant height and leaf area were determined at 11 weeks after germination. Plant height was measured using a metre rule, 2 cm from the base of the plant to annul undulations on the farm. For leaf area, 10 leaves of the sampled plants were pressed onto graph sheets and the outline drawn, after which the boxes were counted; two half boxes were counted as 1.

Leaf damage and percentage defoliation: Percent leaf defoliation, number of holes made in the sampled leaves as well as the number of infested leaves were counted and recorded. Percent defoliation was calculated as follows:

$$\% \text{ Defoliation} = \frac{\text{Total number of leaves defoliated}}{\text{Total number of leaves in a sample}} \times 100$$

Yield analysis: Harvesting of the fresh fruits started 7 weeks after germination and it was done twice a week. Harvested fruits for each treatment were counted, the length each fruit was measured and weighed. Fruits with holes on them were considered damaged. These were also counted and weighed and their means calculated.

Data assessment: Data obtained were subjected to analysis of variance (ANOVA) and where the difference was significant, ($P< 0.05$) the means were separated using Student Neuman Keuls (SNK) test using the SAS programme (version 9) (SAS, 2005). Data on insect numbers were transformed using $\log(x + 1)$ transformation. Percentages were arcsine square root transformed prior to analysis.

RESULTS

Pests encountered on okra: A number of insect pests were identified attacking okra plants. These were: *Aphis gossypii* (Glover) (Hemiptera: Aphididae), the flea beetle *Podagrica uniformis* (Weise) (Coleoptera: Halticinae), white fly, *Bemisia tabaci* (Glenn.)(Homoptera: Aleyrodidae), cotton stainer, *Dysdercus superstitiosus* (H. Schaeffer) (Hemiptera: Pyrrhocoridae), leaf roller, *Sylepta derogata* (Lepidoptera: Pyralidae) and the fruit borer, *Earias vettella* (F.) (Lepidoptera: Noctuidae).

Aphis gossypii score ranged from a mean of 0.47 from the poultry manure plots to 0.84 on the control plots (Table 1). Even though lower *A. gossypii* scores were recorded on the treated plots the difference was not significant (P=0.338). Incidence of *P. puncticollus* was highest on NPK-treated plots and lowest on manure – treated plots. No significant differences were observed between the means (P=0.996). Mean score of *B. tabaci* ranged from 0.54 on manure plot to 0.71 on the control plots. Mean scores of *B. tabaci* for the various treatments did not differ significantly (P= 0.850). In the case of *D. suturellus*, even though larger numbers were recorded on the control plots than on the treated plots, the difference in mean numbers was not significant (P= 0.643). *S. derogata* numbers were largest on the control plots and least on manure –treated plots even though the difference was not significant (P=0.657).

Natural enemies of okra pests: The natural enemies of pests of okra identified were the ladybird beetle, *Coccinella* sp. (Coleoptera: Coccinellidae), huntsman spider, *Heteropoda venotoria* (Araneae: Lnyphiinae) and black carpenter ant *Camponotus pennsylvanicus* (Hymenoptera: Formicidae). The mean numbers of the various natural enemies are presented in Table 2. Ladybird beetle population was least on NPK-treated plots and largest on the control plots, even though the difference was not significant (P=0.641). *H. venotoria* numbers were larger on NPK-treated plots and least on the control plots. The difference was not significant (P=0.0739). Similarly, the numbers of *C. pennsylvanicus* on all the plots did not differ significantly (P= 0.145).

Table 1: The effect of nutrient application on insect-pests population of okra.

Treatment	Mean score of aphids	Mean no. of *Podagrica puncticollis*	Mean score of whiteflies	Mean no. of cotton stainer	Mean no. of leaf roller
NPK	0.77±0.21[a]	64.67±39.77[a]	0.62±0.26[a]	7.33±2.33[a]	57.33±13.53[a]
Poultry manure	0.47±.21[a]	45.00±8.31[a]	0.54±0.09[a]	5.33±1.67[a]	42.67±14.67[a]
Control	0.84±0.10[a]	45.67±11.11[a]	0.71±0.16[a]	14.33±6.94[a]	44.00±14.42[a]

Within columns, means with the same letter are not significantly different (P>0.05).

Table 2: The influence of nutrient application on the numbers of natural enemies of pests of okra.

Treatment	Mean no. of ladybird beetles	Mean no. of spiders	Mean no. of ants
NPK	0.67±0.33[a]	8.33±1.45[a]	28.67±8.09[a]
Poultry manure	1.00±0.58[a]	4.33±1.45[a]	8.33±4.26[a]
Control	2.33±1.45[a]	2.67±0.88[a]	25.67±3.84[a]

Within columns, means with the same letter are not significantly different (P>0.05).

Damage to okra plants: The results of the influence of nutrient application on plant damage are presented in Table 3. The number of infested leaves was largest on the control plots and least on the NPK treated plots. The number of infested leaves was not significantly different on the various plots (P=0.953). Thus application of soil amendments did not influence the extent of damage to okra leaves. The numbers of damaged leaves on the different treatments were not significantly different (P=0.675). The influence of nutrient application on leaf damage was not significantly different (P=0.975). Holes on the leaves were done by *P. puncticollis*. The number of holes per leaf was largest on NPK-treated plots and least on the control plots. Percent defoliation was highest on NPK-treated plots and least on poultry manure treated plots. The difference was not significant (P= 0.852). Fruit damage was caused by *Earias biplaga* and it was highest on the control plots and least on manure-treated plots even though the differences were not significant (P=0.641).

Table 3: The influence of nutrient application on damage to okra plants.

Treatment	No. of infested leaves	Holes by *Podagrica spp.*	Percentage defoliation (%)	Fruit borer damage (%)	
				no. basis	weight basis
NPK	138±35.51[a]	1144.33±457.96[a]	26.40±0.64[a]	25.72±3.33[a]	16.31±1.98[a]
Poultry manure	141±15.04[a]	1042.00±209.60[a]	24.52±0.89[a]	20.03±4.09[a]	13.19±1.67[a]
Control	156.67±43.67[a]	988.33±318.59[a]	25.85±3.79[a]	36.50±16.96[a]	24.50±5.94[a]

Within columns, means with the same letter are not significantly different (P>0.05).

Growth Parameters: Mean plant height ranged from 44.5 cm on the control plots to 47.1 cm on the manure-treated plots. Plant height did not differ significantly (P=0.919). Mean leaf area was largest on NPK-treated plots and least on the control plots (Table 4). The difference was significantly different (P=0.030). Significantly larger leaf area was recorded on NPK-treated plots than on poultry-manure treated plots. Leaf area on manure-treated plots was significantly larger than that on the control plots. Mean fruit length was longest on the NPK –treated plots and shortest on the control plots (P=0.440). Mean number of fruits harvested at the end of the sampling period ranged from 53.7 on the NPK-treated plots to 68.3 on poultry manure treated plots. The difference was not significant (P=0.717). Yield analysis indicated no significant differences between the treatments (P=0.356) (Table 4).

Table 4: The influence of nutrient application on growth parameters.

Treatment	Plant height (cm)	Leaf area (cm^2)	Length of fruit (cm)	Mean no. of fruits /plot	Yield (t/ha)
NPK	15.28±1.5^a	292.42±3.96^a	7.41±0.24^a	53.67±7.17^a	4.00±0.39^a
Poultry manure	15.70±0.72^a	240.08±6.81^b	7.04±0.63^a	68.33±10.68^a	4.11±0.40^a
Control	14.95±1.51^a	186.42±20.47^c	6.40±0.60^a	57.67±17.94^a	2.94±0.54^a

Within columns, means with the same letter are not significantly different (P>0.05).

DISCUSSION

The results of the study indicated that the use of poultry manure as soil amendment generally reduced the incidence of attack by *A. gossypii, P. puncticollis, B. tabaci* and *S. derogata*, even though the differences were not significant. The attack by sucking pests such as *A. gossypii* and *B. tabaci* robbed the plant of manufactured food needed for growth resulting in stunted growth and reduction in yield. Reduction in aphid population due to the application of organic manure in brinjal crop has been reported in India (Godase and Patel, 2001). Similarly, report by Sureka and Rao (2001) indicated that application of vermicompost at 7.5t/ha was more effective in bringing down aphid population on okra. The artificial fertilizer used, NPK contains nitrogen which promoted better vegetative growth of the plants. Application of artificial fertilizer had more significant effects on both vegetative and reproductive growth of okra plant than poultry manure. The pests were attracted onto the NPK-treated plots due to the better growth of plants which supported their survival and reproduction. This resulted in plots treated with NPK prone to higher pest infestation than the manure-treated plots.

Podagrica puncticollis was responsible for the defoliation observed during the study. The feeding activities of this pest resulted in holes in the leaves, giving them a sieve-like appearance. The number of infested leaves, number of holes in a leaf as well as percentage defoliation determined the extent of damage to the plants. Percent defoliation was higher on NPK-treated plots. As a consequence of lower *Earias* sp numbers on the manure-treated plots the overall damage caused by this insect was lower than on the NPK-treated plots. Similarly, larger numbers of *Earias* sp on the control plots accounted for the relatively larger percent fruit damage. The lower numbers of *Earias* sp also accounted for the least weight loss of fruits on the manure-treated plots compared to the control plots. The application of soil amendments resulted in an increase in leaf area. NPK-treated plots recorded the largest leaf area whilst plants on the control plots had the least leaf area. Increase in leaf area resulted in more radiation intercepted by the plants for photosynthesis. However, this increased leaf area also resulted in highest incidence of *P. punticollis* and *S. derogata* attack on NPK-treated plots.

Okra plants grown with poultry manure were tallest due to the fact that relatively fewer pests attacked them. Increased plant height due to application of organic manure has been observed by other workers (Abusahela and Shanmugavelu, 1988; Yadav *et al*., 2004). Increased plant height as a result of poultry manure was due to the presence of high phosphorus content which increased the availability of native soil phosphorus and increased biological activity (Adilakshmi *et al*., 2008). Increased vegetative growth as a result of poultry manure application resulted in increased synthesis of carbohydrates which resulted in higher yield. Higher availability of phosphorus in poultry manure was likely due to the effect of organic acids on soil minerals (Patiram, 1994). Organic manure has also been shown to release sufficient potassium into the soil for growth of plants (Rao *et al*., 1996). Soil physical and chemical conditions have a direct effect on performance of crop plants on the field. Hence the effectiveness of soil amendments with respect to okra does not depend only on its ability to meet nutritional demands, but also on the influence it exerts on the physical and chemical properties of the soil. Thus the quantity of nutrient applied has a direct effect on its effectiveness as soil amendment. Poultry manure and NPK were applied at the recommended rates; thus differences in nutrient sources with regard to phosphorus and potassium contributed to differences in growth parameters and yield.

One of the attributes of organic manure is its ability to hold adequate amounts of water needed for the growth of plants. This was reported by Rakshit (2004) who showed that the water-holding capacity of organic manure-treated plots was higher compared to plot treated with chemical fertilizers. Increased water holding capacity of soil makes enough water available to plants for growth. Addition of organic manure decreases bulk density of soil. A decreased bulk density of soil makes it easier for plant roots to proliferate in order to absorb water and nutrients for growth (Alison, 1973).

It appears that the pests were attracted to the NPK-treated plots due to better vegetative growth of plants on those plots which supported their survival and reproduction. Despite the fact that pest infestation on NPK-treated and manure-treated plots were high it did not significantly affect yields. This was due to the phenomenon of tolerance. On the other hand plants that suffer from mineral deficiency normally have lower tolerance to pests (Huber, 1989). The substances known to influence pest activity include amino acids, sugars, enzymes, phenols and alkaloids (Palaniapan and Annadurai, 1999). When nutrients are made available to crop plants in required quantities, they aid in the formation of these substances that impart resistance/tolerance to insect pests.

CONCLUSION

The use of poultry manure as soil amendment reduced infestation of okra plant by *A. gossypii, P. puncticollus, B. tabaci and S. derogata.* The overall damage caused by the fruit borer, *Earias* sp was reduced on the poultry manure-treated plots. The use of organic manure did not only enhance the nutrient status of the soil and consequently vegetative growth of the plants but also reduced the incidence of pests of okra. The use of poultry manure should be encouraged to achieve substantial reduction in pest numbers and improve yield since chemical insecticide application and the use of artificial fertilizer might not be the option for the average resource-poor farmer.

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