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A survey of the insect pests and farmers' practices in the cropping of yellow pepper *Capsicum annuum* Linnaeus in Enugu State of Eastern Nigeria

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Yellow pepper (*Capsicum annuum* L.) is the second market gardening crop after tomato, and subsequently, a major source of income to farmers in Nigeria. Pests and diseases reduce yields and quality of marketable fruits. A study was conducted in Ibagwa-Agu, Lejja, Edem, Alor-Uno and Eha-Alumona agro-based communities of Nsukka Local Government Area to assess the economic implications of insect infestation and control strategies on yellow pepper yield. Data on insect pests was collected using the modified Whittaker sampling techniques from July to September 2015, while farming practices and economic consequences of pest infestation were monitored using questionnaires in December 2015. A total of 2,279 insects comprising 10 pests and 2 predators were collected. *Myzus persicae* Sulzer (27.6% of total collections), *Bemisia tabaci* Genn. (21.1%), *Aphis gossypii* Glov. (14.1%) and *Zonocerus variegatus* Gestro(7.99%) were the four prominent insect pests, while Ladybird beetle larva of *Harmoni axyridis* (2.3%) and praying mantis *Stagmonantis crolina* (1.4) were the main predators encountered. Mean percentage of plants attacked and yield losses were significantly (P <0.05) lower in communities with a high percentage of farmers utilizing cultural control methods. A higher percentage of the farmers were females. Farmers in Edem, Eha-Alumona, Lejja, Alor-Uno and Ibagwa-Agu in Nsukka Local Government Area of Enugu State therefore experience enormous economic loss in yellow pepper cultivation from the infestation of insect pests. Communities with a high percentage of farmers practicing cultural control methods had fewer plants attacked, while the predators were also more abundant. Further research is needed to ascertain the efficacy of these cultural methods.

Key words: Yellow pepper, Insect pests, Yield reduction, Farmers' cropping practices, Control measures, Gender perception.

INTRODUCTION

Yellow pepper (*Capsicum annuum* L.) is a spicy fruit, consumed extensively at world level (Dias et al., 2013). It has both nutritive and medicinal values. Some health-related phytochemical compounds found in yellow peppers are important in preventing chronic diseases such as cancer, asthma, coughs, sore throats, toothache,

diabetes and cardiovascular diseases (El-Ghoraba et al., 2013; Wahyuni et al., 2013). *C. annuum* also has antioxidant, anti-mutagenesis, hypocholesterolemic and immunosuppressive properties (El-Ghoraba et al., 2013), as well as inhibits bacterial growth and platelet agglomeration (Wahyuni et al., 2013). Consequently, yellow pepper is in high demand both by the general public and pharmaceutical companies (Nwankiti, 1981; Denton and Swarug, 2007).

In Nigeria, yellow pepper is the second market gardening crop after tomato (Assogba-Komlan et al., 2009), and it is a major income source for farmers. The Nsukka Area in Enugu State, eastern Nigeria, is especially important in the cultivation of yellow pepper as it has the environmental conditions suitable for its cultivation. Yellow pepper cultivation is the major and sometimes the only agricultural activity of rural women in the State. Yellow pepper production in Nigeria has been facing many biotic and environmental constraints. Prominent among such constrains are pests and diseases which reduce yields and quality of marketable fruits (Echezona and Nganwuchu, 2006) In the tropics, particularly in Nigeria, some insect pests are directly associated with yellow pepper damage and yield losses, while others are important as vectors of diseases (Khan et al., 2009; Segnou et al., 2013; Zhani et al., 2013).

Information on the insect pests and farmers' practices in the cultivation of yellow pepper in Nsukka area is lacking.

This survey was conducted in some major yellow pepper producing communities in Nsukka Area to assess the status of yellow pepper production with a view to address production problems related to insect pests. The survey had the objective of (i) identifying through questionnaire, technologies which influence insect spread and damage and (ii) identifying through field sampling major yellow pepper insect pests and their spread.

MATERIALS AND METHODS

Study area

The Nsukka Local Government Area (6°5' 24" N and 7°23'45"E) is located in the northern part of Enugu State in south-eastern Nigeria. The study was conducted between June and July, and December (2015) in five agro-based communities: Ibagwa-Agu, Lejja, Edem, Alor-Uno, and Eha-Amluona, chosen based on the following criteria: (i) relative importance of the yellow pepper crops in the communities, and (ii) its level of production. The average annual temperature falls between 27 and 28°C and average annual rainfall is about 1600 mm. The natural vegetation of the area is a derived savannah type and the trees found are usually drought resistant (Ugwu, 1964). Inhabitants in the Nsukka area have agriculture as their main source of income, being yellow pepper the main crop with economic importance.

Ethical consideration

Consent was obtained from the University of Nigeria ethical committee. The respondents were acquainted with the purpose of the study and assurances of confidentiality and anonymity were given to them.

Data collection

Insect collection: Whittaker sampling protocol

Twenty (20) yellow pepper farms were chosen each from the five agro-based communities, making a total of 100 farms, using systematic random selection. A total of 310 m^2 per farm were sampled using the modified Whittaker sampling protocol (Whittaker, 1972). Whittaker plots (20x50 m) were centrally outlined with wooden pegs, threaded with rope, at each farm. Nested in each plot were ten 0.5x2 m subplots systematically spaced along the inside border, two 2x5 m subplots in alternate corners, and a 5x20 m subplot in the center of the plot. Fifty plants were sampled randomly from the mapped out area in each of the sampled farmlands, 30, 10 and 10 from the 5x20, two of the 2x5 m and ten 0.5x2 m subplots respectively. Handpicking and insect sweep nets were used to collect the insects. Collection was biweekly and at the morning and evening hours when the insects were less active.

Observations were made on leaves, stems and fruits for insects and insect damage. Percentages of plants damaged by insects per farm were calculated. Insects' samples were identified in the field and the laboratory with a hand lens and a microscope, using picture vouchers and specimens in the museum in the Department of Zoology and Environmental Biology, University of Nigeria, Nsukka. Insects with mean percentage abundance of above 6% were regarded as prominent.

Knowledge/attitude of farmers and socio-economic impacts of insect pests of *C. annuum:* Descriptive survey method

The study population consisted of the twenty farmers whose farms were sampled for insect pests and an additional twenty randomly selected, in each community, making it a total of 200 respondents. The farmers' knowledge on insect pests of yellow pepper, yield losses from the insects and farming practices used to control them, were investigated using descriptive survey method, involving interview questions administered as semi-structured questionnaire. The interview questions were coined from 4 research questions: 1.Is yellow fever cultivation the major source of income amongst the farmers?; 2. What is the level of knowledge of the farmers of insect pests of pepper?; 3. What are the economic impacts of insect pests on *Capsicum annuum* on farmers in Ibagwa-Agu, Lejja, Edem, Alor-Uno and Eha-Alumona agro based communities of Nsukka Local Government Area? ; 4. What are the insect pest control methods practiced in Ibagwa-Agu, Lejja, Edem, Alor-Uno and Eha-Alumona agro based communities of Nsukka Local Government Area?

Nine interview questions were coined from the four

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Table 1. No of farmers' using yellow pepper cultivating as their major source of income in the agro-based communities.

Age range (years)	No of farmers	Sex		Edem		Lejja		Eha-Alumona		Alor uno		Ibagwa Agu	
		Male	Female	Male	female	male	female	male	Female	Male	Female	Male	Female
21-25	12	8(11.77%)	4(3.03%)	4(22.20%	-	-	-	2(14.20%)	-	2(16.60%)	-	-	4(13.30%)
26-30	22	10(14.71%)	12(9.09%)	4(22.2%)	2(9.0%)	2(14.2%)	-	-	2(7.6%)	2(16.60%)	4(14.2%)	2(16.6%)	2(15%)
31-35	28	10(14.71%)	18(13.6%)	2(11.1%)	6(27.2%)	2(14.2%)	2(7.6%)	2(14.2%)	4(15.3%)	2(16.60%)	2(7.1%)	2(16.6%)	4(13.30%)
36-40	46	12(17.65%)	34(25.7%)	4(22.29%)	8(36.3%)	2(14.2%)	2(7.6%)	4(28.5%)	6(23.07%)	-	12(42.8%)	2(16.6%)	620%)
41-45	48	12(17.65%)	36(27.20%)	2(11.1%)	6(27.2%)	4(28.5%)	2(7.6%)	2(14.2%)	8(30.7%)	2(16.60%)	8(28.5%)	2(16.6%)	2(15%)
46-50	28	8(11.75%)	20(15.1%)	2(11.1%)		-	12(46.1%)	4(28.5%)	6(2.07%)	-	2(7.1%)	2(16.6%)	6(20%)
51-60	12	6(8.87%)	6(4.5%)	-		4(28.5%)	6(23.07%)	-	-	2(16.60%)	-	-	4(13.30%)
< 60	4	2(2.94%)	2(1.5%)	-		-	2(7.6%)	-	-	2(16.60%)	-	-	2(15%)
Total	200	68(34%)	132(66%)	18(45%()	22(55%)	14(35%)	26(65%)	14(35%)	26(65%)	12(30%)	28(70%)	10(25%)	30(75%)

research questions: 1. Is yellow pepper cultivation your major source of income?; 2. How long have you cultivated yellow pepper?; 3. Do you utilize manual or mechanized farming method?; 4 What is your annual income from yellow pepper cultivation?; 5 Are you aware that some insects destroy yellow pepper?; 6. Can you identify at least one pest of yellow pepper from the pictures of insects provided?; 7 Mention at least two damages done to yellow pepper by a named insect?; 8. Do you suffer from yellow pepper yield losses from insect activities ,if yes how much?; 9. What farming practices do you employ in controlling the insect pests on your farm? The questionnaire was validated by conducting a pilot study to ensure that the questions were clear and appropriate to the level of the respondents' education. Results are grouped into sexes and presented under eight age ranges: 21-25, 26-30, 31-35, 36-40, 41-45, 46-50, 51-60 and <60 years. Metrics assessed through questionnaires are expressed in percentages. The questionnaires were administered in December, 2015 after the major harvesting periods. Yield reduction of above 25% was regarded as high, while cultivation period of above 5 years was regarded as long duration.

Statistical analysis

Data obtained were analyzed using statistical package for social sciences (SPSS) (version 17; SPSS Inc., Chicago, IL, USA, 2009) and descriptive statistics (average, percentage abundance, chi-square, species diversity) at $P < 0.05$).

RESULTS

In all the communities where the survey was conducted, females than males were involved in the production of yellow pepper as follows,55:45; 65:35; 765:36; 70:30 and 75%:25% for Edem, Lejja, Eha-Alumonah and Ibagwa Agu, respectively) (Table 1). Females between the age range 31-50 years were most involved in yellow pepper cultivation than other ranges (Table 1).Yellow pepper cultivation was the major source of income for all the farmers interviewed (100%). Manual farming was the most common and major method of farming (100%). The farmers had cultivated yellow pepper for periods ranging from 6 to 30 years (data not presented).

Insects belonging to six orders, ten families and twelve species were collected during the survey (Table 2). Pests include the green peach aphids (*Myzus persicae* Sulzer), cooton aphid (*Aphis gossypii* Glov), white flies (*Bemisia tabaci* Genn.) bugs (*Helopeltis schoutedni* Reuter), flea beetles (*Nisotra sjostedti* Jacoby), variegated grasshopper (*Zonocerus variegatus* Gestro), striped blister beetle (*Epicauta albovittata* Gestro), thrips (*Scirtothrips dorsali* Glov), leafhopper (*Zonosemata* spp.) and pepper larva (*Biston betularia* Linnaeus).Predators sampled from the crops were ladybirf beetle (*Harmoni axyridis* Pallas) and praying mantis (*Stagmonantis carolina* Johannson) (Table 2). Green peach aphid was the most encountered (27.6%), followed by white flies (*B. tabaci)* with 21.1%, cotton aphid (*A. gossypii)* (14.1%) and the least encountered was the Praying mantis (*S. carolina)* (1.4%). The shoot of the plant was significantly ($P < 0.05$) most attacked as seven species were collected from this plant part, followed by the leaf (2 species), while only one was collected from the fruit. Among the pests, the order Hemiptera was most abundant (4 species), while Thysanoptera and Lepidoptera were least abundant (1 species each) (Table 2). Of the total 2,279 insects collected, the

Table 2. Insect pests and predators collected from yellow pepper plants in the sampled agro-based communities.

Order	Family	Scientific Name	Common Name	%Total Number	Plant Part Attacked
Hemiptera	Aphididea	*Myzus persicae*	Green peach aphid	27.6	Shoot
Hemiptera	Aleyrodidae	*Bemesia tabaci*	White fly	21.1	Leaf
Hemiptera	Aphididea	*Aphis gossypii*	Cotton aphid	14.1	Shoot
Orthoptera	Pyrgomorphidae	*Zonocerus variegatus*	Grasshopper	7.99	Shoot
Diptera	Tephritidae	*Zonosemata spp.*	fruitfly	6.3	Shoot
Hemiptera	Miridae	*Helopeltisschoutedeni*	Bug	4.3	Shoot
Lepidoptera	Geomtridae	*Biston betularia*	pepper larva	4.2	Fruit
Coleoptera	Meloidae	*Epicauta albovittata*	Striped blister beetle	3.9	Shoot
Thysanoptera	Thripidae	*Scirtothripsdorsali*	Thrip	3.5	Shoot
Coleoptera	Chrysomelidae	*Nistorasjostedti*	Flea beetle	3.3	Leaf
Coleoptera	Coccinellidae	*Harmoniaxyridis*	Lady bird beetle larva	2.3	Predatory
Dictyoptera	Mantidae	*Stagmonantiscarolina*	praying mantis	1.4	Predatory

Table 3. Insect pests and number collected from *C. annuum*(Yellow pepper) from the agro-based communities.

Insect	Ibagwa Agu (%)	Edem(%)	Lejja (%)	Eha-Alumona(%)	Alor-Uno(%_)	Total (%)
Myzus persicae	150(23.9)	80(12.7)	100(15.9)	118(18.8)	180(28.7)	628(27.6)
Bemisia tabaci	109(22.7)	55(11.4)	77(16.0)	107(22.2)	133(27.7)	481(21.1)
Aphis gossypii	75(23.3)	43(13.4)	61(18.9)	90(28.0)	53(16.5)	322(14.1)
Zonocerus varigatus	50(27.5)	43(23.6)	10(5.5)	38(20.9)	41(22.5)	182(7.99)
Zonosemata spp.	25(17.4)	36(25.0)	20(13.9)	22(15.3)	41(28.5)	144(6.3)
Helopeltis schoutedeni	21(21.2)	10(10.1)	13(13.1)	19(19.2)	36(36.4)	99(4.3)
Biston betularia	19(20.0)	21(22.1)	16(16.8)	25(26.3)	14(14.7)	95(4.2)
Epicauta albovittata	20(22.7)	12(13.6)	16(18.2)	15(17.0)	25(28.4)	88(3.9)
Scirtothrips dorsali	16(20.0)	13(16.3)	15(18.8)	17(21.3)	19(23.8)	80(3.5)
Nistora sjostedti	16(21.1)	9(11.8)	12(15.8)	17(22.8)	22(28.9)	76(3.3)
Harmoni axyridis	7(13.2)	10(18.9)	13(24.5)	15(28.3)	8(15.1)	53(2.3)
Stagmonanti scarolina	5(16.1)	7(22.6)	4(12.9)	9(29.0)	6(19.4)	31(1.4)
Total	515(22.5)	339(14.9)	357(15.7)	492(21.6)	578(25.4)	2279(100.0)
Simpson's Index of Diversity	0.8309	0.8677	0.8345	0.8468	0.8239	

highest number was collected from Alor-Uno (578:25.4%), followed by Ibagwa Agu (515:22.5%) and the lowest from Edem (339:14.9) (Table 3).

All 12 species of insects (10 pests and 2 predators) were collected from all the sampled locations. The species diversity of insect pest found in the location was almost the same. Edem has the highest level of diversity of insects (0.8677) while Alor-Uno has the least level of diversity (0.8239) (Table 3).

In the locations that were surveyed, all the farmers were aware that some insects destroy pepper, but more female farmers than male could identify at least one of the insect pests (40:15; 50: 25;62.5:30; 20:15;and 60:10% for Edem, Lejja, Eha-Alumona, Alor Uno and Ibagwa agu respectively) (Table 4), and also were able to mention at least two damages done to yellow pepper plant by insects (35:15; 20:15; 50:20; 50:10; 50:5 for Edem, Lejja, Eha-Alumona, Alor Uno and Ibagwa Agu respectively). For all the locations, positive responses for age ranges between 36-<60 were higher than the others (Table 4).

Income generated annually ranged between ₦100,000 and 900,000, with 41% of the women earning between 800.000-900,000, while 20% of the men were found in this income range (data not presented).

In all locations, all the farmers experienced yield loses due to insect infestation (100%).80% farmers in Ibagwa-Agu experienced about 26 to 50% yield reduction, while 20% experienced 51-75% yield reduction. Most farmers in Alor- Uno (91.9%) also experienced 26 to 50% farm yield reduction, while 8.1% experienced 51-75% yield reduction. Those 100% farmers in Eha- Alumonah experienced lower yield reduction (about 1 to 25%) farm yield reduction. Most farmers in Lejja, 44, 50 and 5.6% experienced between 1 to 25%, 26 to 50% and 51 to 75% farm yield reduction respectively. Those in Edem

Table 4. Level of knowledge of the farmers on insect pests of yellow pepper in the agro-based communities

Age range (years)	Edem							Lejja							Eha-Alumona						
	No of farmers	1		2		3		No of farmers	1		2		3		No of farmers	1		2		3	
		M	F	M	F	M	F		M	F	M	F	M	F		M	F	M	F	M	F
	N(%)																				
21-25	4	4(22.2)	-	-	-	-	-	-	-	-	-	-	-		**2**	2(14.2)	-	1(8.3)	-	-	-
26-30	6	4(22.2)	2(9.0)	-	-	-	-	2	2(14.2)	-	-	-	-		2	-	2(7.6)	-	2(8)	-	2(10)
31-35	8	2(11.11)	6(27.2)	-	2(12.5)	-	-	4	2(14.2)	2(7.6)	1(10)	1(5)	-		6	2(14.2)	4(15.3)	2(16.6)	3(12)	1(12.5)	2(10)
36-40	12	4(22.2)	8(36.3)	1(16.67)	8(50)	1(16.67)	8(57.18)	4	2(14.2)	2(7.6)	1(10)	1(5)	2(33.3)		10	4(28.5)	6(23.0)	3(23)	6(24)	3(37.5)	4(20)
41-45	8	2(11.11)	6(27.2)	3(50)	6(37.5)	3(50)	6(42.2)	6	4(28.5)	2(7.6)	4(40)	-	2(33.3)		10	2(14.2)	8(30.7)	2(16.6)	8(32)	1(12.5)	8(40)
46-50	2	2(11.11)	-	2(33.3)	-	2(33.3)	-	12	-	12(46.15)	-	12(60)	-	12(60)	10	4(28.5)	6(23.0)	4(33.3)	6(24)	4(50)	4(20)
51-60	-	-	-	-	-	-	-	10	4(28.5)	6(23.03)	4(40)	4(20)	2(33.3)	6(30)	-	-	-	-	-	-	-
< 60	-	-	-	-	-	-	-	2	-	2(7.6)	-	2(10)	-	2(10)	-	-	-	-	-	-	-
Total	40	18(455)	22(55)	6(15)	16(40)	6(40)	14(35)	40	14(35)	26(65)	10(25)	20	6(15)	20(50)	40	14(35)	26(65)	12(30)	26(62.5)	8(20)	26(50)

	Alor Uno							Ibagwa Agu						
21-25	2	2(17.67)	-	-	-	-	-	4	-	4(13.33)	-	3(12)	-	2(10)
26-30	6	2(17.67)	4(14.29)	-	3(15)	-	3(15)	6	2(20)	2(6.67)	-	1(4)	-	-
31-35	4	2(17.67)	2(7.14)	1(16.67)	1(5)	1(25)	1(5)	6	2(20)	4(13.33)	-	4(16)	-	4(20)
36-40	12	-	12(42.86)	-	10(50)	-	10(50)	8	2(20)	6(20)	1(25)	4(16)	-	4(20)
41-45	10	2(17.67)	8(28.57)	1(16.67)	4(20)	1(25)	4(20)	4	2(20)	2(6.67)	1(25)	2(16)	-	2(10)
46-50	2	-	2(7.14)	-	2(10)	-	2(10)	8	2(20)	6(20)	2(50)	5(20)	2(100)	4(20)
51-60	2	2(17.67)	-	2(33.33)	-	1(25)	-	4	-	4(13.33)	-	4(16)	-	2(10)
< 60	2	2(17.67)	-	2(33.33)	-	1(25)	-	2	-	2(6.67)	-	2(8)	-	2(10)
Total	40	12(30)	28(70)	6(15)	20(5)	4(10)	20(50)	40	10(20)	30(75)	4(10)	25(60)	2(5)	20(50)

1– No. aware that some insects destroy yellow pepper ; 2- No. that can identify at least one pest of yellow pepper; 3- No. that can mention at least two damages done to *C. annum* by a named insect pest.

experienced 1 to 25%, 26 to 50% and 51 to 75% yield reduction in the proportions of 43, 43.29 and 13.8% respectively (Figure 1). No farmer experienced farm yield reduction between 76 to 100%. There was a significant different in the level of farm yield reduction experienced during the time of infestation ($P < 0.05$) in Lejja, Eha-Alumonah and Alor Uno. No significant different existed between the level of farm yield reduction in Edem ($P > 0.05$).

Chemical control strategies were used extensively by the farmers and more by the male farmers than the female farmers (88.8:81.8; 100:73; 100:42.31; 100:79.29; 100:86.6% for male and female in Edem, Lejja, Eha-Alumonah, Alor – Uno and Ibagwa Agu respectively). The farmers used both organic based insecticide(applying palm head husk ashes to the stem and leaves of the plant and application of aqueous extract of leaves and roots of *Azadiracta indica* which were majorly their traditional control strategies) and inorganic based insecticides(spraying a combination of detergent and kerosene mixed with water, DDT, Cypermethin etc). A higher number of female farmers used the organic insecticide (68.18:0; 30.77:0; 30.77:28.57; 22.14:0 and 66.67:0% for female and male in Edem, Lejja, Eha-Alumonah, Alor–Uno and Ibagwa Agu respectively).The cultural control strategies were also practiced more by the females than the males (18.18:11.11; 15.39:0; 57.69:0; 13.57:0 and 13.33:0 for female and male in Edem, Lejja, Eha-Alumona, Alor Uno and Ibagwa Agu respectively. some traditional cultural methods most utilized were Early harvesting of crops where peppers were harvested while they were still green to minimize the effects of rot and fruit cracking, manuring using goats and cow dung, farm sanitation and crop rotation (Table 5).

In the locations, more farmers (71.16-93%) significantly ($P < 0.05$) used chemical treatments, while only 6.66-28.84% applied cultural methods. Chemical control methods were most utilized in Alor Uno, followed by Ibagwa Agu, and Lejja, while cultural control was most utilized in Eha-Alumona, followed by Edem, and Lejja.

More plants were significantly ($P < 0.05$) attacked in communities with a high chemical

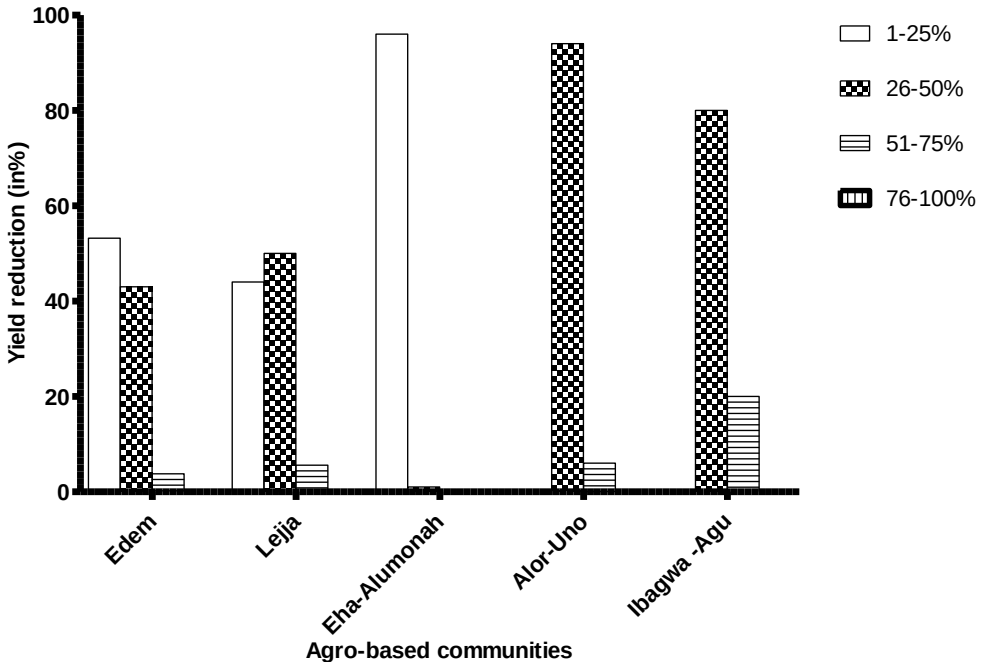

Figure 1. Farmers' perception of percentage reduction in yield from insect infestation in 2015 from the previous year (2014).

control (CH) and low cultural control methods (CC). Thus the highest number of plants attacked (48%) by insects was encountered in Ibagwa Agu, followed by Alor Uno (41%), Edem (32%), Lejja (29%) and Eha-Alumona (27%) with CH to CC ratio of 93:6.66; 98:6.78; 85.3:14.7; 89:15.37 and 71.16:28.84%. The number of pests was higher in communities with high CH and low CC. In communities with high number of predators, lower number of insect pests was encountered, while communities with lower number of predators, higher number of pests was collected (Table 6).

DISCUSSION

The survey of farmers' practices in the cropping of yellow pepper revealed that yellow pepper cultivation was the main source of income of the farmers. Indeed in Nigeria, yellow pepper is the second market gardening crop after tomato (Madu et al., 2005; Assogba-Komlan et al., 2009). In this study, income generated from yellow pepper cultivation was ₦100,000 to 900.000 annually. The cash potentials from this study, combined with previous studies indicating that it is easy to grow, harvest and process, make yellow pepper suitable for use in poverty reduction (Dagnoko et al., 2013). In all the communities sampled a higher percentage of the farmers were females, making women a crucial resource in agriculture and rural economy (FAO, 2011).

The insect pests of yellow pepper probe from Enugu State yielded a greater number of Hemiptera collections than the other orders of insects. Four species belonging to the order Hemiptera were found viz; *M. persicae, A. gossypi, B. tabaci* and *H. schoutedeni,* while two were Coleopterans (*N. sjostdi* and *E. albovittata*), one species for Orthoptera and Diptera each (*Z. variegatus* and *Zonosemata* spp. respectively). One Lepidoptera, *B. betularia* and Thysanoptera*, S. dorsalis* were collected. Praying mantis and Ladybird beetle *H. axyridis* were the only predators collected.

Insect pests have been reported as the main biotic constraints of yellow pepper cultivation (Ingerson-Mahar et al., 2015; Seal and Martin, 2016). Of the 10 insect pests identified, four: *M. persicae, B.tabaci*, *A. gossypii,* and *Z. variegatus* were the prevalent and therefore the major pests of yellow pepper in Nsukka agro-based communities sampled, while *H. schoutedeni, N. sjostedi, S. dorsalis,* E. *albovittata*, *B. betularia* and *Zonosemata* spp were minor pests. This is at variance with an earlier report where *H. schoutedeni* and *N. sjostedi* were the prevalent insest pests of pepper, while *Z. variegatus* was a minor pest (Echezona and Nganwuchu, 2006).

M. persicae which was observed attacking roots, in earlier studies, has been reported as being ubiquitous and attacking nearly130 plant families including pepper (Uzo and Williams, 1989; Helmet, 2013). It causes decreased growth, shriveling of the leaves and the death of various tissues, in addition to transmitting leaf coil and growth distortion denoviruses (Van Munster et al., 2013), while white flies *B. tabaci*, observed attacking leaves and

Table 5. Insect control methods in the agro-based communities

	Sex		Cultural control strategies				Total	Chemical control						No Control
								Organic			Total	Inorganic	Total	
			1	2	3	4		5	6	7		8		
Edem	M	18	-	-	2(100)	-	2(11.11)	-	-	-	-	16(88.88)	16(88.88)	-
	F	22			4(100)		4(18.18)	3(20)	2(13.33)	10(66.67)	15(68.18)	5(22.27)	18(81.8)	-
Lejja	M	14	-	-	-	-	-	-	-	-	-	14(100)	14(100)	-
	F	26	-	1(25)	1(25)	2(50)	4(15.39)	2(22.22)	2(22.22)	4(44.44)	8(30.77)	10(38.46)	19(73.08)	3(11.54)
Eha-alumona	M	14	-	-	-	-	-		1(25)	3(75)	4(28.57)	10(71.43)	14(100)	-
	F	26	2(24.1)	2(24.1)	3(36.14)	1.3(15.66)	15(57.69)	2(25)	1(12.5)	5(62.5)	8(30.77)	3(11.54)	1142.31)	0
Alor uno	M	12	-	-	-	-	-	-	-	-	-	12(100)	12(100)	-
	F	28	1(26.32)	1(26.32)	1.8	-	3.8(13.57)	2.2(35.48)	2(32.26)	2(32.62)	6.2(22.14)	16(57.14)	22.2(79.29)	2(7.14)
Ibagwa agu	M	10	-	-	-	-	-	-	-	-	-	10(100)	10(100)	-
	F	30	1(25)	1(25)	2(50)	-	4(13.33)	3(15)	2(10)	15(75)	20(66.67)	6(20)	26(86.67)	-

1- Early harvesting while fruits were still green; 2- farm sanitation; 3- Manuring using goats, cow dung and chicken droppings; 4- Crop rotation; 5- Farm sanitation; 6- *Elaise guinensis* husk ashes; 7- Aqueous extracts of leaves and seeds of neem (*Azadiracta indica*); 8- Synthetic chemical insecticides.

flowers in this study, have also been reported as vectors of viruses, all of which have led to loss in plant yield (Ingerson-Mahar et al., 2015). *B. tabaci* (silver leaf white fly) is one of the most destructive pests of mainly vegetables and ornamental crop world-wide and has vast host range, polyvoltinism, and short generation time, ability to transmit important plant viruses have contributed to its enormous damage potential (Shadmany et al., 2013).

In addition, *B. tabaci*, is a cryptic species complex with at least 32 biotypes based on the 3.5% divergent limit of the partial mitochondrial cytochrome oxiase subunit 1 (mt CO1) sequence (Dinsdale, 2010; Chowa-Reddy et al., 2012). Among all biotypes, B and Q are the most invasive and the huge losses caused by this pest are almost always associated with these biotypes (Chowa-Reddy et al., 2012). In many cases upon introduction into a region, they establish and partially or completely displace indigenous biotypes (Rao et al., 2011). Both invasive biotypes have already invaded and continue to invade many other countries around the world. Timely identification of the biotypes in Nsukka area can help prevent or reduce huge economic loses. Further studies are recommended to ascertain the biotype(s) in Enugu State and if it is the invasive Q type, quarantine measures can be used to hinder or delay its further spread into other States in Nigeria.

A. gossypii which was found on the shoot of the yellow pepper plants has been earlier reported as a major pest of many crops including pepper and transmits over 50 plant viruses (Blackman and Eastop, 2006).

Z. variegatus was collected from the shoot of the pepper plants in this study and previous studies report *Z. variegatus* as an important polyphagous pest of vegetable and food crops in West and central Africa and in Nigeria, yield loses have been recorded for various crops, including pepper and outside physical damage to leaves and shoots, it also transmits viruses and bacteria (Modder, 1986).

Helopeltis schoutedenti, E. albovittata, S. dorsalis, N. sjostedti collected from shoots (first three pests) and leaf (last pest)have been reported to feed on shoots, branches or whole plants and are known to cause crop failure all over the world, larvae of *B. betularia* and *Zonosemata* spp found in pepper fruits in this study, breed in pepper fruits causing enormous fruit lose (Helmet, 2013).

M. persicae and B. tabaci were more abundant in Ibagwa Agu and Akor Uno than any of the other three sampled communities and may account for the higher number of plants attacked and subsequent loss in yield in this sturdy. In Ibagwa Agu, all the farmers suffered from very high yield loss, 80 and 20% suffered from 26-50% and 51-75% respectively, while in Alor Uno, crop yield loss was also high, 91.9% and 8.1%.

Table 6. Effects of control methods on the numbers of predatory insects, predominant insect pests and plants attacked in the agro-based communities.

Agro-based communities sampled	*Predominant insect pests (% species collection)	*Plants attacked (mean%)	Predatory Insects (%)	Control methods
Ibagwa-Agu	*Myzus persicae* (23.9) *Bemisia tabaci* (22.7) *Aphis gossypii* (23.3) *Zonocerus variegatus* (7.5)	48	*Harmoniaxyridis* (13.2%) *Stagmonantiscarolina* (16.1)	CH(93.34%) CC(6.66%) NC(0%)
Edem	*Myzus persicae* (12.7) *Bemisia tabaci* (11.4) *Aphis gossypii* (13.4) *Zonocerus variegatus* (23.6)	32	*Harmoniaxyridis* (18.9) *Stagmonantiscarolina* (22.6)	CH(85.3%) CC(14.7%) NC(0%)
Lejja	*Myzus persicae* (15.9) *Bemisia tabaci* (16.0) *Aphis gossypii* (18.9)	29	*Harmoniaxyridis* (24.5) *Stagmonantiscarolina* (12.9)	CH(89%) CC(15.39%) NC(6%)
Eha- Alumona	*Myzus persicae* (18.8) *Bemisia tabaci* (22.2) *Aphis gossypii* (28.0) *Zonocerus variegatusi* (22.5)	27	*Harmoniaxyridis* (28.3) *Stagmonantiscarolina* (29.0)	CH(71.16%) CC(28.84%) NC(0%)
Alor-Uno	*Myzus persicae* (27.6) *Bemisia tabaci* (21.1) *Aphis gossypii* (14.1) *Zonocerus variegatus* (7.99)	41	*Harmoniaxyridis* (15.1) *Stagmonantiscarolina* (19.4)	CH(89.65%) CC(6.78%) NC(3.57%)

*Field observations. CH = Chemical Control method; CC= Cultural Control method; NC = No Control.

Yeild loses were lower in Edem, Lejja and lowest in Eha-Alumona, and this correlated with the lower percentage of plants attacked. Lower numbers of the major pests may also have accounted for this reduction in yield lose. This explanation may be plausible for Edem and Lejja, but not for Eha-Alumonah. In Eha-Alumonah, higher numbers of the major insect pest were encountered than Edem and Lejja, but fewer plants and yield loses were recorded in Eha-Alumonah than Lejja and Edem. This may be as a result of the presence of a higher number of the predatory insects in Eha-Alumonah, *H. axyrids* (28.3%) and *Stagmonantis carolina* (29.0%), when compared to the lower numbers in Edem (18.9:22.6% and 18.9:22.6% for *H. axyrids* and S *carolina* for Edem and Lejja respectively). Furthermore, the two communities (Edem and Lejja) with the highest number of plants attacked had the lowest number of predators (Table 3). Communities with high number of predators had low number of the insect pets. The predators may have eaten some of the insect pests reducing their numbers. Praying mantis have been reported in previous studies as large insects that feed on beetles, grasshoppers, wasps, bees, and any insect they can catch Bodson (2014), while *H. axyridis* preys on aphids and scale insects (Emden, 2011).

Chemical and cultural practices were the major control methods utilized by farmers in these communities in this study. The survey also showed that most of the farmers use insecticides to mitigate pests. Chemical insecticides therefore, seems to be the popular pest control method among famers. In assessing the pest management techniques among farmers in Cameroon, West Africa, 92% of the farmers used synthetic pesticides (Abang et al., 2014).

The chemicals utilized for chemical control included organic and inorganic based chemicals. The inorganic based chemicals were DDT, Cypermethrin, detergent and kerosene solution, etc., while the inorganic based chemicals control strategies which were mostly their traditional control methods were *Elaise guinensis* husk ashes sprinkled on the stem and leaves of the plant, aqueous extracts of leaves and seeds of neem sprayed on the plants. Some of these strategies are already being utilized such as soap solution which was reported to be effectively used in the control of *A. gossypii* (Blackman and Eastop, 2006). The use of wood ashes sprinkled around yellow pepper plants and other vegetables kept

away caterpillars and was reportedly used to control insectsin ealier studies (Golob and Webley, 1980). The water extracts of the seeds and the leaves of neem tree were also previously reported by Suhmutter et al. (1984).In addition, in all the localities sampled, more farmers utilized inorganic based insecticides than organic. This study also revealed that communities with high percentage of farmers utilizing chemical control, experienced higher insect pest attack on plants and higher yield loss, and lower numbers of predatory insects. The insects may have become resistant to the insecticides as reported for *B. tabaci* which has developed resistance against almost all groups of insecticides (Rao et al., 2011). Synthetic chemical insecticides have also been reported as affecting non-target organisms. In this study, non- target organisms such as the predators may have been killed by the insecticide, reducing their numbers and off course the number of insect pests eaten. Furthermore, exposure to pesticides is one of the most important occupational risks among farmers in developing countries (Wesseling et al., 2001; Konradsen et al., 2003). Hepatic dysfunctions (El-Demerdash et al., 2001), nephrotoxic effects such as cholinesterase inhibitor poisoning have been reported (Zahm and Blair, 1992). Cancer and even death are more frequent among farmers than the general population (Gertrudis et al., 2001; Mansour, 2004). Furthermore, cytogenetic studies showed an increase in DNA damage and higher chromosomal aberrations (CAs) in exposed farmers compared to the control subjects (Naravaneni, 2007. These adverse effects from synthetic chemical insecticides mandates farmers to explore other eco-friendly, safe and efficacious insect pest control strategies such as organic based traditional chemical control methods and cultural methods. Further studies are necessary to determine the efficaciousness of the traditional organic base chemical control strategies.

A diverse number of cultural methods were used by some of the farmers in this study to control pests, these were early harvesting of crops, (a traditional method of pest control where crops were harvested while they were still green to minimize the effects of rot and fruit cracking). This method also prevented damage by fruit worms which attack pepper fruits when they begin to ripen. In the study also, some farmers claimed that chicken droppings, goat and cow dung have proved useful in plant protection, when sprayed on all green plants of vegetable and fruits. Earlier studies revealed that while the use of animal excrement may increase soil nutrient, and subsequently, increase plant growth, increased rates of poultry droppings, increased aphids (except *B. tabaci*), mired and grasshopper infestations as well as incidences and severities of pepper venial mottle virus (PVMV) symptoms, compared to where no manure was applied; but not (Echezona and Nganwuchu, 2006). Chicken droppings may have selective effects on the insect pests. In this study, the lowest percentage reduction in yield was from the community utilizing the highest percentage of cultural control (Eha Alumnoah). Further studies are needed to ascertain the efficacy of these control measures, indicating the pests that can be effectively controlled by the measure as was indicated for chicken droppings. And also the effects of the cultural control methods on non- target insects especially the predators.

The survey also showed some perceptional gender differences in the derived savannah zone of Eastern Nigeria. Males perceived the pest incidence with an equal importance, while females recognized *Z. variegatus* as one of the major pests. Males used vague attributes like harmful or harmless, while females were more specific e.g gave vivid description of *Z. variegatus* biting off the shoot of the young transplanted pepper plants. A higher percentage of the females used the cultural control methods more than the males such as sprinkling of ash on shoots and leaves, spraying with goats and cow dung, early harvesting, farm sanitation and crop rotation, while the males used chemical insecticides to control the insect pests more frequently. This choice of cultural control amongst the females was not in recognition of the reduced impact on non- target organism, or its sustainable and environment safety measures, but because it was cheap and also easier to use. The females who could afford chemical insecticides used them. A higher number of females than males also observed that yellow pepper farms close to herbaceous fallows were attacked by greater number of *Z. variegatus* than those far away from them and close to the forests. Herbaceous fallows provide favorable breeding sites for *Z. variegatus* (Modder, 1986). This observation made the fallow cultural farming system unpopular among farmers, while crop rotation was encouraged. Crop rotation is the practice of growing a series of dissimilar or different types of crops in the same area in sequential seasons. Among other advantages, it mitigates the build -up of pathogens and pests that often occur when one species is continuously cropped (Francis, 2003). This is especially important as the study revealed that yellow pepper was not intercropped with other crops, therefore monoculture was the major practice among the farmers and pests population and pathogens are commonly built up in mono culture unlike in polyculture (Francis, 2003). Crop rotation is one component of polyculture and should be encouraged amongst the farmers.

Conclusion

It is evident from the investigations, that the farmers in Edem, Eha-Alumona, Lejja, Alor-Uno and Ibagwa-Agu in Nsukka Local Government of Enugu State experience enormous economic loss in yellow pepper cultivation from the infestation of insect pests. Most of them use chemical methods to mitigate insect pests, while only a

few, which were mostly females utilize cultural methods. Some of the communities with a high percentage of farmers practicing cultural control methods had fewer pest and plants attacked, while the predators' numbers were also higher than communities with fewer farmers utilizing cultural control methods. Further research is needed to ascertain the efficacy of the cultural methods. Given the wide array of human health effects from pesticide exposure, cultural control measures should be encouraged, especially crop rotation to avoid a build-up of pests and pathogens.

Conflict of Interests

The authors have not declared any conflict of interests.

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REFERENCES

Abang AF, Kouame CM, Abang M, Hanna R, Fotso AK (2014). Assessing Vegetable Farmer knowledge of Diseases and Insect Pests of Vegetable and Management Practices Under Tropical Conditions. Int. J. Veg. Sci. 20:240 -253.

Assogba-Komlan F, Sikirou R, Sodjinou E, Mensah A (2006). Production durable du piment au Benin. MAEP/INRAB. Référence technico-économique de la production agricole, France.

Blackman RL, Eastop V F (2006). Aphids on the World's Herbaceous Plants and Shrubs: An Identification Guide. Wiley, Chichester P 140.

Bodson L (2014). Campel, Gordon Lindsay, ed. The Oxford Handbook of animals in classical thought and life. Oxford University Press pp. 557-558.

Chowa- Reddy RV, Krankummer M, Seal SE, Muniyappa V, Valad GB, Govindappa MR, Covin J (2012). *Bemisia tabaci* Phylogenetic groups in India and the relative transmission efficacy of tomato leaf curl virus by an indigenous and exotic population. J. Integr. Agric. 11:235-248.

Dagnoko S, Yaro- Diarisso N, Sanogo PN, Adetula O, Dolo- Nantoume A, Gamby-Toure K, Traone-Thera A, Katile S, Diallo-Ba D (2013).Overview of pepper (*Capsicum*spp.) breeding in West Africa. Afr. J. Agric. Res. 8(13):1108-1114.

Denton I, Swarug V (1981). Pepper cultivation and its potential in Nigeria. A paper presented at the 6th African horticultural symposium, Ibadan, Nigeria.

Dias GB, Gomes VM, Moraes TM, Zottich UP, Rabelo GR, Carvalho AO, Moulin M, Goncalves L S, Rodrigues R, Da-Cunha M (2013).Characterization of capsicum species using anatomical and molecular data. Genet. Mol. Res. 28:10-53.

Echezona BC, Nganwuchu OG (2006). Poultry manure application and varietal effects of chilli pepper (*Capsicum* species) on insect pests and diseases in a humid- tropical environment. Agro-Science 5(2):49-58.

El-Demerdash FM, Yousaf MI, Elagamy EI (2001). Influence of paraquat, glyphosphate and cadmium on the activity electrophoretic behaviour (*in vitro*). J. Environ. Sci. Health 36:29-42.

El-Ghoraba AH, Javedb Q, Anjumb FM, Hamede SF, Shaabana HA (2013). Pakistani bell pepper (*Capsicum annuum* L): chemical compositions and its antioxidant activity. Int. J. Food Prop. 16(1):18-32.

Emden HF (2012). Ecology and Behaviour of the Ladybird Beetles (Coccinellidae). John and Sons Ltd. pp. 526-531.

Food and Agriculture Organization (1994). Current Status of *Bemisia tabaci* as a plant pest and virus vector in agro ecosystems worldwide. FAO Plant Prot. Bull. 42(1/2):3-32

Food and agriculture organization (FAO) (2011). FAO STAT database. FAO, Roma, Italy URL http://www.fao.org. Accessed on September 12. 2014.

Francis CA (2003). Advances in the design of resource- efficient cropping systems. J. Crop Prod. 8:15-32.

Gertrudis C, Mario V, Amaldo V, Viviana D, Isolde R, Nicolas H, Gloria C (2001). A rat mammary tumor model induced by the organophosphorus pesticide parathion and malathion, possibly through acetyl cholinesterase inhibition. Environ. Health J. 109(5):211-221.

Helmet van E (2013). Handbook of Agricultural Entomology, Willey-Blackwell 334 p.

Ingerson-mahar J, Eichinger B, Holstrom K (2015). How does pepper weevil (Coleoptera: Curculionidae) become an important pepper pest in New Jersey. Integr. Pest Manage. 6(1):23.

Khan HA, Ayub CM, Pervez MA, Bilal RM, Shahid MA, Ziaf K (2009). Effect of seed priming with NaCl on salinity tolerance of hot pepper (*Capsicum annum* L.) at seedling stage. J. Exp. Bot. 60:77-85.

Konradsen F, Van der Hoek W, Cole DC, Hutchinson GI, Daisley H, Singh S, Eddleston M (2003). Reducing acute poisoning in developing countries-options for restricting the availability of pesticides. Toxicology 192:249-261.

Madu EA, Uguru MI, Ugwoke KI (2005). Inter-relations of Growth and Disease Expression in Pepper using Principal Component Analysis. In Genetics and Sustainable Agriculture. Proceedings of the 30th Annual Conference of the Genetics Society of Nigeria, University of Nigeria (5th-8th September). P. 55.

Mansour SA (2004). Pesticide exposure – Egyptian scene. Toxicology 198:91-15.

Modder WWD (1986). An integrated pest management strategy for the African grasshopper *Zonocerus variegatus.* Niger. Field 51:41-52.

Naravaneni R, Jami K (2007). Determination of AChE levels and genotoxic effects in farmers occupationally exposed to pesticides. Human Experimental. Toxicology 26(9):723-31.

Nwankiti OC (1981). Sterility in intra-specific hybrid of *Capsicum*. Indian J. Genet. 41:200-204.

Rao Q, Luo C, Zhag H, Guo X, Devine GJ (2011). Distribution and dynamics of *Bemisia tabaci* invasive biotypes in central China. Bull. Entomol. Res. 101:81-88.

Seal DR, Martin CG (2016). Pepper weevil (Coleoptera: Curculionidae) preferences for specific pepper cultivas, plant parts, fruit colours, fruit sizes and timing. Insects 7:9.

Shadmany M, Omar D, Muhamed R (2013). First Report of *Bemisia tabaci* (Hemiptera: Aleyrodidae) Biotype Q in Malaysia. Fl. Entomol. 96(1):280-283.

SPSS Inc (2009). Released 2008>SPSS Statistics for windows, Version 17.0, Chicago: SPSS Inc.

Suhmutter H, Ascher KRS (1984). Natural pesticides from the Neem Trees and Tropical Plants .Proceedings from 2nd international Neem conference (Rauischholzhausen).

Segnou J, Amougou A, Youmbi E, Njoya J (2013). Effect of chemical treatments on pests and diseases of pepper (*Capsicum annuum* L.). Greener J. Agric. Sci. 3(1):12-20.

Ugwu DC (1964). This is Nsukka. Second edition.Nigeria printing press, Lagos.

Uzo JO, Williams M (1989). Vegetable Production In The Tropics. Longman publishers, England.

Van Munster A, Dullemans M, Clerivet MV, Vander F (2003). Characterization of a new denovirus infecting the green peach aphid *Myzuzpersicae.* J. Invertebr. Pathol. 84(1):6-14.

Wahyuni Y, Ballester AR, Sudarmonowati E, Bino RJ, Bovy AG (2013). Secondary metabolites of *Capsicum* species and their importance in the human diet. J. Nat. Prod. 10:10-21.

Wesseling C, Aragon A, Castillo L, Corriols M, Chaverri F, De la Cruz E, Keifer M, Monge P, Partanen TJ, Ruepert C, Van Wendel de Joode B (2001). Hazardouspesticidesin Central America. Int. J. Occup. Environ. Health 7:287-294.

Whittaker RH (1972). Evolution and measurement of species diversity. J. Taxon. 21:231-250.
Zamm SH, Blair A (1992).Pesticides and non-Hodgkin's lymphoma. Cancer Res. 52:5485-88.
Zhani K, Hermans N, Ahmad R, Hannachi C (2013). Evaluation of salt tolerance (NaCl) in Tunisian chili pepper (*Capsicum frutescens* L.) on growth, mineral analysis and solutes synthesis. J. Stress Physiol. Biochem. 9(1):209-228.