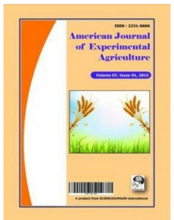

American Journal of Experimental Agriculture
9(1): 1-10, 2015, Article no.AJEA.17715
ISSN: 2231-0606

SCIENCEDOMAIN *international*
www.sciencedomain.org

Effect of Different Levels of Nitrogen in Liquid Fertilizer on the Population Dynamics and within Plant Distribution of *Aphis gossypii* and *Thrips palmi* and Yield of Eggplant

Foster Appiah Baah[1], Enoch Adjei Osekre[1*], Moses Brandford Mochiah[2] and Vincent Logah[1]

[1]*Faculty of Agriculture, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.*
[2]*Entomology Section, CSIR-Crops Research Institute, P.O.Box 3785, Kumasi, Ghana.*

Authors' contributions

This work was carried out in collaboration between all authors. Authors FAB, EAO and VL designed the study, wrote the protocol and wrote the first draft of the manuscript. Author MBM reviewed the experimental design and all drafts of the manuscript. Authors FAB and EAO managed the analyses of the study and performed the statistical analysis. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJEA/2015/17715
Editor(s):
(1) Masayuki Fujita, Department of Plant Sciences, Faculty of Agriculture, Kagawa University, Japan.
(2) Daniele De Wrachien, State University of Milan, Italy.
Reviewers:
(1) Angelo Maria Giuffrè, Department "AGRARIA", University of Reggio Calabria, Italy.
(2) Anonymous, Morocco.
(3) Fernando José Cebola Lidon, Earth Sciences Department, Faculty of Sciences and Technology, New University of Lisbon, Portugal.
(4) Anonymous, Alexandria University, Egypt.
(5) Azidah Abdul Aziz, Faculty of Science, University of Malaya, Malaysia.
Complete Peer review History: http://sciencedomain.org/review-history/9987

Original Research Article

Received 24th March 2015
Accepted 11th June 2015
Published 29th June 2015

ABSTRACT

A study was conducted in 2011 at the Kwame Nkrumah University of Science and Technology, Kumasi, Ghana to evaluate the effect of different levels of nitrogen in liquid fertilizer on the population dynamics and within plant distribution of *Aphis gossypii* (Glover) and *Thrips palmi* Karny on eggplant (*Solanum melongena* L). In the major cropping season, whereas significantly more *A. gossypii* aggregated on the leaves in the lower canopy than the upper canopy in the treatment 2 (Sidalco liquid fertilizer + 1% sulphate of ammonia solution), treatment 3 (Sidalco liquid fertilizer + 0.5% sulphate of ammonia solution) and treatment 4 (Sidalco liquid fertilizer), no significant

**Corresponding author: E-mail: osek652001@yahoo.co.uk;*

differences were recorded in the densities of the insect on the leaves in the canopy levels in the control (treatment 1). In the minor cropping season, it was only in the treatment 4 that significantly more *A. gossypii* aggregated on the leaves of the lower than the upper canopy. *T. palmi* densities were higher in the minor than in the major cropping season. In the major cropping season, it was only in the control that significantly more *T. palmi* aggregated on the leaves of the lower than the upper canopy. In the minor cropping season, however, significantly more *T. palmi* aggregated on the leaves of the lower than the upper canopy of plants on treatment 3 plots. Plots with the highest doses of N received the highest number of *A. gossypii* and *T. palmi* in both cropping seasons. The plots with the highest doses of N recorded the highest yield in both seasons. The study showed that higher levels of N in the liquid fertilizer increased aggregations of *A. gossypii* and *T. palmi*, and increased levels of N also resulted in increased yield.

Keywords: Liquid fertilizer; Thrips palmi; Aphis gossypii; population dynamics; eggplant.

1. INTRODUCTION

Eggplant (*Solanum melongena* L.) is a tropical and subtropical plant which grows in high temperatures and can produce up to 15 kg of fruits per plant. It comes in various colors and tastes from bland to sweet or slightly bitter [1]. Eggplant cultivation in Ghana is done in most agro-ecological zones with or without pepper, okra and other crops by subsistence farmers whilst mono-cropping is practiced in commercial farms. Almost every household in Ghana consumes eggplant fruit (garden egg) in the form of soup or stew daily due to its associated good nutritional value [2] and therapeutic properties [3].

According to [4], production of eggplant is highly concentrated, with 90% of output coming from five countries and about 1,600,000 ha devoted to its cultivation worldwide. Both local and exotic varieties of eggplant are grown in Ghana mainly for local consumption. Yield of eggplant in Ghana is low, prompting farmers to use fertilizers to increase productivity. Foliar nutrition is ideally designed to provide many nutrient elements to a crop that may be limiting production at a time when nutrient uptake from the soil is inefficient or nonexistent [5]. Farmers are being encouraged to patronize foliar fertilizers on the market to increase yield due to the long time effect of inorganic fertilizers on the soil through soil amendments.

Several studies have been done on fertilizer supply through the leaves and on viable fertilization alternatives on a number of nutrients like potassium [6], boron [7], phosphorus [8] and silicon [9] using lower amounts that would provide the needed nutrient or stimulate its beneficial effects [10]. These studies highlight the importance of foliar fertilizers in the face of certain problems associated with excessive use of fertilizers applied to the soil. Studies on insects' aggregations in response to fertilizer applications have also been undertaken by several workers. However, behavioral variations of insects on host plants in response to fertilizer applications have varied among host plants and insects. There is a need to investigate how plant phenology and architecture influences the distribution of insects on host plants, especially how the distribution of insects is affected by the application of liquid fertilizers. Sidalco (Eagle Media House Lt, UK: Wienco Ghana limited, Ghana) foliar N fertilizer (SLF) was introduced to the Ghanaian market recently for vegetable crops but very little information is available on its effects on insect pests. From this background this study was carried out with the objective to determine the effect of different levels of N from Sidalco liquid fertilizer and sulphate of ammonia solution on the aggregation and distribution of *Aphis gossypii* (Glover) and *Thrips palmi* Karny within eggplant.

The specific objectives of this study were to determine the impact of different levels of N liquid fertilizer on the population dynamics of *A. gossypii* and *T. palmi* on eggplant, distribution of the insects within eggplant, and yield of eggplant.

2. MATERIALS AND METHODS

2.1 Study Site and Location

The study was carried out at the Department of Crop and Soil Sciences' experimental site (Plantation) of the Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, Ghana from April to November, 2011. The area lies within semi-deciduous forest zone with bimodal rainfall. The major cropping season lasted from April - July and the minor cropping season from August-November. The mean highest and lowest monthly temperatures for the area were 33.3 and 21.7ºC, respectively, whereas the mean highest and lowest monthly rainfalls were 241.6 and 71.5 mm, respectively [11].

2.2 Experimental Field and Treatments

The experimental field comprised four blocks, each measuring 31.0 m by 10.0 m. Each block comprised four treatment plots, each measuring 10.0 m x 7.0 m, with an alley of 1.0 m between them. Between each of the four blocks was an alley of 2.0 m. There were five rows of ten plants per treatment plot. The sources of the nitrogen were NPK (10:10:10) in Sidalco liquid fertilizer and sulphate of ammonia solution (1% and 0.5%). The Sidalco liquid fertilzer was applied two weeks after transplanting after which the sulphate of ammonia solution was added two days later, and this was repeated weekly for eight weeks. A knapsack sprayer (CP 14) was used to apply the treatments to the leaves of the plants.

An initial soil test was done to ascertain the soil's nutrient status before the study was undertaken. The study was arranged in a randomized complete block design with four replications. The treatments i) T1: Control (No Fertilizer Application), ii) T2: SLF (NPK 10:10:10) + 1% sulphate of ammonia solution, iii) T3: SLF (NPK 10:10:10) + 0.5% sulphate of ammonia solution and iv) T4: SLF (NPK 10:10:10). Sidalco liquid fertilizer was chosen for this study because it is a new product being promoted for use on crops, especially vegetables to increase the yield, and that was also why eggplant was chosen.

2.3 Source and Variety of Seeds

Eggplant variety "Oforiwaa" which is popular in most local communities and early maturing was obtained from the Horticulture Department of the Crops Research Institute of the Council for Scientific and Industrial Research (CSIR – CRI), Fumesua, Kumasi, Ghana.

2.4 Planting and Other Agronomic Practices

The seeds were sown on a raised seedbed with friable soil in rows 10 cm apart. Ridomil fungicide (a. i. Metalaxyl-M) solution was mixed with the soil as pre-disinfectant and also applied to the seedlings on the nursery bed to prevent damping-off disease. The seedlings were transplanted on the main field after four weeks at one seedling per hill with 1.0 m inter- and intra-row spacing. Weeds were controlled by the use of a hoe at 14, 28, 42 and 56 days after transplanting (DAT).

2.5 Insects' Data

Insect samples were taken from the three middle rows starting at two weeks after transplanting and continued weekly for eight weeks. Sampling of insects was between 09.00 and 10.00 GMT when their population was high. At the three-leaf stage when sampling began, the above-ground parts of five plants of each treated plot were randomly cut and put into separate high density polyethylene plastic containers containing 70% ethanol. This continued for three weeks. From the 4th week, the plant canopy was partitioned into upper and lower canopies (upper and lower halves of canopy) and a leaf from each canopy level was cut into the plastic containers containing 70% ethanol. Sampling of flowers for insects was not included because negligible number of insects was collected from them. The samples were transported to the laboratory for identification with the aid of a stereomicroscope at 10-40x magnification. No insecticides were applied to the plants and the study was undertaken in both major and minor cropping seasons.

2.6 Yield Data

Harvesting of matured fruits started on the eighth week after transplanting and it was done five days interval for four consecutive weeks. Harvested fruits of each treatment were counted and weighed in the laboratory using a Switzerland-made Metler Toledo PB302 electronic weighing scale.

2.7 Data Analysis

Data for each season were subjected to analysis of variance [ANOVA] using SAS (9.0) GLM procedure (SAS institute, 2010). For the insects, data were pooled over date and data for each season transformed using square-root transformation to normalise the distribution of the insect population and separate analyses performed for each season. Analysis of the data for the two canopies (upper and lower) was run separately. Insects' data for comparison between the two seasons was pooled over time across the seasons before analysis. Tukey's procedure was used for mean separation at 5% probability level.

3. RESULTS

3.1 Initial Soil Analysis

The results of the initial soil analysis of the experimental site are shown in Table 1. The initial soil total N content recorded was low.

Table 1. Initial nutrient content of the soil

Soil property	Level
Organic carbon (%)	1.04
Total nitrogen (%)	0.09
Exchangeable bases (cmol$_{(+)}$/kg soil)	
Calcium	4.01
Magnesium	2.40
Potassium	0.09
Sodium	0.21

3.2 *A. gossypii* Densities in Response to N Application in Major Cropping Season of 2011

The highest density of *A. gossypii* was recorded in treatment 2 (Sidalco liquid fertilizer, SLF + 1% sulphate of ammonia) plots with 4.98 per leaf on 23rd June, 2011. The plot treated with SLF + 0.5% sulphate of ammonia (treatment 3) had a gradual increase of *A. gossypii* and peaked at 3.5 per leaf on 9th and 30th June. The population of the insect in the Sidalco liquid fertilizer treated plots (treatment 4) was at a peak of 3.5 per leaf on 9th June. The control plots (treatment 1) however, had a peak of 1.7 per leaf on 9th June and 1.5 per leaf on 30th June (Fig. 1).

3.3 *A. gossypii* Densities in Response to N Application in Minor Cropping Season of 2011

Mean densities of *A. gossypii* in the minor cropping season did not differ significantly from that recorded in the major cropping season (Table 7). The density of *A. gossypii* increased steadily and peaked at 3.8 per leaf on 15th September and declined thereafter in the treatment 2 plots (Sidalco liquid fertilizer, SLF + 1% sulphate of ammonia). The density of insects in the treatment 3 plots (SLF + 0.5% sulphate of ammonia) also followed a steady increase and peaked at 2.9 per leaf on 22nd September and declined thereafter. Densities of *A. gossypii* in treatment 4 (Sidalco liquid fertilizer treated plots) peaked at 2.6 per leaf on 22nd September and also declined thereafter. The control plots (treatment 1) had a steady increase and peaked at 1.6 per leaf on 6th October only to decline thereafter (Fig. 2).

3.4 *T. palmi* Densities in Response to N Application in Major Cropping Season of 2011

The peak density of *T. palmi* was recorded on 16th June for all treatments (Fig. 3). Whilst the control plots (treatment 1) had a peak of 1.0 per leaf, 1.8, 1.5 and 0.9 of *T. palmi* per leaf were respectively recorded in the treatment 2 (Sidalco liquid fertilizer, SLF + 1% sulphate of ammonia), treatment 3 (Sidalco liquid fertilizer, SLF + 0.5% sulphate of ammonia) and treatment 4 plots (Sidalco liquid fertilizer). Treatment 2 plot received another high density of 1.8 per leaf on 30th June whilst treatment 3 also had a density of 1.5 per leaf on 6th July.

3.5 *T. palmi* Densities in Response to N Application in Minor Cropping Season of 2011

Significantly more *T. palmi* aggregated on the leaves in the minor cropping season than in the major cropping season (Table 7). Mean densities of *T. palmi* for treatment 2 (Sidalco liquid fertilizer, SLF + 1% sulphate of ammonia) peaked at 2.0, 2.1 and 2.2 per leaf on 8th September, 15th September and 29th September, respectively, before it declined thereafter. Treatment 3 (Sidalco liquid fertilizer, SLF + 0.5% sulphate of ammonia) also peaked at density of 1.7 per leaf on 22nd September and declined thereafter. Peak densities of 0.8 and 1.1 per leaf were recorded on 15th September for treatment 1 (control plots) and treatment 4 (Sidalco liquid fertilizer), respectively, and also haboured 1.4 and 1.5 per leaf on 6th October (Fig. 4).

3.6 Distribution of *A. gossypii* (Major Cropping Season)

There are no significant differences in the densities of *A. gossypii* that aggregated in the lower and upper canopies of the control plots. However, there are significant differences in their numbers in the lower and upper canopies in the N treated plots (Table 2).

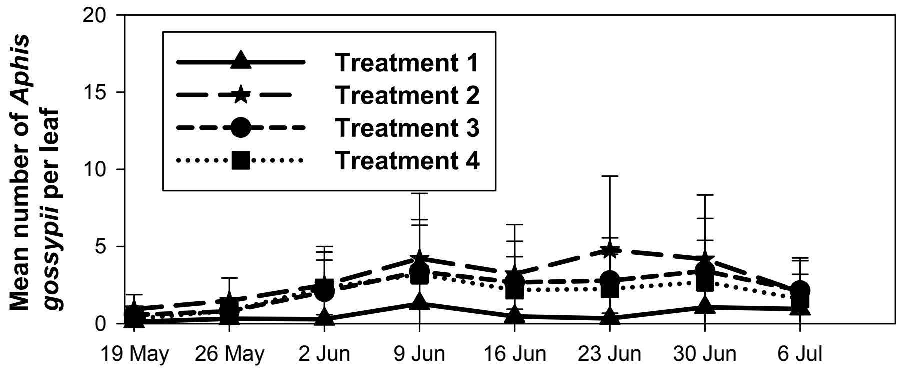

Fig. 1. Mean densities (±SEM) of *Aphis gossypii* per eggplant leaf in fertilizer treatments from May to July (major cropping season) in Kumasi, Ghana in 2011

Treatment 1 = Control; Treatment 2 = Sidalco liquid fertilizer + 1% sulphate of ammonia; Treatment 3 = Sidalco liquid fertilizer + 0.5% sulphate of ammonia; Treatment 4 = Sidalco liquid fertilizer only

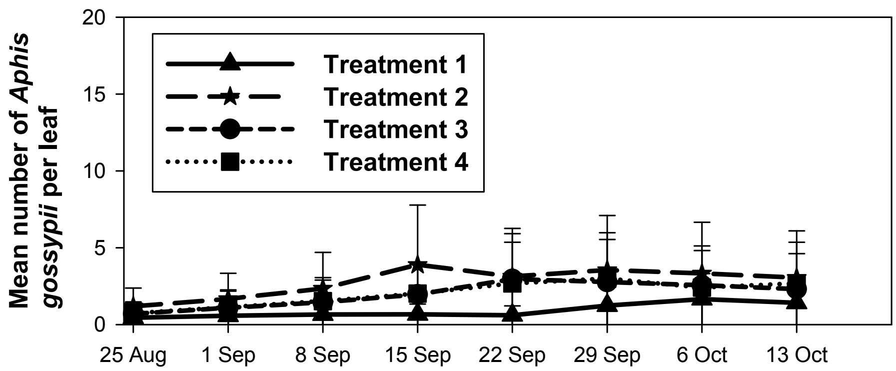

Fig. 2. Mean densities (±SEM) of *Aphis gossypii* per eggplant leaf in fertilizer treatments from August to October (minor cropping season) in Kumasi, Ghana in 2011

Treatment 1 = Control; Treatment 2 = Sidalco liquid fertilizer + 1 % sulphate of ammonia; Treatment 3 = Sidalco liquid fertilizer + 0.5 % sulphate of ammonia; Treatment 4 = Sidalco liquid fertilizer only

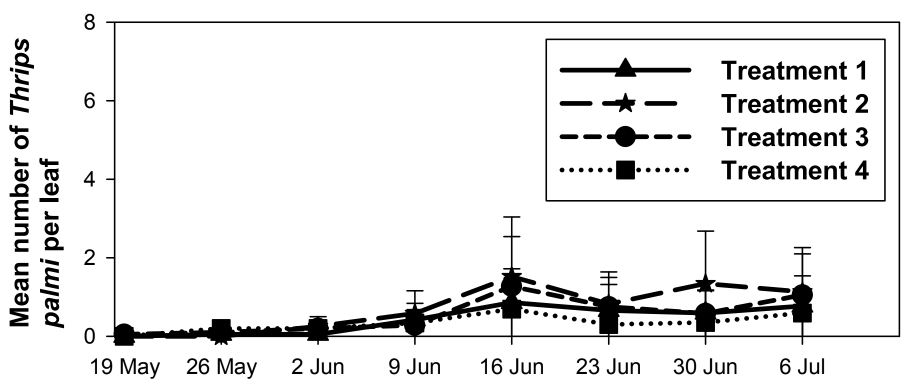

Fig. 3. Mean densities (±SEM) of *Thrips palmi* per eggplant leaf in fertilizer treatments from May to July (major cropping season) in Kumasi, Ghana in 2011

Treatment 1 = Control; Treatment 2 = Sidalco liquid fertilizer + 1% sulphate of ammonia; Treatment 3 = Sidalco liquid fertilizer + 0.5% sulphate of ammonia; Treatment 4 = Sidalco liquid fertilizer only

3.7 Distribution of *A. gossypii* (Minor Cropping Season)

The treatment 1 and treatment 2 (Sidalco liquid fertilizer, SLF + 1% sulphate of ammonia) and treatment 3 (Sidalco liquid fertilizer, SLF + 0.5% sulphate of ammonia) showed no significant differences in the aggregation of the insect between the lower and upper canopies; while the treatment 4 (Sidalco liquid fertilizer) received significantly higher number of *A. gossypii* in the upper canopy than that in the lower canopy (Table 3).

3.8 Distribution of *T. palmi* (Major Cropping Season)

There are no significant differences in the densities of *T. palmi* in the treatments 2 (Sidalco liquid fertilizer, SLF + 1% sulphate of ammonia), treatment 3 (Sidalco liquid fertilizer, SLF + 0.5% sulphate of ammonia) and treatment 4 (Sidalco liquid fertilizer); but significant differences were recorded between the lower and upper canopies in the control plots (Table 4).

3.9 Distribution of *T. palmi* (Minor Cropping Season)

There are no significant differences in the number of *T. palmi* collected from the canopies in, treatment 1, treatment 2 (Sidalco liquid fertilizer, SLF + 1% sulphate of ammonia) and treatment 4 (Sidalco liquid fertilizer) plots, there were significant differences in treatment 3 (Sidalco liquid fertilizer, SLF + 0.5% sulphate of ammonia) (Table 5).

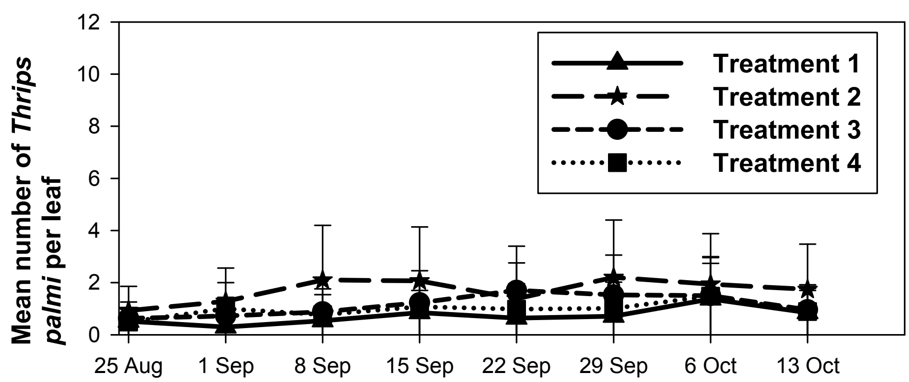

Fig. 4. Mean densities (±SEM) of *Thrips palmi* per eggplant leaf in fertilizer treatments from August to October (minor cropping season) in Kumasi, Ghana in 2011

Treatment 1 = Control; Treatment 2 = Sidalco liquid fertilizer + 1% sulphate of ammonia; Treatment 3 = Sidalco liquid fertilizer + 0.5% sulphate of ammonia; Treatment 4 = Sidalco liquid fertilizer only

Table 2. Mean (±SEM) distribution of *Aphis gossypii* per eggplant leaf in fertilizer treatments from May to July (major cropping season) in Kumasi, Ghana in 2011

Canopy	Control	SLF + 1% SA	SLF + 0.5% SA	SLF
Lower	0.70±0.11 [a]	3.66±0.19 [a]	2.87±0.16 [a]	2.27±0.17 [a]
Upper	0.53±0.11 [a]	1.82±0.16 [b]	1.48±0.15 [b]	0.97±0.11 [b]

Means with same letter(s) within a column are not significantly different (P < 0.05; Tukey test).
[SLF = Sidalco Liquid Fertilizer; SA = sulphate of ammonia]

Table 3. Mean (±SEM) distribution of *Aphis gossypii* per eggplant leaf in fertilizer treatments from August to October (minor cropping season) in Kumasi, Ghana in 2011

Canopy	Control	SLF + 1% SA	SLF + 0.5% SA	SLF
Lower	1.23±0.13 [a]	3.27±0.20 [a]	2.65±0.19 [a]	3.19±0.14 [a]
Upper	1.34±0.12 [a]	3.37±0.17 [a]	2.70±0.14 [a]	2.39±0.16 [b]

Means with same letter(s) within a column are not significantly different (P < 0.05; Tukey test).
[SLF = Sidalco Liquid Fertilizer; SA = sulphate of ammonia]

Table 4. Mean (±SEM) distribution of *Thrips palmi* per eggplant leaf in fertilizer treatments from May to July (major cropping season) in Kumasi, Ghana in 2011

Canopy	Control	SLF + 1% SA	SLF + 0.5% SA	SLF
Lower	0.40±0.06 [a]	1.40±0.11 [a]	0.85±0.09 [a]	0.53±0.08 [a]
Upper	0.75±0.09 [b]	1.13±0.12 [a]	0.89±0.09 [a]	0.45±0.06 [a]

Means with same letter(s) within a column are not significantly different (P < 0.05; Tukey test).
[SLF = Sidalco liquid fertilizer; SA = sulphate of ammonia]

Table 5. Mean (±SEM) distribution of *Thrips palmi* per eggplant leaf in fertilizer treatments from August to October (minor cropping season) in Kumasi, Ghana in 2011

Canopy	Control	SLF + 1% SA	SLF + 0.5% SA	SLF
Lower	0.89±0.11 [a]	1.81±0.17 [a]	1.17±0.14 [a]	1.43±0.12 [a]
Upper	1.11±0.12 [a]	2.12±0.15 [a]	1.67±0.15 [b]	1.40±0.14 [a]

Means with same letter(s) within a column are not significantly different (P < 0.05; Tukey test).
[SLF = Sidalco liquid fertilizer; SA = sulphate of ammonia]

3.10 Yield

There are significant differences between the control and the N treatment plots with respect to fruit yield in the major season. There are also significant differences between the treatment 2 (Sidalco liquid fertilizer, SLF + 1% sulphate of ammonia) and treatment 3 (Sidalco liquid fertilizer, SLF + 0.5% sulphate of ammonia) but there is no significant difference between treatments 3 and treatment 4 (Sidalco liquid fertilizer) plots. Significant differences in the yield are observed among the treatments in the minor season (Table 6).

4. DISCUSSION

The presence of *Aphis gossypii* and *Thrips palmi* on plants is due to the availability of food in the phloem sap [12]. The increase in the population can be attributed to increase in N in the tissues of the plants as result of the application of the foliar fertilizer, which supported the finding that N may influence semio-chemicals and nutritional values of plants and also behavioral characteristics of herbivores [13,14]. Jahn [15] argued that improved nutrition in the insects contributes to increase in reproduction, longevity and overall fitness of pests. The increase in *A. gossypii* and *T. palmi* infestation began two weeks after transplanting of the seedlings. N content in host plants is generally considered as an indicator of food quality that affects host selection by aphids and thrips [16]. The initial N in the soil appeared to be low [17] as per the results of the initial soil analysis but the addition of N in the liquid fertilizer increased N content in the leaves which may have significantly impacted reproduction by aphids and thrips, resulting in population increase [18]. N was found to modify the plant nutrition and reduce the resistance against aphids [19,20,21,22]. N application usually results in partitioning in the form of phenols and amino acids (protein) in the crop, making the foliage extremely succulent and therefore susceptible to both diseases and pest incidence [23,24,25], and the succulent nature of the leaves may have served as major attractant to the insects and positively impacted reproduction.

Table 6. The yield of eggplant treated with different levels of N in liquid fertilizers (in both cropping seasons) in Kumasi, Ghana in 2011

Treatment	Major season yield (kg/ha)	Minor season yield (kg/ha)
SLF + 1% SA	402.8 [a]	370.0 [a]
SLF + 0.5% SA	368.0 [b]	311.8 [b]
SLF	338.0 [b]	273.0 [c]
Control	258.8 [c]	197.8 [d]
CV (%)	4.2	4.2

Means with same letter(s) within a column are not significantly different (P < 0.05; Tukey test).
[SLF = Sidalco liquid fertilizer; SA = sulphate of ammonia]

Table 7. Mean (±SEM) distribution of *Thrips palmi* and *Aphis gossypii* per eggplant leaf in fertilizer treatments in both cropping seasons in Kumasi, Ghana in 2011

Season	Mean number of insects	
	Thrips palmi	***Aphis gossypii***
Major cropping	0.53±0.05 [a]	2.22±0.12 [a]
Minor cropping	1.02±0.08 [b]	1.97±0.12 [a]

Means with same letter(s) within a column are not significantly different (P < 0.05; Tukey test)

The number of *A. gossypii* recorded in the major cropping season was comparable to that recorded in the minor cropping season but [26] reported that aphids population could become very important in the cool dry season which is associated with the minor season in Ghana. *T. palmi* numbers, however, was significantly higher in the minor season than that recorded in the major season and this is in agreement with the report by [27] that thrips mostly attack eggplants during the cool dry season. Peak abundance of the insects was recorded half-way through the study period in both seasons which also coincided with the time of the highest succulence of the tissues of the plants, an indication that both insects prefer succulent to hardy tissues.

There were mixed results in the abundance of both insects in the canopy levels as far as the treatments are concerned making it difficult to pronounce clear behavioral activities of the two insects' habitation within the canopy levels of the plants. It appears plant phenology plays a less important role in *A. gossypii* and *T. palmi* numbers than seasonal variation. [28] suggested same reason for the abundance of thrips in their work. It is unclear why negligible densities of *T. palmi* inhabited the flowers of the plants because thrips usually prefer flowers to leaves when the former start appearing. Several authors have alluded to this fact in their works [29,30,31,32]. Generally, aphids are known to occur more on the leaves of plants than the flowers possibly because the leaves offer a more stable habitat to them than the flowers.

The number and weight of eggplant fruits do not depend only on environmental factors but on the combined effects of pests and diseases and good nutrition of the crop on the field. Higher number of fruits was recorded on the treatment with the highest N fertilizer rate. The control plots recorded the lowest yield. The mean weight of fruits was significantly higher in the highest N treatment plots than the lower N treatment plots, with the control having the least. This result was expected because the N applied was expected to improve plant performance and increase leaf area and sunlight interception to enhance the rate of photosynthesis [33,34]. Plots with high doses of N also recorded a higher yield. It has been reported that the main effect of N fertilization is the increases in the dry matter production in crops such as eggplant (*Solanum melongena* L.) [35], lettuce (*Lactuca sativa* L. 'Vegas') and lucerne (*Medicago sativa* L.) [36]. [37] found that applying the equivalent of 5 g N/plant to maize in soil with about 0.096% total N increased mature dry matter weight by 9-26% compared to plants that received no N depending on variety and soil moisture. This agrees with the results of this study because increase in N led to increases in fruit yield. Despite the fact that aphids and thrips pest densities increased with increasing N treatment, their numbers did not affect yield. This could be due to the fact that the densities were not high enough to adversely affect the overall performance of the plants and subsequently yield.

5. CONCLUSION

The study showed that higher levels of N in liquid fertilizer increased aggregations of *A. gossypii* and *T. palmi*, and increased levels of N also resulted in increased yield. Generally, there was no clear indication of the canopy level preference for the aggregation of *A. gossypii* and *T. palmi* in eggplant with increased N content, which therefore suggests that designing sampling protocols for these insects in eggplant may have to go with the specific objective underpinning the sampling.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Filgueira FAR. Novo Manual de Olericultura. Universidade Federal de Viçosa. 2000;402.
2. Ribeiro CS, Brune CS, Reifchneider FJB. *Cultivo da berinjela*. Brasília: Embrapa Hortaliças. 1989;23.
3. Reis A, Lopes CA, Moretti CL, Ribeiro CSC, Carvalho CMM, França FH, et al. Berinjela (*Solanum melongena)*. Brasília: Embrapa Hortaliças. n.p. (Embrapa Hortaliças. Sistemas de Produção 3). Disponível: http://www.cnph.embrapa.br Acessado em 21 de dezembro de 2007.
4. FAO (2010). Available: http://www.fao.org Accessed 18 June 2011.
5. Hiller LK. Foliar fertilization bumps potato yields in Northwest: Rate and timing of application, plus host of other considerations, are critical in applying foliars to potatoes. Fluid J. 1995;10:28–30.

6. Weir B. Foliar potassium bumps cotton yields: California researcher reports consistent yield increases to foliar-applied potassium over a period of years in the San Joaquin Valley. Fluid J. 1998;6:10–13.
7. Shabaan MM, El-Fouly MM, Abou-El-Nour EAA. Boron/nitrogen interaction effect on growth and yield of faba bean plants grown under sandy soil condition. Int. J. Agric. Res. 2006;1(4):322–330.
8. Avaliable:http://ex-epsilon.slu.se:8080/archive/00001853/ Accessed 18 June 2011.
9. Buck GB, Korndorfer GH, Nolla A, Coelho L. Potassium silicate as foliar spray and rice blast control. J. Plant Nutr. 2008;31: 231–237.
10. Elwan MWM. Ameliorative effects of di-potassium hydrogen orthophosphate on salt stressed eggplant. J. Plant Nutr. 2010; 33:1593–1604.
11. Ghana Meteorological Service. The Annual Report of Ghana Meteorological service; 2011.
12. Gomez S, Oosterhuis DML, Donald HR, Donald J, Donald CS. Diurnal pattern of aphid feeding and its effect on cotton leaf physiology. Environ. Exp. Bot. 2006;55:77–86.
13. Hunt DWA, Drury CF, Maw HEL. Influence of nitrogen on the performance of Colorado potato beetle (Coleoptera: Chrysomelidae) on tomato. Environ. Entomol. 1992;21: 817–821.
14. Herms DA. Effects of fertilization on insect resistance of woody ornamental plants: Reassessing an entrenched paradigm. Environ. Entomol. 2002;31:923–933.
15. Jahn GC. Effect of soil nutrients on the growth, survival and fecundity of insect pests of rice: An overview and a theory of pest outbreaks with consideration of research approaches. Multitrophic interactions in Soil and Integrated Control. Intl Organization for Biological Control *(IOBC)* wprs. Bull. 2004;27(1):115–122.
16. Jansson RK, Smilowitz Z. Influence of nitrogen on population parameters of potato insects: Abundance, population growth, and within-plant distribution of green peach aphid, *Myzus persicae*. Environ. Entomol. 1986;15:49–55.
17. Landon, J.R. Booker tropical soil manual. Longman Scientific and Technical Essex, UK. 1991;474.
18. Kalule T, Wright DJ. Tritrophic interactions between cabbage cultivars with different resistance and fertilizer levels, cruciferous aphids and parasitoids under field conditions. Bull. Entomol. Res. 2002;92: 61–69.
19. Kasyap RK, Batra BR. Influence of some crop management practices on the incidence of *Heliothis armigera* (Hiibner) and yield of tomato *(Lycopersicon esculentum* Mill.) in India. Trop. Pest Manage. 1987;33:166–169.
20. Eigenbrode SD, Pimentel D. Effects of manure and chemical fertilizers on insect pest populations on collards. Agric. Ecosyst. Environ. 1988;20:109–125.
21. Bentz JA, Reeves J, Barbosa P, Francis B. Within-plant variation in nitrogen and sugar of poinsettia and its effects on the oviposition pattern, survival, and development of *Bemisia argentifolii*. Environ. Entomol. 1995;24:271–277.
22. Phelan PL, Mason JF, Stinner BR. Soil fertility management and host preference by European corn borer, *Ostrinia nubilalis*, on *Zea mays*: A comparison of organic and conventional chemical farming. Agric. Ecosyst. Environ. 1995;56:1–8.
23. Jansson RK, Smilowitz Z. Influence of nitrogen on population parameters of potato insects: Abundance, population growth, and within-plant distribution of green peach aphid, *Myzus persicae*. Environ. Entomol. 1986;15:49–55.
24. Marschner H. Mineral nutrition of higher plants. London: Academic Press. 1995; 889.
25. Youdeowei A. Integrated pest management practices for the production of vegetables. Ministry of Food and Agriculture (MoFA) Plant Protection and Regulatory Services Directorate (PPRSD) publications with German Development Cooperation. United Kingdom. 2002;49.
26. Hosoda A, Hama H, Susuki K, Ando Y. Insecticide resistance of the cotton aphid, *Aphis gossypii* Glover. III. Host preference and organo-phosphorus susceptibility. J. Appl. Entomol. 1993;37:83–90.
27. Gallo D, Nakano O, Silveira NS, Carvalho RPL, Batista GC, BertiFilho E, Parra JRP, Zucchi RA, Alves SB, Vendramim JD, Marchini LC, Lopes JRS, Omoto C. Manual de entomologia agrícola. Piracicaba: FEALQ. 920 pp. de tripes, *Thrips tabaci* Lind., emcebolaem Ituporanga, Santa Catarina. Am. Soc. Entomol. 2002;26:365–369.

28. Salguero Navas VN, Funderburk JE, Beshear SN, Olson SM, Mack TP. Seasonal patterns of *Frankliniella* spp. (Thysanaptera: Thripidae) in tomato flowers. Econ. Entomol. 1991;64:1818-1822.
29. Funderburk JE, Stavisky J, Olson S. Predation of *Frankliniella occidentalis* (Thysanaptera: Thripidae) in field pepper by *Orius insidiosus* (Hemiptera: Anthocoridae). Environ. Entomol. 2000;29: 376-382.
30. Hansen EA, Funderburk JE, Stuart RR, Ramachandran S, Eger JE, Mcauslane H. Within-plant distribution of *Frankliniella* species (Thysanoptera: Thripidae) and *Orius insidiosus* (Heteropera: Anthocoridae) in field pepper. Environ. Entomol. 2003;32:1035–1044.
31. Reitz SR, Yearby EL, Funderburk JE, Stavisky J, Momol MT, Olson SM. Intergrated management tactics for *Frankliniella* thrips (Thysanoptera: Thripidae) in field–grown pepper. Econ. Entomol. 2003;96:1201–1214.
32. Osekre EA, Wright DL, Marois JJ, Funderburk JE. Population abundance and within plant distribution of *Frankliniella* spp. thrips (Thysanaptera: Thripidae) in cotton. Environ. Entomol. 2009;38(4):1205-1210.
33. Varela AM, Seif A. A Guide to IPM and Hygiene Standards in Okra Production in Kenya. ICIPE. Kenya. ISBN: 92 9064 161 5. Webb, S.E. 2004. Insect Management for Okra. Entomology and Nematology Department document ENY–466. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. 2004.
Available: http://edis.ifas.ufl.edu/IG152
Accessed 18 June 2011.
34. John LW, Jamer DB, Samuel LT, Warner LW. Soil fertility and fertilizers: An introduction to nutrient management pearson education, India. 2004;106–153.
35. Rosati A, Badeck FW, Dejong TM. Estimating canopy light interception and absorption using leaf mass per unit leaf area in (*Solanum melongena* L.). Ann. Bot. 2001;88:101–109.
36. Lemaire G, Avice JC, Kim TH, Ourry A. Developmental changes in shoot N dynamics of lucerne (*Medicago sativa* L.) in relation to leaf growth dynamics as a function of plant density and hierarchical position within the canopy. J. Exp. Bot. 2005;56:935–943.
37. Zhang LX, Li SX, Zhang H, Liang ZS. Nitrogen rates and water stress effects on production, lipid peroxidation. J. Agron. Crop Sci. 2007;193:387–397.

Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/9987