Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
www.entomoljournal.com
JEZS 2021; 9(6): 60-65

Received: 25-09-2021
Accepted: 27-10-2021

Grandawa MM
Department of Science Laboratory Technology, School of Science, Mai Idris Alooma Polytechnic, P.M.B. 1020, Geidam, Yobe State. Nigeria

Mustapha AU
Department of Science Laboratory Technology, School of Science, Mai Idris Alooma Polytechnic, P.M.B. 1020, Geidam, Yobe State. Nigeria

Maina UM
Department of Crop Protection, Faculty of Agriculture, University of Maiduguri, P.M.B. 1069, Maiduguri, Borno State, Nigeria

Bukar A
Department of Agricultural Technology, Mohamet Lawan College of Agriculture, P.M.B. 1427, Maiduguri, Borno State, Nigeria

Audu S
Sanda Kyarimi Park Zoo, Borno State Ministry of Environment, Maiduguri, Borno State, Nigeria

Corresponding Author:
Mustapha AU
Department of Science Laboratory Technology, School of Science, Mai Idris Alooma Polytechnic, P.M.B. 1020, Geidam, Yobe State. Nigeria

Comparative efficacy of botanicals and synthetic pesticide in the management of tomato fruit-worm; *Helicoverpa armigera* infesting tomato (*Lycopersicon esculentum*) in Maiduguri; Sudan Savanna and Toshia; Sahel savanna Nigeria

Grandawa MM, Mustapha AU, Maina UM, Bukar A and Audu S

Abstract
An experiment was conducted at Lake Alau, Maiduguri of Borno state (11º50ˈ48.9ˈˈ N 13º9.427ˈˈ E), Sudan Savanna and Toshia, Yunusari local government area of Yobe state (13º 14ˈ56ˈˈ N 11º 47ˈ52ˈˈ E); Sahel Savanna Nigeria during the 2020/ 2021 dry season to determine the efficacy of Aqueous neem seed extracts (ANSE) and Mahogany seed extracts (MSE) and compared with cypermethrin (A synthetic pesticide commonly used by farmers in the two zones) in the management of tomato fruit; Helicoverpa armigera infesting tomato. The experiment was laid in randomize complete block design with three replications. The tomato variety Roma VFN was used and it was assigned to the main plot. Four treatments were used: ANSE at 50 grams per liter, MSE at 60 grams per liter, cypermethrin and control (un-treated plots) which were assigned to the sub-plots. Each block has four treatments and each treatment was replicated four times making a total of twelve plots per block. Data was recorded on the number of fruits, number of fruit-worm, number of bored fruits, number of un-bored fruits, weights of bored fruits and weight of un-bored fruits per plot. The results obtained showed significant effect of the botanicals and cypermethrin over the untreated control ($P<0.01$) at both zones. At both locations significantly ($P<0.01$) higher number of fruits, higher number of un-bored fruits, higher weights of un-bored, lower number fruit-worms, lower number and weights of un-bored fruits were recorded in plots treated with cypermethrin which were followed by ANSE, which was followed by MSE. The untreated controls recorded significantly ($P<0.01$) higher number of fruit-worms, higher number and weights of bored fruits. Further research is recommended on the synergistic effects of ANSE and MSE in the management of the fruit-worm on tomato and other vegetables such as garden eggs, etc.

Keywords: *Lycopersicon esculentum, Helicoverpa armigera,* ANSE, MSE, cypermethrin

Introduction
Tomato *Lycopersicon esculentum* is a member of the genus *Solanum* within the family *Solanaceae*. The *Solanaceae* commonly known as the nightshade family also encompasses other important plants such as chilli pepper, eggplant, potato and tobacco. The cultivated tomato originated from south America; Peru but because of its economic importance it is grown worldwide: Middle and South Europe, Asia, African countries and Australia, [1,2]. The popularity of the crop is related to its acceptable flavor, nutritive value, the short life cycle and high productivity [3]. Nigeria is one of the African countries where tomato serves as an important source of nutrient in human diet, the major producing areas lie between latitudes 7.5^0 11"and 25^0 to 30 [4]. In Nigeria, it is mostly cultivated in the semi-arid region during the cool dry season using irrigation. High temperature limits the production of tomato to the cooler period of the year. The crop is cultivated for both cash and as food crops, and generates revenue returns, with net revenue of up to 2.50 million naira per annum [5]. In Nigeria tomato is mainly grown by rural small farm-holders and import of tomato products supplement the local production. Nigeria is the 14th largest producer of tomatoes in the world and 3rd in Africa (Producing 1.51 million metric tons valued at N87 billion; $556.1 million) with a cultivated land area of 264,430 [6]. However, the country imports processed tomato products to the tune of several tones valued at several millions of dollar annually [6]. The reason for such massive import is due to low yield and lack of storage facilities. Not less than 50% of the tomato produced in the country is lost to lack of preservation [7].

Tomato production in Nigeria like many other African countries is constrained by so many problems which results in low production. Among these problems insect pest constitutes a major problem to tomato production which affects all parts of the crop (roots, stems, leaves, and the fruits) and cause crop losses. Tomatoes are naturally found to be attacked by a large number of insect pests from the time plants first emerged in the seed-bed until harvest. Most insect pests of tomato are not host specific, but polyphagous which attack many other alternative crop varieties of the same family *Solanaceae*, such as potato, eggplant and tobacco. However, at any time or place, only a few species of these insects are major pests of economic importance on tomato. One of such insects is the tomato fruitworm, *H. armigera* (Hubner) (Lepidoptera: Noctuidae), which causes heavy fruit losses. Farmers in most tomato producing areas in Nigeria rely on synthetic insecticides to manage the tomato fruit-worm; *H. armigera*. The use of synthetic insecticides is however associated with many problems such as introduction of toxic residues into the food of man and other mammals. It is detrimental to environment, destabilizes the micro-ecosystem by eradicating natural enemies, it leads to the development of resistance by pests and increases pest population levels. Therefore, it is very necessary to control *H. armigera* due to its high economic damage to tomato crop in a way that neither the environment nor human beings and other mammals are harmed. One of such methods is the use of botanicals (pesticides of plant origin) which are considered (with some exceptions) as plant protectants which are environmentally safe and harmless to health. In the present world, botanical insecticides are often applied where the production of safe food stuffs is expected. Safe food stuffs are produced especially by ecological farms. Beside ecological producers, plant insecticides have been used ever more by vegetable producers to provide protection against common greenhouse pests, such as aphids, spider mites, or caterpillars of phytophagous lepidoptera. As a result of these disadvantages, in this study, the efficacy of two botanicals: Mahogany seed extracts (MSE) and aqueous neem seed extract (ANSE) are compared with Cypermethrin (a synthetic insecticide) in the control of tomato fruit-worm *H. armigera*. Mahogany and neem derivatives have been reported to provide broad spectrum control of over 200 species of phytophagous insects [8]. This method shall reduce the farmer's reliance on the synthetic pyrothroids as the only means of controlling tomato pests particularly the Fruit-worm. The objective of this study is therefore, to evaluate the effect of mahogany seed extract, neem seed extracts and cypermethrin in the management of the tomato fruit-worm *H. armigera* in lake alau; Maiduguri of Sudan savanna zone of Nigeria and Toshia; Yunusari of Sahel savannah zone of Nigeria.

Materials and Methods

Location of the experiments

The experiment was conducted at Lake Alau, Maiduguri of Borno state (11º41'36.8" N 13º15'57.8" E), Sudan savanna and Toshia, Yunusari local government area of Yobe state (13º 11'26.2" N 11º 51'33.2" E); Sahel savanna Nigeria during the 2020/ 2021 dry season. The land was cleared, harrowed by a tractor and leveled manually using a hoe.

Experimental design

The experiment was laid in randomize complete block design with three replications. The tomato variety Roma VFN was used and it was assigned to the main plot. Four treatments were used: MSE at 60 grams per liter, ANSE at 50 grams per liter, cypermethrin and control (un-treated plots) which were assigned to the sub-plots. Each block has four treatments and each treatment was replicated four times making a total of twelve plots per block.

Source of materials

The Tomato variety Roma VFN and the synthetic insecticide cypermethrin were purchased from Monday market Maiduguri, Borno state, Nigeria while the neem seeds and mahogany seeds were picked from University of Maiduguri main campus, Maiduguri, Borno State, Nigeria.

Treatments and their application, sowing and other management operations

Land preparation

Land preparation started with clearing, ploughing and harrowing by a tractor. This was done to give fine textured plots suitable for seed sowing. The plots were marked out into 36 plots to accommodate the four treatments.

Transplanting and spacing

Seedlings were transplanted using hand trowel in late afternoons because at this time the rate of transpiration is low. The seedlings were transplanted at a plant spacing of 60cm by 60cm between stands to give a total of 9 stands per sub-plot.

Irrigation

Irrigation was done after every two days. The experimental plots were adequately irrigated every two days to ensure that the soil retains moisture to a reasonable depth.

Weeding

Weeding was done using a hoe at three (3), six (6) and nine (9) weeks after transplanting.

Preparation and application of MSE

Two 50kg bags of mahogany seeds were collected and sun-dried for two days. Thereafter; seeds were grounded to powder by grinder. Four liters of water was added to 240 g of mahogany seeds powder and then boiled for 40 minutes. After cooling down the solution was sieved out using a white fine cloth. The filtered extract was then ready for spraying at a concentration of 60 g/liter of mahogany seeds extract solution using a knapsack sprayer at weekly intervals.

Preparation and application of ANSE

Five 50Kg bags of neem seeds obtained were sun dried and grounded into powder by a grinder. A measurement of the neem seed powder at 50 g were weighed out. These measurements were separately soaked overnight for an hour in one litter of hot water which were allowed to cool down and the solutions were sieved out using a white fine cloth. An application of aqueous neem seed extract at 50 g/ liter of water using a knapsack sprayer was done at weekly intervals.

Data collection

Number of fruits per plant

Number of fruit per each plant was inspected for fruit production once every week and the total number of fruit set per plant per plot was counted and recorded.

Number of fruit-worm per plant
The number of fruit-worm was determined by directly counting the number of fruit-worm from each plant.

Fruit damage per plant per plot
As the fruits begin to ripe, the number of fruits on individual plants, number of fruit-worm larvae per fruit, the number of fruits damaged (bored) per plot, number of undamaged (un-bored) fruits per plot, weight of damaged fruits per plot and the weight of undamaged fruits per plot were assessed physically. The number of bored tomato fruits was counted by carefully separating fruits with holes from those without holes. The bored fruits were counted to determine the number of bored tomato fruits per plot. The weight of fruits that have holes on them (bored) were determined by weighing the total number of fruits that have holes per plot using a sensitive weighing balance. The weight of un-bored tomato fruits was determined by weighing total number of tomato fruits that have no holes per plot using the same sensitive weighing balance.

Data analysis
All the data obtained were subjected to statistical analysis appropriate to completely randomize block (RCB) design analysis of variance (ANOVA). Difference between means were determined using the least significant difference (LSD) Statistic at ($P \leq 0.05$).

Results and Discussion
In this study significant differences exist among the treatments used in the management of tomato fruit worm; *H. armigera* infesting tomato in the two agro-geographical zones.

Number of fruits: Both ANSE, MSE and cypermethrin recorded higher number of fruits over the untreated control. In Maiduguri, (Table 1) significantly higher number of fruits were recorded in the cypermethrin treated plots (93.09^a) and the ANSE treated plots (84.54^a) which were followed by MSE treated plots (77.32^b). Significantly, lower number of fruits were recorded in the untreated control plots (67.17^c). Similar result was obtained in Yunusari, (Table 2) in which significantly higher number of fruits were recorded in the cypermethrin treated plots (72.82^a) and the ANSE treated plots (68.29^a) which were followed by the MSE treated plots (62.18^b) and the untreated controls (59.34^b). This work corresponds with the work of Sharah *et al.*, (2017) [9] who found that ANSE treated sub plots at the rate of 50 g/l recorded significantly higher number of fruits over untreated plots. Smriti *et al.*, (2015) [10] conducted a research and reported that among the botanicals tested significantly higher number of fruits were recorded in the plots treated with neem seed oil at 3.0 m/l of water after three days.

Number of fruit-worm: Data recorded on the mean number of tomato fruit- worm in Maiduguri shows that significantly higher number of tomato fruit worms were recorded in the untreated control (20.18^a) which was followed by MSE treated plots (15.33^b), followed by the ANSE treated plots (7.28^c). Significantly lower number of tomato fruit-worm was recorded in the cypermethrin treated plots (0.88^d), (Table 1). Similar results were obtained in Yunusari (Table 2) in which significantly higher number of tomato fruit worms were recorded in the untreated control (15.36^a) which was followed by the MSE treated plots (12.40^b), followed by the ANSE treated plots (4.20^c). Significantly lower number of fruit – worms were recorded in the cypermethrin treated plots (0.00^d). This finding is in line with the work of Patil *et. al.*, (2018) [11] who found that the botanical pesticide chlorantraniliprole 18.5 SC (0.055%) to be most effective against tomato fruit borer followed by spinosad 45 SC (0.018%) and indoxacarb 14.5 SC (0.0145%) and that azadirachtin 10,000 ppm was observed to be in middle order of their efficacy. Similarly, Shah *et. al.*, (2013) [12] reported in their experiment in which they compared the effect of botanicals with chemical pesticides that minimum number of fruit-worm per plant (0.40 and 0.46) was recorded in neem seed extracts treated plots and emamectin benzoate treated plots while the maximum number of fruit-worm per plant (1.00) was recorded in the untreated controls.

Number of Bored and Un-bored Fruits: Tables 3 and 4 presents data recorded on the mean number of bored and un-bored tomato fruits in Maiduguri and Yunusri respectively. In Maiduguri, significantly higher number of bored fruits were recorded in the untreated controls (14.82^a) while lower number of bored fruits were recorded in the Cypermethrin treated plots and the ANSE treated plots followed by the MSE treated plots which are 6.82^c, 8.44^c and 11.54^b respectively. Similarly, in Yunusari significantly higher number of bored fruits were recorded in the untreated controls (15.24^a) while lower number of bored fruits were recorded in the Cypermethrin treated plots and the ANSE treated plots followed by the MSE treated plots which are 6.18^c, 7.04^c and 10.8^b respectively. Tables 3 and 4 also presents data obtained on the number of Un-bored tomato fruits. In Maiduguri, significantly higher number of un-bored tomato fruits was recorded in the cypermethrin treated plots (58.25^a), followed by the ANSE treated plots (43.41^b) while the MSE treated plots recorded (34.91^c). Significantly lower number of un-bored fruits was recorded in the untreated controls (27.07^d). Similar result was recorded in Yunusari in which cyepermethrin treated plots recorded statistically higher number of un-bored tomato fruits (72.61^a), followed by ANSE treated plots (63.16^b) while significantly lower number of un-bored tomato fruits were recorded in the MSE treated plots and untreated control which were 50.13^c and 44.98^c respectively. This finding corroborates with the work of Shah *et al.*, (2013) [12] who found significantly higher number of un-bored tomato fruits in plots treated with neem seed extracts and lower number of un- bored fruits in the untreated controls. Similarly, Rahman *et. al.*, (2014) [13] conducted a research on the efficacy of botanicals in the control of tomato fruit worm and reported that of the botanicals tested significantly lowest fruit infestation by number and weight was observed in neem seed kernel extract treated plots (27.15%, 22.29%) which was statistically similar to tobacco leaf extract treated plot (27.71%, 23.31%) and cypermethrin treated plots (28.87%, 25.44%). While no significant difference was found among mahogany oil, mahogany seed extract and control treatments.

Weight of bored and Un-bored tomato fruits: Table 5 and 6 shows results obtained on the mean weight of bored and un-bored tomato fruits in Maiduguri and Yunusari respectively. The data obtained shows that in Maiduguri significantly higher weight of bored tomato fruits were recorded in the untreated control (836.95^a) and MSE treated plots (694.60^a), while statistically lower weight of bored tomato fruits were

recorded in the ANSE treated plots and the cypermethrin treated plots which were (420.60[b]) and (322.90[b]) respectively. From this finding it was also revealed that in Maiduguri significantly higher weights of un-bored tomato fruits were recorded in the cypermethrin treated plots (3149.25[a]) which is statistically followed by the ANSE treated plots (2725.10[b]), significantly lower weights of un-bored tomato fruits were recorded in the Untreated control and the MSE treated plots which were (2000.80[c]) and (2291.35[c]) respectively. Similar results were recorded in Yunusari in which statistically higher weights of bored tomato fruits were recorded in the untreated controls and MSE treated plots which were 799.00[a] and 648.50[a] respectively, significantly lower weight of bored tomato fruits were recorded in the cypermethrin and ANSE treated plots which were (400.60[b]) and (462.20[b]) respectively. Significantly higher weights of un-bored tomato fruits were obtained in the cypermethrin treated plots (3028.80[a]) which is followed by the ANSE treated plots (2556.70[b]), while significantly lower weights of un-bored tomato fruits were recorded in the untreated controls and the MSE treated plots which were (1988.00[c]) and (2094.50[c]) respectively. This finding is in conformity with the work of Ahmed *et al.*, (2015) [14] who tested the efficacy of cypermethrin, dimethoate and neem seed extract against tomato fruit worm infesting tomato and reported that plots sprayed with dimethoate had the least weight of holed tomato fruits which is followed by cypermethrin and neem seed extract in both dry and wet seasons, there was no significance difference (P<0.05) between cypermthrin and neem seed extracts with respect to weight of bored and un-bored tomato fruits. Similarly, Shah *et.al.*, (2013) [12] reported that the mean weight of tomato fruits recorded after treatment with neem seed crude extracts (2.5%), turmeric crude extracts (3.5%), garlic crude extracts (5%), heng crude extracts (2.5%) and Thiodan (0.07%) were 7540, 6033, 4800, 5900 and 7300 kg respectively are significantly higher as compared to control plot where the yield of tomato fruit was 3640 kg. The highest yield (7540 kg ha^{-1}) was recorded with neem seed extracts which was non-significant from the yield recorded with the synthetic pesticide thiodan (7300 kg ha^{-1}).

The findings of this work showed that managing tomato fruit worm using neem seed extracts as effective as the synthetic pesticide; cypermethrin. It was also observed in most of the parameters assessed that mahogany seed extracts performed better than the un-treated control even though it is significantly less effective compared to neem seed extract and cypermethrin. Pest control using extract from the neem plant *(A. Indica)*, currently occurs in more than 55 countries throughout the world and neem products have been in use in parts of Asia, such as Buma and India for over 2500 years [12]. It has been reported by various scientists that neem products have several biological effects on insects. Wondafrash *et al.*, (2012) [15] reported that water extract of neem seed and leaf at various concentration levels have extended the larval development period and reduced adult emergence, longevity, fecundity and fertility of *H. armigera*. Among the botanical insecticides tested, neem (*A. indica*) have long been considered as alternative to synthetic insecticides for pest management because they are environment friendly, non-toxic to non- target organisms and non - persistent in nature [16]. Siva *et al.*, (2015) [17] propose an eco-friendly method of *H. armigera* control using the aqueous leaf extract of *A. indica*. The leaf extract of *A. indica* is environmentally benign and the result obtained showed antifeedant activities of (92.40 %) and larvicidal activities of (100 %) against *H. armigera*. Murthy *et al.*, (2004) [19] reported that neem spray effectively reduced *H. armigera* damage in chickpea and yielded 23% more and incurred 15% less cost of production. Furthermore, the neem products apart from being environmentally safe and compatible with other IPM strategies it has the potential to be adopted on broader scale together with other measures, to provide low cost management strategies [20].

Table 1: Effect of MSE, ANSE and Cypermethrin on the mean number of Fruits (NF) and mean number of Fruit-worm (NFW) in Maiduguri

Treatments	NF	NFW
T_1	77.32[b]	15.33[b]
T_2	84.54[a]	7.28[c]
T_3	93.09[a]	0.88[d]
T_4	67.17[c]	20.18[a]
LSD	10.58	3.49

Means followed by the different letter(s) along the column are not statistically different at 5% probability level, NF= Number of fruits, NFW= Number of fruit- worm, T_1 =MSE (60 grams/ liter of water), T_2 =ANSE (50 grams/ Liter of water), T_3 = Cypermethrin (10 ml/ liter of water), T_4 =Untreated control and LSD= Least significant difference

Table 2: Effect of MSE, ANSE and Cypermethrin on the mean number of Fruits (NF) and mean number of Fruit-worm (NFW) in Yunusari.

Treatments	NF	NFW
T_1	62.18[b]	12.40[b]
T_2	68.29[a]	4.20[c]
T_3	72.82[a]	0.00[d]
T_4	59.34[b]	15.36[a]
LSD	7.47	1.58

Means followed by the different letter(s) along the column are not statistically different at 5% probability level, NF= Number of Fruits, NFW= Number of Fruit- worm, T_1 =MSE (60 grams/ liter of water), T_2 =ANSE (50 grams/ Liter of water), T_3 = Cypermethrin ((10 ml/ liter of water), T_4 = Untreated control and LSD= Least significant difference.

Table 3: Effect of MSE, ANSE and Cypermethrin on the mean number of Bored fruits (NBF) and mean number of Un- bored fruits (NUF) in Maiduguri.

Treatments	NBF	NUF
T_1	11.54[b]	34.91[c]
T_2	8.44[c]	43.41[b]
T_3	6.82[c]	58.25[a]
T_4	14.82[a]	27.07[d]
LSD	3.12	7.43

Means followed by the different letter(s) along the column are not statistically different at 5% probability level, NBF= Number of bored fruits, NUF= Number of un-bored fruits, T_1 = MSE (60 grams/ liter of water), T_2 = ANSE (50 grams/ Liter of water), T_3 = Cypermethrin (10 ml/ liter of water), T_4 = Untreated control and LSD= Least significant difference.

Table 4: Effect of MSE, ANSE and Cypermethrin on the mean number of Bored fruits (NBF) and mean number of Un- bored fruits (NUF) in Yunusari

Treatments	NBF	NUF
T_1	10.8[b]	50.13[c]
T_2	7.04[c]	63.16[b]
T_3	6.18[c]	72.61[a]
T_4	15.24[a]	44.98[c]
LSD	2.90	9.36

Means followed by the different letter(s) along the column are not statistically different at 5% probability level, NBF= Number of bored fruits, NUF= Number of un-bored fruits, T_1 = MSE (60 grams/ liter of water), T_2 =ANSE (50 grams/ Liter of water), T_3 = Cypermethrin (10 ml/ liter of water), T_4 =Untreated control and LSD= Least significant difference.

Table 5: Effect of MSE, ANSE and Cypermethrin on the mean weight of bored fruits (WBF) and mean weight of un- bored fruits (WUF) in Maiduguri.

Treatments	WBF	WUF
T_1	694.60[a]	2291.35[c]
T_2	420.60[b]	2725.10[b]
T_3	322.90[b]	3149.25[a]
T_4	836.95[a]	2000.80[c]
LSD	172.50	415.80

Means followed by the different letter(s) along the column are not statistically different at 5% probability level, WBF= Weight of bored fruits, WUF= Weight of un-bored fruits, T_1 = MSE (60 grams/ liter of water), T_2 =ANSE (50 grams/ Liter of water), T_3 = Cypermethrin (10 ml/ liter of water), T_4 = Untreated control and LSD= Least significant difference.

Table 6: Effect of MSE, ANSE and Cypermethrin on the mean weight of bored fruits (WBF) and mean weight of un- bored fruits (WUF) in Yunusari.

Treatments	WBF	WUF
T_1	648.50[a]	2094.50[c]
T_2	462.20[b]	2556.70[b]
T_3	400.60[b]	3028.80[a]
T_4	799.00[a]	1988.00[c]
LSD	184.00	460.88

Means followed by the different letter(s) along the column are not statistically different at 5% probability level, WBF= Weight of bored fruits, WUF= Weight of un-bored fruits, T_1 = MSE (60 grams/ liter of water), T_2 =ANSE (50 grams/ Liter of water), T_3 = Cypermethrin (10 ml/ liter of water), T_4 = Untreated control and LSD= Least significant difference.

Conclusion

It can be concluded from this studies that there is incidence of tomato fruit-worms in both the agro-geographical zones (Maiduguri and Yunusari) and of the two botanicals tested Aqueous neem seed extract is as effective as the synthetic pesticide cypermethrin in the management of the tomato fruit worm. Mahogany seed extract is not as effective as the ANSE and cypermethrin but further studies should be carried out to determine the synergistic effect of ANSE and MSE in the control of tomato fruit worm because of the readily availability of these two botanicals in the two agro-geographical zones and it is also preferable to use botanicals instead of synthetic pesticides since botanicals can degrade rapidly and are less persistence in the environment and pose less toxic effect to mammals, beneficial and non-targeted organisms.

Acknowledgement

We are thankful to Tertiary Education Trust Fund (TETFUND) for giving us the financial support in conducting and publishing this research work.

References

1. Sukhareva IL. “Family Noctuidae,”. in Insects and Acarines as Agricultural pests, Vol 3: Lepidoptera, Part 2, Ed. by V. I Kuznestov (Nauka, St. Petersburg. 1999;3(2):332- 376. [in Russian].
2. Lutwana JJ, Matanni BA. Efficacy of *Bacillus thuringiensis, Kurstakii, Baculorines, heliothis* using foliar applications for suppression of *H. armigera* and other *Lepidopterous* larvae on tomato in south western Nigeria. Journal of Arid Agriculture 1998;15:66-69.
3. Adil HA, Gruda N, Geyer B. Effect of high temperature and heat shock on tomato (*Lycopersicon esculentum* Mill) genotypes under controlled condition. Conference for International Agricultural Research for Development. Deutscher, Tropentag Gootingen, October 8 -10 2003.
4. Umeh VC, Kuku FO, Nwanguma EI, Adebayo OS. Manga A. A survey of the insect pests and Farmers practices in the cropping of tomato in Nigeria. Tropiculture 2002;20:181-186.
5. Kabura BH, Dada YM, Kamai N. Effects of *mulching* materials on irrigation water conservation and weed control on the yield of tomato. (*Lycopersicon esculentum*) in semi- arid region of Nigeria. J Arid Agr. 1999;9:17- 20
6. Oladejo JA, Oladiran JO. Marketing Analysis and Consumption Pattern in Oyo State, Nigeria. International Journal of Agriculture Innovations and Research 2014;2(3):22-29.
7. Chidi A. Tomato, Nutritious Vegetable. Seventeen Nigerian Economic Summit. Manufacturing today in Nigeria. An African post web team 2012, 1-3.
8. Ascher KRS. Non-conventional insecticidal effects of pesticides available from the neem tree, *Azadirachta indica*. Arch. Insect Biochem. Physiol 1993;22:433-449.
9. Sharah HA, Lawan M, Mustapha AU. Effect of tomato variety and aqueous neem seed extracts in the management of the tomato fruit worm; *Helicoverpa armigera* in Maiduguri, sudan savanna, Nigeria. University of Maiduguri, Journal of Agriculture, agricultural economics and extension 2017;2(1):38-49.
10. Smriti SB, Mustafiz MD, Tazul IC, Ayesha A. Efficacy of Some Botanicals in Controlling Fruit Borer (*Heliothis armigera*) in Tomato. Academic Journal of Entomology 2015;8(3):140-149.
11. Patil PV, Pawar SA, Kadu RV, Pawar DB. Bio-efficacy of newer insecticides, botanicals and microbial against tomato fruit borer *Helicoverpa armigera* (Hubner) infesting tomato. Journal of Entomology and Zoology Studies 2018;6(5):2006-2011.
12. Shah JA, Inayatullah M, Sohail K, Shah SF, Shah S, Iqbal T *et al*. Efficacy of botanical extracts and a chemical pesticide against tomato fruit worm, *Helicoverpa armigera* (Lepidoptera: Noctuidae). Sarhad J. Agric 2013;29(1):93-96.
13. Rahman AKMZ, Haque MH, Alam SN, Mahmudunnabi M, Dutta NK. Efficacy of Botanicals against *H. armigera* (Hubner) in Tomato. The Agriculturists 2014;12(1):131-139. ISSN 2304-7321
14. Ahmed IA, Kutama AS, Umma M, Hassan KY, Ibrahim M. Control of Tomato Fruit-worm (Helicoverpa armigera H.) on Tomato using Cypermethrin, Dimethoate and Neem Extracts in Samaru, Zaria, Nigeria. Global Advanced Research Journal of Agricultural Science. 2015;4(2):113-117. (ISSN: 2315-5094), also Available online http://garj.org/garjas/index.htm.
15. Wondafrash M, Emana G, Geremew T. Life-cycle Parameters of African bollworm, *Helicoverp armigera* (Hubner) (Lepidoptera: Noctuidae) affected by Neem, *Azadirachta indica* (A. Juss) Extracts. Agricultural Science Research Journal 2012;2(6):335-345.
16. Isman MB. Botanical insecticides, deterrents and repellants in modern agriculture and in increasingly regulated world. Ann Rev. Entomol 2006;51:45-66.
17. Siva C, Santhosh MK. Pesticidal activity of eco-friendly

synthesized silver nanoparticles using *Aristolochia indica* extract against *Helicoverpa armigera* Hubner (Lepidoptera: Noctuidae). International Journal of Advanced Scientific and Technical Research. 2015;5(2):197-226. ISSN 2249-9954 Also available online on http://www.rspublication.com/ijst/index.html

18. Murthy SD, Krishna PN, Prabhakara BS, Raja ME, Gowdra MJ, Shinvann C. Economic evaluation of neem botanicals to control pests. Proceedings on impact of vegetable research in India. Indian Cur. Agric. Res 2004, 138p.
19. Gahukar RT. Use of neem products/Pesticides in cotton pest management. Int'l. J Pest Mgt 2000;46:149-160.