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Assessing the Efficacy of Imidacloprid 20% SL as an Insecticide against Aphids in Cultivated Okra Plants in a Tropical Ecosystem: A Case Study of Mamponteng – Kumasi, Ghana for the 2011 and 2012 Cropping Period

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ABSTRACT

Okra, Abelmoschus esculents is an important vegetable widely grown in Ghana. The nutritional value derived from the consumption of okra cannot be over emphasized. However, okra has been regarded as a minor crop in Ghana, and for that matter, little or no attention is paid on the cultural practices that need to be adhered to in the cultivation of this important vegetable. The production of Okra in Ghana is severely affected by pests infestation, notably among them is aphids (Aphis gossypii Glover). It is therefore considered imperative and worthwhile to find a more robust and effective method of controlling aphids infestation in okra plantations in Ghana rather than resorting to the traditional methods which are to larger extent less effective in controlling aphids population in tropical ecosystem. A field experiment was therefore conducted to find the biological efficacy of imidacloprid 20% SL on aphids in okra. The research was conducted in 2011 and 2012 planting periods. Three doses of imidacloprid (25g, 50g and 75g active ingredient per ha) were used to test the efficacy of the treatment as compared to untreated plots (control). In both seasons, plants in the untreated plots recorded the highest mean number of aphids whereas those in the imidacloprid-treated plots had the lowest mean count. This study however shows that imidacloprid-treated plots had relatively more yield than the control (untreated plots). The research shows that efficacy of the insecticide is found to have a positive correlation with the rate of application. We therefore recommend 75g active ingredient of imidacloprid 20% SL /ha to effectively deal with aphids infestation in okra plants.

Keywords: *Okra, aphids, imidacloprid, efficacy and tropical ecosystem*

1. INTRODUCTION

Okra, Abelmoschus esculents is mainly grown for its young immature pods which are consumed as a vegetable. It is a common ingredient of soups and sauces. The pod is usually conserved by drying or pickling. Okra is a vegetable widely grown in Ghana. The crop is available almost throughout the year and cultivated in a wide range of soils. In the African context, okra has been called as —a perfect villager's vegetable because of its robust nature, dietary fibers and distinct seed protein balanced in both lysine and tryptophan amino acids (unlike the proteins of cereals and pulses) it provides to diet [1]. Okra is also rich in minerals, carbohydrate fibre, protein, fat, and phenols [2]. Pods and seeds are rich in phenolic compounds with important biological properties like quartering derivatives, catechin oligomers and hydroxycinnamic derivatives [2]. These properties, along with the high content of carbohydrates, proteins, glycol-protein, and other dietary elements enhance the importance of this foodstuff in the human diet [2, 3]. Kendall and Jenkins [4] affirmed that fresh okra pods are the most important vegetable source of viscous fiber, an important dietary component to lower cholesterol. According to Agbo et al. [5], seven-days-old fresh okra pods have the highest concentration of nutrients.

The West and Central African region accounts for more than 75% of okra produced in Africa, but the average productivity in the region is very low (2.5 t/ha) compared to East (6.2 t/ha) and North Africa (8.8 t/ha) [6]. Nigeria is the largest producer (1,039,000 t) followed by Cote d'Ivoire and Ghana [6]. Okra has huge potential for enhancing livelihoods in urban and rural areas and to several stakeholders [1]. It offers a possible route to prosperity for small-scale and large-scale producers alike and all those involved in the okra value chain, including women producers and traders [7]. However, the production of Okra in Ghana is severely affected by pests infestation, notably among them is aphids.

In Ghana, the plant is attacked by aphids (Aphis gossypii Glover) that have the tendency to hamper the growth of the crop (okra) and subsequently reduces yield [8]. These insects also transmit the okra mosaic virus which causes significant yield losses [9].

Arguably, okra remains a neglected crop in Ghana for which little attention has been given to by research scientists irrespective of its great potential. It can be said that there is rare information on the extent of damage and yield losses caused by insect pests occurring on okra. Traditionally, farmers resorted to conventional methods of pest control by dusting wood ash on leaves to protect their okra plants from pests' infestation. This traditional method to a large extent does not curtail or eradicate the harmful effects of pests on okra. It is has therefore become necessary to devise up to date technologies needed to combat pests and diseases of okra in Ghana. It is in light with this that a field experiment was conducted to find the biological efficacy of imidacloprid 20 % SL on aphids in okra. Imidacloprid is a systemic

insecticide with translaminar activity, capable of controlling sucking insects such as aphids, thrips, whitefly etc [10].

A field trial was carried out in 2011 and 2012 in Mamponteng in the Ashanti region of Ghana with unprotected and protected plots of okra with increasing doses of Imidacloprid 20% SL to score aphids damage and yield losses. Aphids have been identified as one of the major pest problems of okra in Ghana, and they are the most important inspect pests [11]. They cause damage by sucking plant sap, weakening the plants, and by excreting a sticky substance (honeydew), which results in growth of sooty mould affecting photosynthesis. Contamination of pods with aphids, aphid skins, honeydew and/ or sooty mould may result in their rejection in the market. The feeding behaviour of aphids causes leaf distortion and curling which debilitates the plant especially when the attack is severe in its early growth stage [12].

Several control methods having been evaluated against this insect pest. However, chemicals are widely used due to their quick action [13, 14]. In spite of this, the pest has developed resistance to most of the chemicals as a result of high exposure, hence limiting their use [15].

The main objective of the field experiment was to establish the efficacy of Imidacloprid 20% as an insecticide capable of controlling aphids in okra plants in Mamponteng in the Ashanti Region, with untreated okra plants as control.

2. MATERIALS AND METHODS

2.1 Characterization of the Experimental Site

Efficacy test of the product (imidacloprid 20% SL) was carried out at Mamponteng in the forest zone of Ashanti Region. The climate is humid tropical, and the soil type is Asuansi series (Orthi-Ferric Acrisol) which belong to the "Asuansi-Kumasi/Nta-Ofin" compound Association. Asuansi series are found on middle slope positions below Kumasi series (Orthi-Ferric Acrisol). They are the most extensive soils within the association and are very well drained soils. The trial was set up on a land with 7 years history of okra cultivation. Aphids' infestation on okra plants in this area is known to be high.

2.2 Environmental Conditions of The Area

The study area falls within the moist semi-deciduous forest zone of Ghana which is primarily characterized by two rainy seasons and two dry seasons. The area is also characterized by relatively high rainfall (1400 mm per annum) with a bimodal pattern. The major rainy season starts in April and ends in mid-July with a peak in the month of June (200mm). The minor season commences from September to mid-November with a peak in the month of September (168.7mm). A short dry spell separating the two rainy seasons occurs from mid-July to mid-August. The main dry season in which there is relatively long period of drought is experienced from November to March. Temperatures are high throughout the year with mean monthly temperatures ranging from 20^0C in June to 28^0C in April. Generally, there are little variations in the mean monthly temperature values in the study area.

2.3 Vegetation and Land Use

The site occurs in the semi-deciduous rain forest ecological zone of Ghana. The vegetation consists of short, medium and tall trees, widely spaced and a ground flora composed of different species of weeds and grasses. For most part of the site, the vegetation is relatively little degraded. The tree cover is moderately dense.

2.4 Geology, Relief and Drainage

The study area is underlain by Granite from which the soils are developed. The area is gently undulating with moderate steep slopes between 1-2% in the lowlands, and about 5-8% on the uplands. The summits of the catena in the study site are broad and flat. Few streams or drainage grooves occur in the area.

2.5 Soil Characterization

Particle size analysis was carried out by the Bouyoucous hydrometer method after hydrogen peroxide (H_2O_2) treatment and dispersion with 5% Sodium hexametaphosphate [16]. The pH was determined in distilled water at a soil-solution ratio of 1:2.5. The suspension was shaken for ten minutes and allowed to stand for thirty minutes, after which the pH of the suspension was measured using the pH meter. The organic carbon was determined by the Walkley-Black method [17]. The procedure involved oxidation of organic carbon using 1/V $K_2Cr_2O_7$ and Conc, H_2SO_4. The digest was then titrated with 0.5M Ferrous Ammonium Sulphate using diphenylamine as indicator after addition of Phosphoric acid and 0.2g NaF. The exchangeable bases (Mg^{2+}, Ca^{2+}, Na^+ K^+) were extracted with 1.0M Ammonium Acetate at pH 7.0. The Calcium and Magnesium ions were determined by complex metric titration with EDTA, using cal red indicator for Calcium and erichrome black T indicator for Calcium plus Magnesium. Potassium and Sodium ions in the extract were determined by flame photometry. The results were expressed in cmol(+)kg^{-1}.

2.6 Experimental Design

Okra seeds were hand-sown with intra-row spacing of 0.50 m and inter-row spacing of 0.80 m. Plots were separated by 2 m wide border margin and blocks by 3 m. Plot sizes were 25 m^2 and each plot consisted of 6 lines of 5 m. The Okra plants were transplanted on ridges. Nitrogen and phosphorus fertilizers were applied in the form of Diammonium phosphate (DAP) and ammonium nitrate respectively. DAP was applied at the time of planting at the rate of 120 kg/ha. Ammonium nitrate was applied 21 days after planting at the rate of 60kg/ha as a top dresser. All locally recommended agronomic practices were adhered to accordingly. A Randomized complete Block Design with 4 treatments and 4 replications was used. The treatments considered for the field experiment were 3 doses of imidacloprid 20% SL (25g, 50g and 75g active ingredient per ha) and an untreated plot serving as

the control. The treatments were applied as foliar application using a high volume sprayer after the first signs of aphids infestations were observed.

2.7 Data Sampling

The number of aphids present on 25 randomly chosen plants per plot was counted in situ on a biweekly basis. Counting of aphids on the plants (okra) was done in the morning between 8 and 9 am. The selected plants were subsequently visualized, and quantification of the damages on the leaves was done by scoring the percentage of defoliation. Fresh fruits were harvested from all the plants in the plots at weekly intervals for four consecutive weeks before lignifications. The fruits were accordingly sorted out into wholesome and unwholesome fruits. Fruit yield was calculated based on mean yield of wholesome fruit per hectare.

2.8 Data Analysis

Data obtained were analyzed with the analysis of variance (ANOVA) using Genstat 5 release 3.23 (PC/window NT) Copyrigh1995, Lawes Agricultural Trust (Rothamstead Experimental Station) statistical software. Means were separated at 5% level of significance using Least Significant Difference (LSD) where significant differences were obtained.

3. RESULTS AND DISCUSSION

The Physico-chemical characteristics of the soil in the study area are presented in Table 1.

Table 1: Physico-chemical properties of the soil in the study area

pH (H_2O)	6.10±0.31
% Organic Carbon	1.03±0.24
% Organic Matter	1.92±0.03
% Nitrogen	0.09±0.21
Calcium [cmol(+)kg^{-1}]	5.41±0.04
Magnesium [cmol(+)kg^{-1}]	1.74±0.04
Potassium [cmol(+)kg^{-1}]	0.41±0.10
Sodium [cmol(+)kg^{-1}]	0.34±0.23
Cation Exchange Capacity [cmol(+)kg^{-1}]	7.90±0.24
Exchangeable acidity [cmol(+)kg^{-1}]	0.60±0.06
Effective CEC [cmol(+)kg^{-1}]	8.50±0.04
% Sand	54.44±0.31
% Silt	31.56±0.20
%Clay	140±0.23

The number of aphids counted on the leaves of the okra in the experimental plots during the two season (2011, 2012) was significantly different ($p>0.05$). Infestations started from 30 to 33 days after planting in 2011 and 2012 planting years respectively. In both seasons, plants in the untreated plots recorded the highest mean number of aphids whereas those in the Imidacloprid-treated plots had the lowest mean count. Similar observation was made by Nedritu et al. [12] when they evaluated Imidacloprid and neem-based insecticides for managing aphids in okra in Kenya.

In 2011 planting period, the number of aphids increased rapidly to reach an average of 230 aphids per plant 35 days after planting. The aphid infestation was lower in 2012 with a maximum of 87 aphids per plant (Figures 1 and 2). This may be attributed to the residual effect of the insecticide that was applied in 2011 which subsequently reduced the population of aphids in the subsequent year (2012). Obeng-Ofori and Sackey [8] reported the presence of a few numbers of flea beetles and thrips on some of the leaves; blister beetle, Mylabris spp on flowers; cotton stainer bug, and Dysdercus spp on okra fruits. The same insects were also recorded on okra at the experimental site.

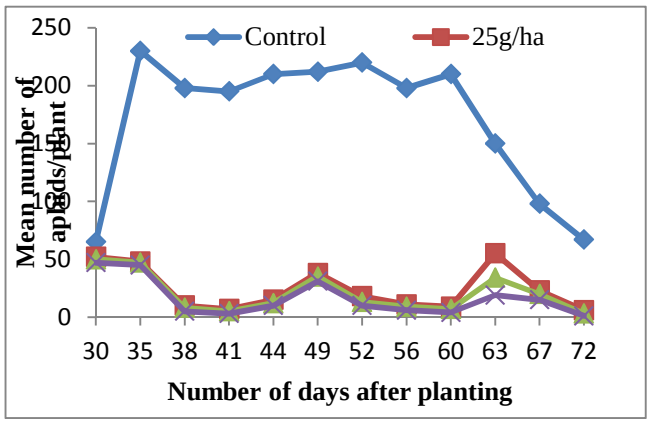

Fig 2: Temporal variation of mean number of aphids on okra treated with increasing doses of imidacloprid 20% SL in 2011.

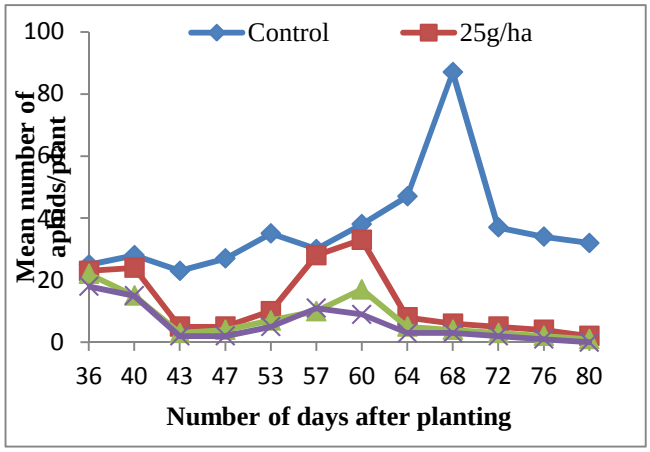

Fig 3: Temporal variation of mean number of aphids on okra treated with increasing doses of imidacloprid 20% SL in 2012.

Aphid population was observed to be significantly ($P > 0.05$) lower in the treated plants than the untreated plants in both years irrespective of imidacloprid 20% SL doses. The imidacloprid treatments induced an average reduction of aphids' population on treated plots.

This is in agreement with studies conducted by Misra [18]. The reduction in average of the pest's mean population could be attributed to the systematic nature of assimilation of the insecticide (imidacloprid) into the okra plants [12].

The significantly lower yield observed in the untreated plot may be attributed to the heavy infestation of aphids, resulting in the growth of sooty mould on the leaves of okra, which reduces the photosynthetic ability of the leaves, with a consequent lower reduction in the yield [8] (Table 2). Wanja et al. [19] also observed that, infestation of aphids in okra usually causes a reduction in plant height, fresh weight and yield. Several authors have however reported contrasting reports regarding yield reduction in okra as a result of aphids' infestation. An evaluation of several okra varieties by Shakeel et al. [20] did not find appreciable difference in their productivity amidst aphids' infestation. These contrasting outcomes could be ascribed to the diversity of the tested okra varieties which could differ in genetic compositions [21]. It could also be due to the environmental conditions prevailing throughout the experiment [22].

This present study however shows that imidacloprid-treated plots had relatively more yield than the control (Table 2), which conforms to the findings of Bhargava et al. [23] who observed that the use of imidacloprid results in better yields in okra production due to its effectiveness in controlling aphids. It must be emphasized that the variety of okro used in this experimental was "Asontem" which is an early maturing and high yielding variety in Ghana. Environmental conditions such as temperature and rainfall were adequate and conducive during the planting periods which might have also contributed to the better yield in the insecticide treated plot.

Table 2: Effects of increasing doses of imidacloprid 20% SL treatments on okra leave damage (% visual estimation)

	Leaf damage (%)	
Treatment	2011	2012
Untreated control	75 a	53 a
25g/ha	24 b	19 b
50g/ha	29 b	14 b
75g/ha	15 c	11 b
	P>5%	

*The data in the table are means of 4 replications
[a] Rows that have common superscripts are not significantly different

Table 3: Effects of increasing doses of imidacloprid 20% SL treatments on okra fruit yield (tons/ha ± SE)

	Fresh fruit yield	
Treatment	2011	2012
Untreated control	0.46 a ± 0.30	0.46 a ± 0.53
25g/ha	1.58 b ± 0.82	1.33 b ± 0.21
50g/ha	1.59 b ± 0.20	1.59 b ± 0.54
75g/ha	1.58 b ± 0.82	1.68 c ± 0.77
	P>5%	

*The data in the table are means of 4 replications
[a] rows that have common superscripts are not significantly different

More emphasis should be laid for clarity on the fact that, pests of okra have the propensity to significantly reduce crop yield. Mohammed-Ahmed [24] observed that aphids have a significant impact of reducing yield in okra. Several studies mentioned that insecticide spraying enhances yield increase in okra [25, 26, 8, 27]. Therefore, the use of insecticides should be encouraged to eradicate Aphids from okra farms. Insecticide spraying can control several insect pests and can lead to a better yielding of okra especially in Sub Saharan Africa.

4. CONCLUSION

The significant difference observed in the imidacloprid-treated plots as compared to the untreated (control) plot suggests that, infestation of aphids can result in higher yield reduction. Imidacloprid 20% SL was effective against aphids in okra plants. Effective control of aphids in okra plants is achieved when treatment is started at the early onset of aphids' infestation. The results show that efficacy of the insecticide is found to have a positive correlation with the rate of application. We therefore recommend 75g/ha of imidacloprid 20% SL to effectively deal with aphids infestation in okra plants. In conclusion, it can be said that the test product (imidacloprid 20% SL) can therefore be relied on in reducing aphids' infestation in okra plants. Further research should be geared towards assessing the chemical residual accumulation in the pods of the okra fruits.

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