

Evaluation of Insecticides for the Management of Insect Pests of Tomato, *Solanum Lycopersicon* L.

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Abstract
Field studies were undertaken in Kumasi, Ghana in 2012 and 2013 to evaluate the efficacy of two insecticides i.e. Lambda Super 2.5 EC (a.i- lambda cyhalothrion) and Cymethoate Super EC (a. i.-cypermethrin and cymethoate) for the management of insect pests on tomato, *Solanum lycopersicum* L. Lambda Super was applied at 1.5 ml/0.5 L of water whilst Cymethoate Super was applied at 0.25 ml/0.5 L of water. A control plot (water application only) was also maintained. Whiteflies, *Bemisia tabaci* (Gennadius), thrips, *Thrips tabaci* Lindeman, aphids, *Aphis gossypii* (Glover), leaf miners, *Liriomyza* sp. and the tomato fruit worm, *Helicoverpa armigera* (Hubner) were the most important insect pests collected on tomato in the area. In 2012, there were no significant differences among the insecticide-treated plots and the control with respect to the densities of *B. tabaci*, *A. gossypii*, *Liriomyza* sp. and *H. armigera*. Cymethoate Super treated plots recorded significantly lower number of *T. tabaci* than the control plots. However, in 2013, the control plots recorded significantly more aggregations of *B. tabaci*, *H. armigera* and *A. gossypii* than the Lambda Super and Cymethoate Super treated plots. No significant differences were obtained in the numbers of *Liriomyza* sp. and *T. tabaci* among the treatments. In 2012, the insecticide-treated plots recorded significantly higher fruit yield than the control but there were no significant differences among the treatments with respect to percent damaged fruits and mean shoot dry weight in 2013. Lambda Super and Cymethoate Super can be used to manage insect pests on tomato for increased yield.
Keywords: Insecticides, efficacy, tomato pests, population densities, yield

1.0 Introduction

Tomato (*Solanum lycopersicum* L.) is one of the most important vegetable crops cultivated worldwide (Naika *et al*., 2005; Alam *et al*., 2007). It is consumed in many ways and this has played a major role in its rapid and widespread adoption as an important food component in Ghana (Horna *et al*., 2006). Tomato production in Ghana is mainly a smallholder activity, and its distribution throughout the year is markedly seasonal with a few large scale ventures at designated irrigation sites (FAO, 2005). In Ghana, average yield of tomato ranged from 7.5 to 15 mt / ha in the early 2000s (Adu-Dapaah and Oppong-Konadu, 2002; Obeng-Ofori *et al*., 2007). The highest and lowest annual production levels ever recorded in Ghana were 213,000 mt and 35,800 mt in 1995 and 1997, respectively (Adu-Dapaah and Oppong-Konadu, 2002).

Tomato production has intensified over the years; however, yields continue to be low due to several production constraints such as insect pests, diseases, and other environmental factors (Blay, 2005; Osei *et al*., 2010). The major economically important insect pest species of the crop include whitefly, *Bemisia tabaci* Gennadius, leaf miners, *Liriomyza* sp., thrips, *Thrips tabaci* Lindeman, cotton aphids, *Aphis gossypii* Glover, tomato fruitworm, *Helicoverpa armigera* Hubner (Obeng-Ofori *et al*., 2007; Enomoto, 2008).

Tomato farmers in many parts of the world and, Ghana in particular, rely entirely on the use of pesticides to manage insect pests and diseases and the high susceptibility of tomato cultivars to insect pests and diseases has caused farmers to obtain low yields (Bonsu, 2002). According to Horna *et al*. (2008) and Gianessi (2009), fresh tomato yield losses in Ghana can be as high as 64 % without the use of insecticides.

Even though insecticides have proven to be highly effective in protecting vegetable crops under extreme pressure from insect pests (Cooper and Dobson, 2007; Gianessi, 2009), the indiscriminate and widespread use of synthetic insecticides in vegetable cultivation usually has resulted in insecticide resistance development (Wintuma, 2009; Odhiambo *et al*., 2010). On the other hand, it has been established that farmers limited knowledge on appropriateness of pesticides to use, timely application, and the quantity to apply have led to low yield and undesirable accumulation in food. Because of the critical role pesticides play in vegetable crop production, there is a need to evaluate some of the most common ones used by farmers in order to provide useful information for effective management of insect pests for increased yield of tomato.

The objectives of this study were to (i) determine the efficacy of Lambda Super EC (Lambda cyhalothrin a. i.) and Cymethoate Super EC (Cypermethrin & Dimethoate a. i.) against insect pests of tomato, and (ii) determine the effects of the insecticides on the yield of tomato.

2.0. Materials and Methods

The study was conducted at the Plantation Crops Section of the Department of Crop and Soil Sciences of the Kwame Nkrumah University of Science and Technology (KNUST), Kumasi. The first study lasted from mid-August to mid-November, 2012 with the second planting from January to April, 2013.

2.1. **Field lay-out:**

The tomato variety used was PO34 and the seeds were collected from the Crops Research Institute of the Council for Scientific and Industrial Research (CSIR – CRI), Kwadaso, Kumasi. P034 is a local improved open pollinated variety, susceptible to insect pests of tomato. The seeds were nursed and seedlings transplanted at spacing of 1 m x 0.5 m on ridges 40 cm high. There were seven rows of 10 plants in each treatment plot. The experimental field was laid in a randomized complete block design in four blocks. Each treatment plot measured 5 m x 5 m, with 1.5 m alley between treatment plot and 2 m alley between blocks.

Fertilizer was applied in two splits; the first was NPK (15-15-15) applied three weeks after transplanting at 10 g per plant and the second split, Urea (46 % N) at six weeks after transplanting as side dressing at 2.2 g per plant. Weeds were controlled and watering done when necessary.

2.2. Insecticide treatments and their application

The treatments used were (i) Lambda Super at 1.5 ml / 0.5 l of water, (ii) Cymethoate Super at 0.25 ml / 0.5 l of water and (iii) a Control (sprayed with water only). Application of treatments was done using separate knapsack sprayers (CP 15) at two weeks interval, starting three weeks after transplanting and terminated three weeks to harvesting.

2.3. Sampling of insect pests

Sampling of insect pests began three weeks after transplanting before treatments were applied. The three inner rows of each treatment plot were used for the sampling. Five plants were selected at random from each plot every week to sample for insect pests. For the first three weeks of sampling, two leaves were cut from each sampling plant and put into high density polyethylene bottles containing 70 % ethanol. From then on, three leaves from the upper and lower canopies were collected. Samples were later transported to the insectary for processing, counting and identification using a stereo microscope. Sampling for whiteflies was by visual examination of the leaves with the aid of a magnifying glass. Sampling was done for nine weeks.

Yield (fruit weight) was taken from the inner rows.

2.4. Data Analysis

Insect data were transformed using square root transformation and data in percentages by arc sin transformation before subjected to Analysis of Variance (ANOVA) using SAS software version 9 (2008). Treatment means were separated using Tukey at 5 % probability.

3.0. Results

3.1. Insect pests collected in 2012

Significant differences ($P < 0.05$) were observed in *T. tabaci* densities between treatments. Plots treated with Cymethoate Supper recorded significantly ($P < 0.05$) lower number of *T. tabaci* than the control but there was no significant difference between *T. tabaci* densities collected in the Lambda Super and Cymethoate Super treated plots and between Lambda Super and untreated, control. There was no significant difference ($P > 0.05$) in *B.*

tabaci densities between treatments (Table 1). Also, *Liriomyza* sp., *A. gossypii* and *H. armigera* densities showed no significant differences ($P > 0.05$) between the treatments.

3.2. Insect pests collected in 2013

There were significant differences ($P < 0.05$) between treatment means with respect to the densities of *B. tabaci*, *H. armigera* and *A. gossypii* (Table 2). The control plots recorded significantly ($P < 0.05$) more aggregations of the insects than the Lambda Super and Cymethoate Super treated plots. However, there was no significant difference ($P > 0.05$) in their densities in the Lambda Super and Cymethoate Super treated plots. There were also no significant differences ($P > 0.05$) in the number of leaf miners (*Liriomyza* sp.) and *T. tabaci* in the insecticides treated plots.

3.3. Insect pests population dynamics as influenced by insecticide applications

Whiteflies (*B. tabaci*)

The population of *B. tabaci* increased steadily in the insecticide - treated plots and the control in October and comparatively reduced in November (Figure 1) with the control plots recording higher numbers in the sample dates except the last sampling in November. There were four insecticide applications in the minor season (2012). The mean number of *B. tabaci* at the beginning of the spray regime was about two per plant but reduced to about one by the end of the season (Figure 2). After the 1st, 2nd and 3rd insecticide applications, *B. tabaci* numbers generally reduced with the exception of the control plots which recorded slightly higher numbers after the first applications.

In the second planting in early 2013, before application treatments, *B. tabaci* numbers were between 1 and 1.5 per plant in the insecticides - treated plots but more than 1.5 per plant in the control (Figure 2). There were three insecticide applications in 2013. After the 1st applications, *B. tabaci* numbers reduced in all the insecticides - treated plots. However, the control recorded the highest mean number of about two per plant, and later reduced to about one before the 2nd spray applications. After the 2nd treatment. *B. tabaci* density reached its peak in April. *B. tabaci* number reduced drastically after the 3rd spray applications in all treatments including the control, recording a mean value of about one per plant in the control with the rest of the treatments recording below one per plant.

Thrips (*T. tabaci*)

No thrips were recorded in the first sampling date. Their numbers, however, increased steadily to a peak of 1.5 per plant in the 3rd week (Figure 3). After a month into the experiment, till the end, thrips numbers reduced in all the treatments plots.

Aphids (*A. gossypii*)

Aphids' densities were below a mean of one per plant throughout the experimental in both 2012 and 2013 (Figures 4 and 5). Its population recorded peaks of 0.75 per plant on March 17 and April 14 in the control plots in 2013.

Tomato Fruitworm (*H. armigera*)

Helicoverpa armigera numbers were very low before the 2nd application (Figure 6). The results revealed that the first application of treatments was effective in reducing *H. armigera* numbers. However, its densities increased after the 3rd application, with the control plots recording higher densities.

3.4. Fruit yield, damaged fruits and shoot dry weight of PO34 tomato as affected by various treatments

Significantly ($P < 0.05$) more fruit yield were obtained in the plots treated with insecticides compared with the control but no significantly differences were obtained in the percent damaged fruit and the mean shoot dry weights as affected by the various treatments (Tables 3).

4.0. Discussion

Insect pests as affected by insecticides treatments

Pesticides are used in managing insect pests, diseases and weeds in agriculture for increased yield. However, the behaviour of a pesticide in the environment depends on its stability, physicochemical properties, the nature of the medium into which it is applied, the organisms present in the soil, and the prevailing climatic conditions (Graham – Bryce, 1981).

Generally, the insects' populations throughout the experiment in 2012 were very low. The dosages of the insecticides used in this study did not have significant adverse effect on *T. tabaci* (Table 1) but significantly reduced the densities of *B. tabaci*, *A. gossypii*, and *H. armigera* in 2013. Similarly, Mathirajan *et al*. (2000) reported that Lambda – cyhalothrin applied at the rate of 30 g a.i ha^{-1} was more effective than endosulfan and fenvalerate against shoot and fruit borer on brinjal.

The effectiveness of both insecticides varied depending on the time (season) of application. In the first experiment in 2012, both Lambda Super and Cymethoate Super did not significantly reduce the densities of *B. tabaci*, *Liriomyza* sp., *A. gossypii* and *H. armigera* but in the second experiment in 2013, both insecticides significantly reduced the densities of *B. tabaci* and *A. gossypii* while Lambda Super significantly reduced the numbers of *H. armigera*. The insecticides did not reduce the densities of *Liriomyza* sp. and *T. tabaci.* Environmental factors may have impacted on the effectiveness of the insecticides. This is being suggested because drier conditions were observed in the early part of 2013. Mailhot *et al*. (2007) found in their experiment on cotton that the effectiveness of the insecticides they used including lambda-cyhalothrin varied across locations and years. Generally, controlling some of these insects with insecticides has not been effective. Osekre *et al*. (2009) reported that controlling thrips with insecticides is difficult because of resistance to insecticides in some species and rapid recolonization of treated fields. In their work on cotton, they reported higher numbers of adult *Frankliniella* thrips in lambda-cyhalothrin treated plots than the control plots. Similar results were recorded on other crops by Funderburk *et al*. (2002), Hansen *et al*. (2003) and Reitz *et al*. (2003).

Arguably, the frequency of application of insecticides could contribute to significantly reduce the numbers of certain species of thrips. In the present study, the insecticides were applied once every two weeks and this application regime might not have been enough to significantly reduce the densities of some of the insects. Osekre *et al*. (2009) reported that they achieved control of some of the species of thrips they collected probably because they did weekly application of the insecticides. Romeis *et al*. (1999) had also reported that the management of *H. armigera* is very difficult in many crops, and Ahmed *et al*. (2009) also reported that the same insect showed some resistance to lambda-cyhalothrin in their work.

Application of the insecticides in the early weeks of the experiment usually resulted in reduced densities of most of the insects collected but in the later weeks the densities of the insects began to rise again (Figures 1 and 2). As the plant grew the insects might have located more places to hide and might not have been reached by the insecticides applied. *B. tabaci* and *A. gossypii*, for example, were usually found on the underside of the tomato leaves and therefore some may have escaped contact with the insecticide sprayed on the leaf.

Generally, phenological changes in the growth of the tomato plant in space and time have impact on the distribution of the insects as they are presented with more hiding places and thus difficult to reach by pesticides. Toapanta *et al*. (1996) noted that thrips aggregate and feed on leaves in the initial stage of the plant growth but shift to aggregate in the flowers when blooming begins; it is more difficult to reach them with pesticides when they aggregate in the flowers.

Effect of the Insecticides Treatments on Tomato Yield

The insecticide treatments significantly increased the yield. However, the number of damaged fruits per plant among the treatments was not significantly affected. Osekre *et al*. (2009) reported that weekly application of lambda-cyhalothrin reduced thrips population and subsequently the yield of cotton was also increased significantly. Similar results were reported by Mailhot *et al*. (2007). It is unclear why no significant reduction in the percent damaged fruits was obtained but it might probably be due to the failure of the insecticide application to reduce significantly the number of *H. armigera*, which caused most of the damage in the first planting in 2012.

5.0. Conclusion

The study showed that *B. tabaci*, *T. tabaci*, *H. armigera*, *Liriomyza* sp., and *A. gossypii* were the most important insect pests that attack tomato in the study area (Kumasi). The effectiveness of Lambda Super and Cymethoate Super to significantly reduce the densities of *B. tabaci*, *A. gossypii* and *H. armigera* varied based on the time of application. Fruit yield was significantly increased with insecticides application. Lambda Super and Cymethoate Super can be used to manage insect pests of tomato to increase yield. However, better results may be achieved if weekly applications of the insecticides are done.

6.0. References

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Table 1. Mean number (± SEM) of insect pests collected on tomato as affected by insecticide applications in the first planting (minor season) in 2012 in Kumasi, Ghana.

Treatment	Mean number of insects per plant				
	B. tabaci	*Liriomyza* sp.	*T. tabaci*	*A. gossypii*	*H. armigera*
Lambda Super	1.30 ± 0.08^{a}	0.10 ± 0.06^{a}	0.32 ± 0.06^{ab}	0.19 ± 0.03^{a}	0.05 ± 0.06^{a}
Cymethoate Super	1.35 ± 0.08^{a}	0.09 ± 0.02^{a}	0.24 ± 0.04^{b}	0.17 ± 0.02^{a}	0.08 ± 0.02^{a}
Control (Water)	1.50 ± 0.07^{a}	0.06 ± 0.02^{a}	0.47 ± 0.06^{a}	0.25 ± 0.03^{a}	0.13 ± 0.03^{a}

Means with the same letter(s) in a column are not significantly different from each other ($P < 0.05$, Tukey Test).

Table 1 represents the population densities *B. tabaci*, *Liriomyza* sp., *T. tabaci*, *A. gossypii* and *H. armigera* on tomato as affected by insecticide applications in the first planting (minor season) in 2012 in Kumasi, Ghana.

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Table 2. Mean number (± SEM) of insect pests collected on tomato as affected by insecticide treatments in the second planting in 2013 in Kumasi, Ghana.

Treatment	Mean number of insects per plant				
	B. tabaci	*Liriomyza* sp.	*T. tabaci*	*A. gossypii*	*H. armigera*
Lambda Super	0.86 ± 0.08^{b}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.07 ± 0.02^{b}	0.12 ± 0.03^{b}
Cymethoate Super	0.99 ± 0.18^{b}	0.03 ± 0.01^{a}	0.00 ± 0.00^{a}	0.06 ± 0.02^{b}	0.15 ± 0.04^{ab}
Control (Water)	1.56 ± 0.09^{a}	0.00 ± 0.00^{a}	0.03 ± 0.01^{a}	0.27 ± 0.06^{a}	0.33 ± 0.06^{a}

Means with the same letter(s) in a column are not significantly different from each other at ($P < 0.05$, Tukey Test)

Table 2 represents the population densities *B. tabaci*, *Liriomyza* sp., *T. tabaci*, *A. gossypii* and *H. armigera* on tomato as affected by insecticide applications in the second planting in 2013 in Kumasi, Ghana.

Table 3. Yield, mean damaged fruits and mean shoot dry weight as affected by insecticides treated PO34 tomato in Kumasi, Ghana.

Treatment	Mean % damaged fruits	Mean yield (kg ha^{-1})	Mean shoot dry weight
Lambda Super	30.2 ± 6.3^{a}	8814 ± 213.6^{b}	4.9 ± 0.7^{a}
Cymethoate Super	33.6 ± 4.7^{a}	8704 ± 100.7^{b}	4.4 ± 0.8^{a}
Control	41.9 ± 7.1^{a}	6832 ± 142.9^{a}	3.3 ± 0.5^{a}

Means with the same letter in a column are not significantly different from each other ($P < 0.05$, Tukey test)

Table 3 shows the percentage damaged fruits, fruit yield and shoot dry weight of tomato plants as affected by the insecticide treatments in Kumasi, Ghana.

Appendix 2- Figures

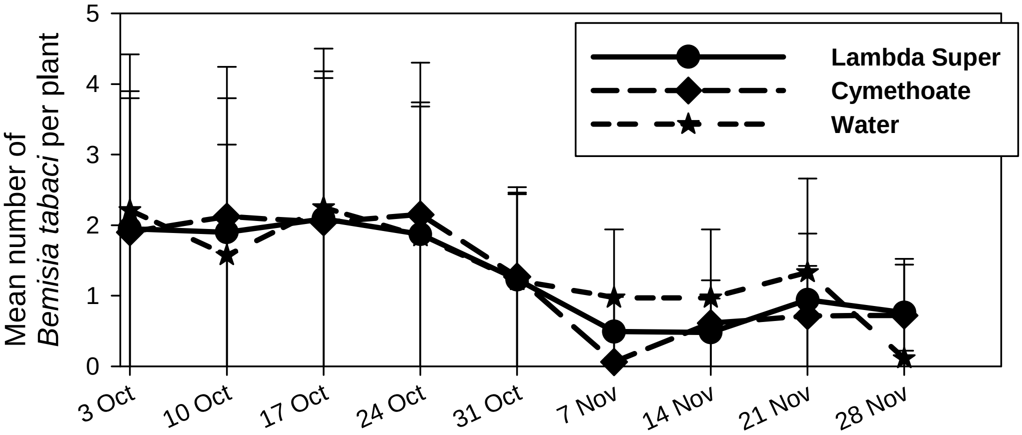

Figure 1. Mean number of *B. tabaci* per plant as influenced by insecticides application in the first planting in the minor season, 2012 in Kumasi, Ghana.

Figure 1 represents the population dynamics of *B. tabaci* as influenced by insecticides application in the first planting in the minor season, 2012 in Kumasi, Ghana.

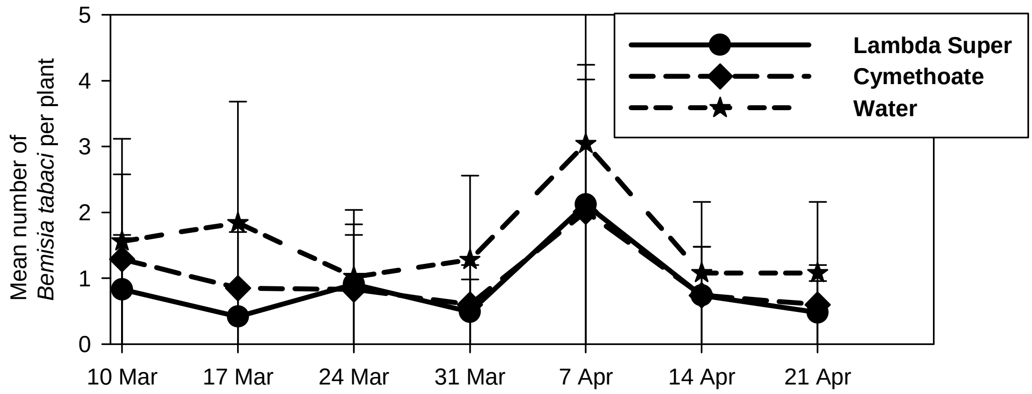

Figure 2. Mean number of *B. tabaci* per plant as influenced by treatments application in the second planting in 2013 in Kumasi, Ghana.

Figure 2 represents the population dynamics of *B. tabaci* as influenced by insecticides application in the second planting in 2013 in Kumasi, Ghana.

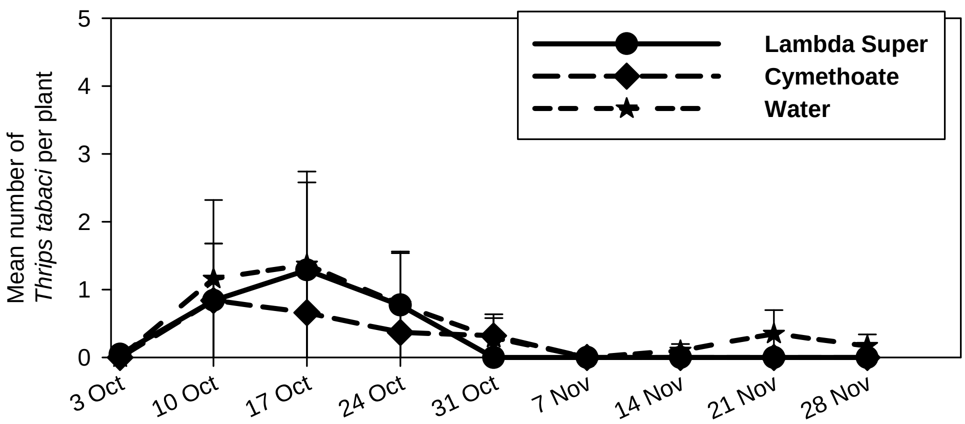

Figure 3. Mean number of *T. tabaci* per plant as influenced by insecticides application in the first planting (minor season) in 2012 in Kumasi, Ghana.

Figure 3 shows the population dynamics of *T. tabaci* as influenced by insecticides application in the first planting in the minor season, 2012 in Kumasi, Ghana.

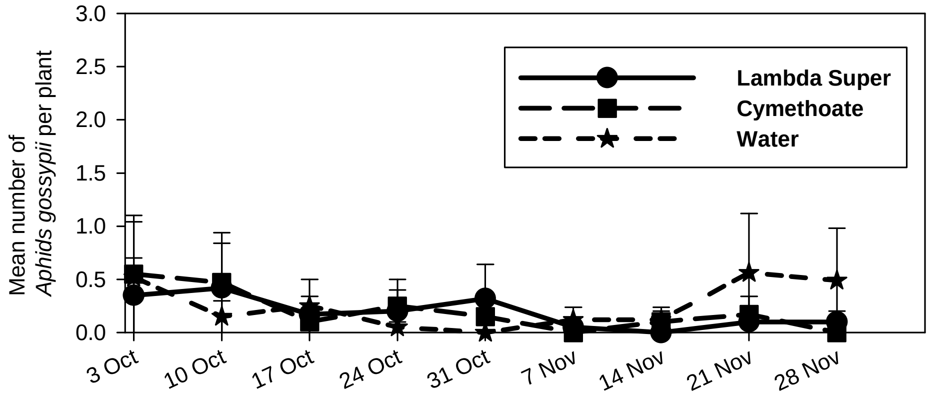

Figure 4. Mean number of *A. gossypii* per plant as influenced by treatments application in the first planting (minor season) in 2012 in Kumasi, Ghana.

Figure 4 shows the population dynamics of *A. gossypii* as influenced by insecticides application in the first planting (minor season) in 2012 in Kumasi, Ghana.

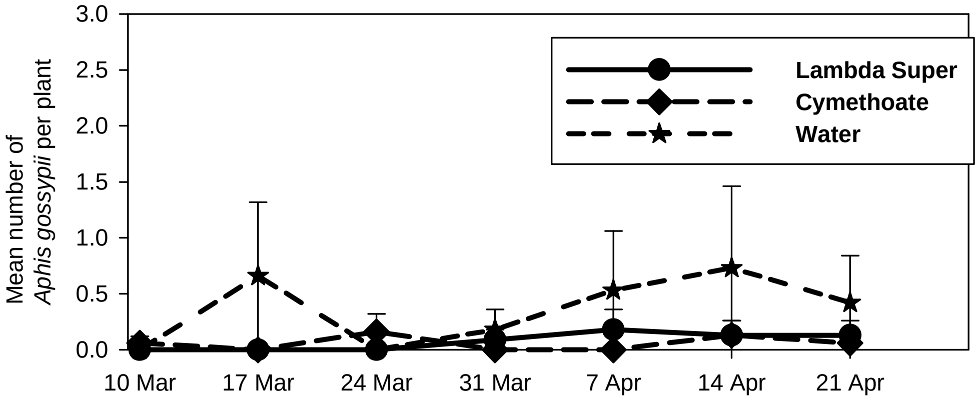

Figure 5. Mean number of *A. gossypii* per plant as influenced by treatments application in the second planting in 2013 in Kumasi, Ghana.

Figure 5 shows the population dynamics of *A. gossypii* as influenced by insecticides application in the second planting in 2013 in Kumasi, Ghana.

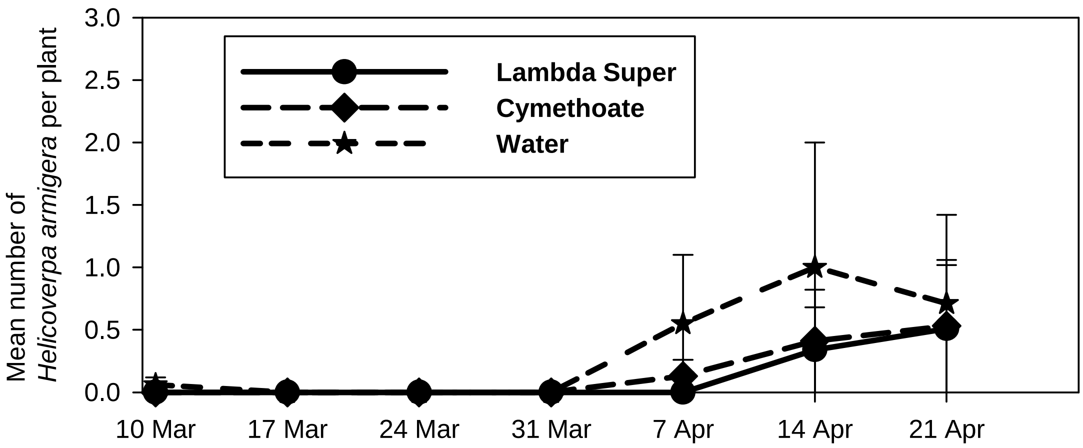

Figure 6. Mean number of *H. armigera* per plant as influenced by insecticides application in the second planting in 2013 in Kumasi, Ghana.

Figure 6 shows the population dynamics of *H. armigera* as influenced by insecticides application in the second planting in 2013 in Kumasi, Ghana.