Asian Journal of Agricultural and Horticultural Research

5(4): 1-8, 2020; Article no.AJAHR.56098
ISSN: 2581-4478

Arthropod Pests and Tomato Value Chain: Review of Research Cocktails in Nigeria

Adeola Abiola Oso[1*]

[1]Department of Plant Science, Faculty of Agriculture and Natural Sciences, University of the Free State, Qwaqwa Campus, Private Bag: x 13, Phuthaditjhaba 9866, Republic of South Africa.

Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

Article Information

DOI: 10.9734/AJAHR/2020/v5i430056
Editor(s):
(1) Dr. Magdaléna Valšíková, Slovak University of Agriculture, Slovakia.
Reviewers:
(1) Mekhloufi Moulai Brahim, University Center of Nour Bachir El-Bayadh, Algeria.
(2) André Ricardo Zeist, Universidade do Oeste Paulista, Brazil.
Complete Peer review History: http://www.sdiarticle4.com/review-history/56098

Review Article

Received 02 February 2020
Accepted 07 April 2020
Published 13 April 2020

ABSTRACT

Background: Tomato is an essential and remunerative staple food widely grown and consumed in all parts of Nigeria. The northern parts of the country produce ninety-eighth percent of the tomatoes consumed annually. However, higher percentages of tomatoes produced in these regions are lost due to gaps recorded in its value chain.
Principal Findings: Tomato value chain needs to be strengthened from production to processing, preservation and good marketing structure. Challenges bedevilling tomato value chain in Nigeria include poor accessibility to production inputs such as seeds, nurseries, fertilizers; poor packing systems and transportation problems; marketing challenges and yield reduction caused by a complex of arthropod pests attacking the crop. The major arthropod pests inflicting economic damage on tomato include fruit borer, whitefly, aphid, thrips and leaf miners.
Interventions: Considering the Nigerian Government's recent interventions: "close border", increased tariffs on the importation, and different incentives such as "tax holiday" and introduction of zero percent import duty on greenhouse equipment, soft loans through Bank of Agriculture as well as a national collaborative effort against the menace of tomato leaf miner (*Tuta absoluta*) invasion; How much of these interjectory efforts have translated to the realization of national self-sufficiency in the tomato value chain?
Conclusion: This paper highlights the general introduction of tomato, its botany, nutritional benefits, tomato value chain in Nigeria, Nigerian government interventions towards its sustainability with particular focus on research cocktails at combating the problems of arthropod pests on the tomato to identify the probable critical solutions to these harmful pests.

**Corresponding author: Email: 2019011440@ufs4life.ac.za, adeola.oso@eksu.edu.ng;*

Keywords: Arthropod pests; cocktails; challenges; Nigeria; tomato; value-chain.

1. INTRODUCTION

Tomato (*Solanum lycopersicum*), is the third world's leading vegetable grown for fresh market and processing [1]. It is a versatile crop of high economic value and is considered as one of the main ingredients in hundreds of dishes and other products all over the world. Global tomato production is currently estimated at around 177 million tons, of which 120 million are bound for the fresh markets and 57 million are processed [2]. Nigeria is currently the second-largest producer of tomato after Egypt in Africa, with an estimated production of 2.3 million tons [3]. The bulk of tomato produced in Nigeria is grown mainly by smallholders' farmers. These farmers cultivate between 0.5 and 4 hectares of land contributing about 90% of the total tomato production, with the balance supplied by commercial producers [4]. Despite the largest area of 541, 800 hectares harvested for tomato in Nigeria, yields are low because of the poor value chain. Nigerian farmers on average generate the lowest yields of about 4 MT/ Ha when compared to countries like Egypt and South Africa which produce 38.7 MT/ Ha and 78.7 MT/ Ha respectively [3]. The poor production practices including cultivation of old varieties, low soil fertility, inadequate weed and pest control and the high post-harvest losses due to poor handling and distribution systems are primarily responsible for the low yield [4,5]. Prominent among these constraints, is the critical challenge posed on tomato production by the diversity of biotic communities including a complex of pests and diseases associated directly with tomato damage, reduction in quality of marketable product and yield losses. Documented prominent insect species attacking tomato in Nigeria include whiteflies, leaf miners, tomato bugs, thrips, fruit borers, aphids, leafhoppers [6,7,8,9]. Diseases include bacterial wilt, fusarium wilt, bacteria canker, early and late blights, powdery mildew, root-knot nematodes and viral infections. The global collapse of natural barriers due to human activities led to the invasion of agro-climates by wild species with attendant significant economic impacts [10]. Among the newly introduced wild species is the leaf miner (*Tuta absoluta*), a highly destructive ruthless and resilient insect pest [11]. It was discovered in Nigeria in the year 2015 and it wiped off thousands of hectares of tomatoes, causing huge and devastating losses to farmers.

2. BOTANY OF TOMATO

Tomato is botanically an edible fruit of the vine but also classified as a vegetable based on its culinary applications [12]. The plant is perennial in its native habitat and typically grows to 1-3 meters in height. Tomato plants are much-branched, spreading 0.6-1.8 m with sprawling weak stems although a few forms are upright and compact [13]. Tomato plants usually have compound leaves and are referred to as regular leave plants; however, some cultivars have simple leaves known as potato leaf due to their resemblance with that particular relative. The leaves are hairy, strongly odorous and about 10 – 25 cm long. The hairs facilitate the vining process, turning into roots whenever the vine's connection to its original root has been damaged or severed. Their petioles comprise of 5-9 leaflets, and each leaflet is up to 8 cm long with serrated margin [14]. The five-petaled flowers are yellow, pendant and clustered. The fruit develops from the ovary, its flesh comprising of pericarp walls and vary in diameter from 1.5-7.5 cm. The fruit colours are usually red, scarlet, yellow, green and sometimes purple. They vary in shape from almost spherical to oval and elongate or pear-shaped. The fruit is made up of hollow spaces full of seeds and jellylike pulp, called locular cavities. The types of locular holes vary among the different cultivated species of tomato. Some smaller cultivars have two cavities; globe-shaped varieties typically have three to five cavities. In contrast, beefsteak tomato has a significant number of smaller holes and paste tomato has very few and small cavities [15].

2.1 Nutritional and Health Benefits of Tomato

Tomato is an essential component of daily diet among Nigerians who consumed it in diverse ways. The fruits are eaten raw in salads; serve as a vital cooking ingredient in many dishes, pickled, and drinks [16]. Tomato is a valuable raw material in processed products such as juice, paste, sauce, dry slices of dehydrated pulp, powder and canned or bottle whole [17,18]. Studies in the areas of the consumption pattern and preference of these processed products have helped in the development and diversification of tomato products in the country [17,19]. Tomato is a crop with a great source of energy and essential nutrients in the diets of humans [8]. It is rich in minerals, essential amino

acids, sugars, dietary fibres and phosphorus. Tomato has a very high nutritional value and contains bioactive substances such as carotenoids (lycopene, β- carotene and lutein), phenolics (flavonoids, phenolic acid and tannins) and vitamins (A, C, E and B). These compounds can be obtained through natural consumption of tomato fruits [20,21] and are reported to positively affect health due to their possession of anti-inflammatory and anti-cancer effects, and prevention of chronic diseases such as diabetes, hypertension and coronary heart disease [22].

2.2 Tomato Value Chain in Nigeria

Major producing areas of tomato in Nigeria lies between latitudes 7.5°N11" and 25°N30", and within a temperature range of 25-34°C [23]. These areas fall mainly in the northern parts of the country namely Kano, Kaduna, Jigawa, Borno, Benue, Gombe, Bauchi states amongst others where off-season traditional and furrow irrigation are practised [24]. Some states like Delta, Oyo, Kwara and Ekiti in the southern parts of the country are also involved in tomato production, but the demand of the populace is not met due to the weak food supply chain. Significant players in tomato value chain system in Nigeria are input suppliers, farmers, marketers and processors [23]. The country would need to cross the hurdles of production, preservation, packaging, transportation and marketing. The production of tomato requires that it should first be raised in the nursery and facilities such as nursery supplies, seeds, fertilizers and greenhouse to enhance its production are not easily accessible to smallholder farmers. Tomato is a highly perishable product, and during harvest season, markets are flooded with tomatoes resulting in gluts and rots of unsold products. The packaging of tomatoes in baskets as it is usually the practice among Nigerian farmers during transportation to the market; leads to huge losses since the majority get crushed. Farmers usually handover these baskets of tomatoes to the middlemen who arbitrarily dictate the price, hence creating marketing hurdle for other consumers and potential retailers.

3. GOVERNMENT INTERVENTIONS

There is an increasing passion in cost-effective interventions to address the high rates of post-harvest losses, as well as some promising practices that can be adopted across the value chain to maximize the shelf life of tomato [4]. The government of Nigeria has put in place several measures to boost domestic production of tomato, improve its value and also attract more investors in the industry. One of such measures is the introduction of a new tomato policy geared at achieving national self-sufficiency. The strategy is aimed at discouraging tomato importation by enforcing high tariffs on tomato concentrate. Another positive development of the plan is the inclusion of tomato production and processing activities in investment incentives. The government's incentives such as zero percent import duty on greenhouse equipment, provision of loans to farmers, installation of solar power cold room, construction of zero energy cooling chambers, and value addition aggregation packing houses, funding of agricultural machinery at a low-interest rate among others are expected to increase investment in the tomato industry. Collaborative partnerships with some private sectors have been explored to improve their business environment for both the smallholder farmers and commercial partners. Hence, connecting them with knowledge, expertise and resources needed to improve tomato production while reducing wastage along its value chain.

4. CRITICAL ARTHROPOD PESTS

The ever-changing nature of the world's climatic conditions due to man's manipulations has dramatically impacted the diversity of biotic communities. Pest's preference for new crops has increased as well as the introduction of new pest species with significant economic impacts [25,26]. Insect pests are the chief biological limitations in tomato production, and they attack the crop at all stages of its growth, causing low yields [27]. Tomato production in Nigeria is constrained by several insect pests including; grasshopper (*Zonocerus variegatus*), fruit borer (*Helicoverpa armigera*), whitefly (*Bemisia tabaci*), leaf hopper (*Amrasca devastans*), leaf miner (*Liriomyza trifolii*), mole cricket (*Gryllotalpa* spp.), tomato aphid (*Myzus persicae*), cotton leafworm(*Spodoptera littoralis*) flower thrips (*Thrips tabaci*)and hadda beetle (*Epilachna dedecastigma*) [6,7,8]. Among the newly introduced pests of tomato is tomato leaf miner (*Tuta absoluta*), a ruthless and highly resilient pest with innate destructive capacity [28].Tomato Fruit Borer (*Helicoverpa armigera*) is the most damaging insect, especially at tomato fruit formation [8,9]. The larval stage is the infective age and it bores and feeds on tomato fruits causing injury. The injury predisposes infested

fruits to fungal and bacterial attack which reduces the fruits to smelly liquid mass [6,29]. *H. armigera* reduces tomato yield and lowers its market value. Losses recorded as a result of infestation by fruit borers have been estimated between 20-50% [30,31]. Whitefly (*Bemisia tabaci*) is also, a polyphagous pest that feeds on various classes of food crops. It feeds on all the aerial parts of tomato plants from early growth stages till the fruit maturation stage resulting in stunting, curling, and yellowing of plant foliage [8]. The insect feeding is characterized by indirectly piercing and sucking of plant saps and transmitting virus diseases such as Tomato Yellow Leaf Curl Virus. Leaf miner (*Liriomyza trifolii*) feeding of tomato leaves by larvae of these flies causes serpentine tunnels on the leaves. Tomato aphids (*Myzus persicae*) also feed on many different types of food crops. They have a piercing and sucking mouthpart with which they remove sap from the tomato plant. Aphids attack the lamina of tomato foliage which results in the reduction of the photosynthetic activity of the plant, thereby affecting crop yield [32,33]. These pests cause damage by sucking plant juices, injecting toxins into the plant, secreting honeydew and transmitting tomato mosaic virus. This viral infection could result in 30-50% yield reduction [8]. Thrips are vectors of virus diseases such as tomato spotted virus. Infested leaves become spotted and pale with lacerate leaf tissues. Thrips feed on flowers causing pre-mature droppings and bud necrosis. Tomato leaf miner (*Tuta absoluta*) is a destructive tomato pest attacking the leaves and feeds voraciously on the plant causing more than 80 percent loss in yield [34]. The pest attacks tomato at all stages of its growth from seedling to till harvest. Feeding damage is done when the larvae penetrate the leaf and feed on the mesophyll parts of leaves. This results in irregular mines on the leaf surface, negatively affecting the photosynthetic capacity of the plant, and potentially decreasing the plant's ability to defend itself from other harmful agents. Under severe attack, the leaves have a burnt appearance [35]. Mature larvae of the pest also bore into tomato stem and fruit creating galleries which serve as entry routes for secondary infection by the pathogen [36]. A state of emergency in tomato sector was declared across the country in 2016 due to the ravaging of many tomato farms by this noxious pest [37,38]. The attack by tomato leaf miner led to an astronomical increase in the price of tomato [39]. The loss was high in the tomato value chain from the labourers picking the fruit to basket makers to the loaders to the transporters to the network of middlemen in the market to the retailers of tomatoes to the individual consumers and the food restaurants.

5. RESEARCH COCKTAILS

Several pest management tactics have been documented in the control of insect pests attacking tomato in Nigeria [6,29,40,41,42]. These management cocktails range from farmers application of their traditional indigenous knowledge, cultural/ husbandry practices, chemical control, use of resistant cultivars, botanical control, biological control and integrated approach combining two or more of the mentioned approaches. Each of these approaches comes with unique benefits and limitations in the advancement of pest control. Farmers' indigenous knowledge cum cultural control is the oldest method used in the management of the pest population. However, these approaches have been de-emphasized because they are mostly dependent on detailed knowledge of bio-ecology of the crop-pests-natural controls-environment relationships, most of which in the past, were poorly understood. The chemical control approach, though documented as the most effective, environmentally stable, dose/ concentration potent but could be toxic, scarce, costly, environmentally unsafe, and bio-accumulate on food products [29]. In the same vein, the alternative natural pesticides documented as readily available and eco-friendly has often contended with the problem of environmental instability and dose dependency [43,44]. Although the biological control approach has also been documented eco-friendly, environmentally stable, compatible with other pest control methods, could be limited with the challenge of culturing the organism. Below are the syntheses of different researches in the control of tomato insect pests in Nigeria.

Control of *Helicoverpa armigera*, *Myzus persicae* and *Bemisa tabaci* has been pretty difficult with a single potent toxicant. These pests exhibit high fecundity, polyphagous nature, cross-resistance to insecticides. Smallholder farmers prefer to intercrop tomato with other crops such as maize, cassava, yam, cabbage, lettuce, pea, carrot, pepper, onion, and other leafy vegetables to reduce pest damage [6,40]. The efficacy of asthma plant, *Mitracarpus villosus Balanites aegyptiaca* was compared to the conventional synthetic, cypermethrin in the management of *H. armigera* [41]. They reported that

cypermethrin was most effective in protecting the tomato fruits against *H. armigera* infestation and damage. However, some levels of repulsion in boring and feeding activities of *H. armigera* were recorded in plants treated with aqueous extracts of the plants. Kharia et al. [27] reported that insecticides like nimbecidine, malathion, cypermethrin, spinosad can be suitably incorporated as an active chemical control tool in integrated pest management schedule against *H. armigera*. In a field studies conducted in Gombe state, one of the major tomato producing areas, Silas et al. [45] evaluated the effects of three aqueous plant extracts (*Balanites aegyptiaca, Momordica balsamina and Mitracarpus villosus*) on *Helicoverpa armigera*. Among the three plants, *M. balsamina* significantly reduced infestation by *H. armigera* as well as increased tomato yield. In the same Gombe state, Degri et al. [42] investigated the effects of cultural practices on the infestation and damage of the major insects of tomato. They found *H. armigera*, *M. persicae* and *B. tabaci* as the predominant insect pests attacking tomato in the area. Their reports recommended that cultural practices; increased plant spacing and weeding frequencies have ample potential for insect pest reduction and improved tomato productivity. Cypermethrin, dimethoate and neem extracts were investigated for their efficiency in the control of tomato fruit worm. Dimethoate was the most effective probably due to its systemic potential; however, the neem extracts compared effectively with cypermethrin in the reduction of the pest [29]. The impact of intercropping maize and tomato on the infestation by *H. armigera* effectively controlled the pest [46]. Martine [47] reported that in a maize-tomato intercrop, adult whitefly and fruit borer presence were decreased and fruit quality was better.

6. CONCLUSION

The synthesis of the literature on efforts to combat arthropod pests attacking tomato production in Nigeria identified *H. armigera*, *M. persicae* and *B. tabaci* and the recently invasive *T. absoluta* as major arthropod pests which pose a threat to tomato production in Nigeria. These array of pests are of economic importance in tomato value-chain because their direct feeding on tomato fruit reduces yield and lowers its market value. Damage on tomato fruit results in income loss for the tomato producer who is a significant participant in the tomato value chain. For the moment, management of these pests relies nearly exclusively on the intensive use of chemical pesticides which have been proven hazardous to humans and other biotic life in the ecosystem. Government agencies and policymakers should explore with researchers the locally available biopesticides and produce formulations with lethal effects on destructive arthropod pests and sub-lethal effects on beneficial arthropods. Awareness should also be raised among the tomato farming communities to integrate highly selective low-risk pest control products, with homemade products of plant origin. The highly selective low-risk product could also be integrated with specific cultural practices that would conserve native natural enemies of these pests within a holistic IPM strategy.

ACKNOWLEDGEMENT

The author acknowledges The University of the Free State for facilitating access to bibliographic databases.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Shiberu T, Getu E. Experimental analysis of ecomomic action level of tomato leafminer, *Tuta absoluta* Meyrick (Lepidoptera: Gelechiidae) on tomato plant under open field. Advances in Crop Science and Technology. 2018;6(1): 1–5.
2. FAO. FAOSTAT. Food and Agriculture Organization of United Nations; 2016.
Available:http://faostat.fao.org/default.aspx
3. FAOSTAT 2014, Global tomato production in Rome, FAO; 2012.
4. Sahel Research. The tomato value-chain in Nigeria. Sahel Newsletter. 2015; 15.
5. Arah IK, Kumah EK, Anku E, Harrison AH. An overview of post-harvest losses in tomato production in Africa: Causes and Possible Prevention Strategies. Journal of Biology, Agriculture and Healthcare. 2015; 5(16):78-88.
6. Umeh VC, Kuku FO, Nwanguma EO, Adebayo OS, Manga AA. A survey of the insect pest and farmers' practices in the cropping of tomato in Nigeria. Tropicultura. 2002;20:181-186.

7. Imam TS, Yusuf AU, Mukhtar MD. A survey of some insect pests of cultivated vegetables in three selected irrigation areas along Jakara River, Kano, Nigeria. Int. J. Biol. Chem. Sci. 2010;4(2): 400-406.
8. Mailafiya DM, DegriMM, Maina YT, Gadzama UN, Galadima IB. Preliminary studies on insect pest incidence on tomato in Bama, Borno State, Nigeria. International letters of Natural Sciences. 2014;5:45-54.
9. Oladokun JO, Ayo-John EI, Odedara OO. Influence of ambient ecology and cypermethrin insecticide on aphids population density, virus disease incidence and yield of two tomato (*Solanum lycopersicon* L.) cultivars. Nigeria Journal of Plant Protection. 2017;31:1-16.
10. Tonnang HEZ, Mohamed SF, Khamis F, Ekesi S. Identification and risk assessment for worldwide invasion and spread of *Tuta absoluta* with a focus on Sub-Saharan Africa: Implications for phytosanitary measures and management. PLoS ONE. 2015;10(8):e0135283.
11. Bawin T, Dujeu D, De Backe L, Francis F,Verheggen J. Ability of *Tuta absoluta* (Lepidoptera: *Gelechiidae*) to develop on alternative host plant species. Can Entomol. 2015;1-9.
12. Abadi M. A tomato is actually a fruit – it's a vegetable at the same time. Business Insider; 2019.
13. Encyclopaedia of life. *Solanum esculentum* – Tomato; 2014.
14. Acquaah G. Horticulture: Principles and practices. New Jersey: Prentice Hall; 2002. [ISBN: 978-0-13-033125-0]
15. Lee E, Sargent SA, Huber DJ. Physiological changes in roma-type tomato induced by mechanical stress at several ripeness stages. Hort Science. 2007;42(5): 1237-1242.
16. Ibitoye DO, Akin-Idowu PE, Ademoyegu OT. Agronomic and Lycopene evaluation in tomato (*Lycopersicon esculentum* Mill.) as a function of genotype. World Journal of Agricultural Sciences. 2009;5(S):892-895.
17. Adeoye I, Aderibigbe O, Amao I, Egbekunle F, Bala I. Tomato products' market potential and consumer preference in Ibadan, Nigeria. Scientific Paper Series Management, Economic Engineering in Agriculture and Rural Development. 2017; 17(4):9-16.
18. Li Y, Wang H, Zhang Y, Martin C. Can the world's favorite fruit, tomato, provide an effective biosynthetic chassis for high-value metabolites? Plant Cell Rep. 2081b; 37:1443–1450.
DOI: 10.1007/s00299-018-2283-8
19. Abba A, Musa S.A. Tomato commodity chain analysis in Kano river irrigation project, Nigeria. Project report, ADENI French Embassy/NAERLS, Zaria, Nigeria; 2004
20. Giovannetti M, Avio L, Barale R, Ceccarelli N, Cristofani R, Lezzi A, Mignolli F, Picciarelli P., Pinto B, Reali D, Sbrana C, Scarpato R. Neutraceutical value and safety of tomato fruits produced by mychorrizal plants. British Journal of Nutrition. 2012;107:242-251.
21. Martí R, Roselló S, Cebolla-Cornejo J. Tomato as a source of carotenoids and polyphenols targeted to cancer prevention. Cancers (Basel). 2016;8:E58.
DOI: 10.3390/cancers8060058
22. Li J, Tao X, Li L, Mao L, Luo Z, Khan ZU., et al. Comprehensive RNA-Seq analysis on the regulation of tomato ripening by exogenous auxin. PloS One. 2016a; 11:e0156453.
DOI: 10.1371/journal.pone.0156453
23. Ugonna CU, Jolaoso MA, Onwualu AP. Tomato value-chain in Nigeria: Issues, challenges and strategies. Journal of Scientific Research and Reports. 2015;7 (7):201-515.
24. ATA. Overview of Tomato production and ATA intervention in Nigeria. Agricultural Transformation Agenda (ATA); 2012.
Available:http://www.fmard.gov.ng/index.php/issues-in
25. Oso AA, Borisade OA. Pest profile and damage assessment of three landraces of eggplant (*Solanum* spp.) in Ekiti State, Nigeria. European Journal of Physical and Agricultural Sciences. 2016;5(1):21-28.
26. Zeist AR, Silva AA, Resende JTV, MalufWR, Gabriel A, Zanin DS, Guerra EP. Tomato breeding for insect pest resistance. In: Recent advances in Tomato Breeding and Production. 2018;1-20.
27. Kharia PM, Kumar R, Kumar V. Evaluation of different management schedules against fruit borer, *Helicoverpa armigera* on tomato. Int. J. Curr. Microbiol. App. Sci. 2019;8(4):477-484.

28. Dias DM, Resende JTV, Zeist AR, Gabriel A, Santos MH, Vilela NC. Resistance of processing tomato genotypes to leaf miner (*Tuta absoluta*). Horticultura Brasileira. 2019;37(1):40-46.
29. Ahmed IA, Kutama AS, Umma M, Hassan KY, Ibrahim M. Control of tomato fruitworm (*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.
30. Karabhantanal SS, Awaknavar JS. Bio intensive approach for the management of tomato fruit borer, *Helicoverpa armigera* (Hubner). Pest Management in Horticultural Ecosystems. 2012;18(2):135-138.
31. Junior JF, Resende JTV, Silva AA, Gabriel A, Zeist AR, Favaro R, Nascimento DA, Zeist RA, Camargo CK. Resistance to *Helicoverpa armigera* mediated by zingiberene and glandular trichomes in tomatoes for industrial processing. Genetic and Molecular Research. 2018;17(2): gmr16039907.
32. Hill DS, Walker JM. Pests and disease of tropical crops. Scientific and Technical, Longman, U.K. 1998;2:432.
33. Silva AA, Carvalho RS, Andrade MC, Zeist AR, Resende JTV, Maluf WR. Glandular trichomes that mediate resistance to green peach aphid in tomato genotypes from the cross between *S. galapagense* and *S. lycopersicum*. Acta Scientiarum Agronomy. 2019;41:e42704. Avialable:https://doi.org/10.4025/actasciagron.v41i1.42704
34. Borisade OA, Kolawole AO, Adebo GM, Uwaidem YI. The tomato leafminer (*Tuta absoluta*) (Lepidoptera: *Gelechiidae*) attack in Nigeria: Effect of climate change on oversighted pest or agro-bioterrorism? Journal of Agricultural Extension and Rural Development. 2017;9(8):163-171.
35. Biondi A, Guedes R, Wan F. Ecology, worldwide spread and management of the invasive South American tomato pinworm, Tuta absoluta: Past, present and future. Annual Review of Entomology. 2018;63: 239–258.
36. Campos MR, Biondi A, Adiga A, Guedes RNC, Desneux N. From the Western Palaearctic region to beyond: *Tuta absoluta* 10 years after invading Europe. Journal of Pest Science. 2017;90(3):787–796.
37. Sanda NB, Sunusi M, Hamisu H, Wudil B, Sule H, Abdullahi A. Biological invasion of tomato leaf miner, *Tuta absoluta* (Meyrick) in Nigeria: Problems and management strategies optimization: A review. Asian J. Agric. Hortic. Res. 2018; 1:1–14.
38. Mansour R, Brévault T, Chailleux A, Cherif A, Grissa-Lebdi K, Haddi K, Mohamed SA, Nofemela RS, Oke A, Sylla S, Tonnang HEZ, Zappalà L, Kenis M, Desneux N, Biondi A. Occurrence, biology, natural enemies and management of Tuta absoluta in Africa. Entomologia Generalis. 2018;38:83–112.
39. FAO. Quarterly early warning bulletin of food and agriculture. FAO, Rome; 2015.
40. Ofuya TI. Observations on insect infestation and damage in cowpea (*Vigna unguiculata*) intercropped with tomato (*Lycopersicon esculentum*) in a rain forest area of Nigeria. Cambridge University Press. 1991;27(4):407-412.
41. Degri MM, Mailafiya MD. Potentials of *Mitracarpus villosus* (L.) and *Balanites aegyptiaca* (Del.) plant extracts and Cypermethrin in the management of tomato fruit worm (*Helicoverpa armigera* Hubner) damage in Maiduguri, Nigeria. International Journal of Agricultural Research, Sustainability and Sufficiency. 2013;1(1):1-6.
42. Degri MM, Samaila AE, Oaya CS. Effects of weeding frequency and plant spacing on the infestation and damage of the major insect pests of tomato (*Solanum lycopersicum* l.) African Journal of Agriculture Technology and Environment. 2019;8(1):124-132.
43. Alao FO, Adebayo TA. Comparative toxicity of botanical and synthetic insecticides against major field insect pests of cowpea (*Vigna unguiculata* (L) walp). Jouralof Natural Plant Resources. 2011;1 (3):SL–95.
44. OsoAA, Okunoye JA. Efficacy of turmeric (*Curcuma longa*) and lambdacyhalothrin on insect pest infestation and performance of okra in Ado-Ekiti, Nigeria. Asian Journal of Advances in Agricultural Research 2019;11(4):1-6.
45. Silas L, Degri MM, Zakaria D. Effects of three aqueous plant extracts in the control of tomato fruit worm (*Helicoverpa armigera* Hubner) (Lepidoptera: *Noctuidae*) in Gombe, Sudan Savannah of Nigeria. Journal of Environmental Issues and

Agriculture in Developing Countries. 2011; 3(2):110-115.

46. Degri MM, Samaila AE. Impact of intercropping tomato and maize on the infestation of tomato fruit borer [*Helicoverpa armigera* (Hubner)] Journal of Agricultural and Crop Research. 2014;2 (8):160-164.

47. Martine VW. Intercropping of annual food crops. Agromisa, Agro. Brief. 2011;4:1-10.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/56098