BOTANICAL INSECTICIDES: THE WAY TO GO FOR SUSTAINABLE ENVIRONMENTAL MANAGEMENT

[1]*George-Onaho, J. A.., Ete, J.A., Ayandokun, A.E. and Agboola, I.S.
Forest Protection and Conservation Department, Forestry Research Institute of Nigeria,
P.M.B. 5054, Jericho Hills, Ibadan, Nigeria.
**jokafor95@yahoo.com*

Abstract
The menace of insect pests have been a major challenge in agriculture and public health, and the need for its control without damaging the environment have been the focal point in recent years. Over the years, excessive dependence on agrochemicals in combating insect pests problems have been employed however, interest in using insecticides of plant origin for pest control has increasedin the last few decades owing to the drawbacks of conventional synthetic insecticides on agro ecological systems. Here, we review the drawbacks of synthetic insecticides and the potentials inherent in botanical insecticides as a tool for effective insect pest management and sustainable environment.

Key word: *Botanical Insecticides, Sustainable Environment, Insect Pest, Synthetic Insecticide*

Introduction
Insects are the most diverse group of organism, their diversity and success is attributed to their ability to adapt to almost all environments. They have invaded human habitations causing severe havoc to human and livestock as many have been implicated as pest of plants and animals and as vectors of diseases. Although many insects are considered harmless and some beneficial, their presence especially in large numbers are nuisance to human and livestock. Merriam-Webster dictionary (2012), defined a pest as a plant or animal detrimental to humans or human concerns. This definition encompasses all human concerns such as agriculture, livestock production and public health. Pest insects can cause a huge economic loss to food production as they can ravage a whole field, as well as in storage.

Insects can easily become a nuisance, causing severe havoc in large numbers owing to their short generation time and high fecundity and thus, the need for their control or better still, the outright elimination of these pests have become an issue of major concern to the entomologists as they explore various control strategies. Several control practices which include cultural practices, biological control, and chemical control among others have been utilized. Chemical control (Insecticides) have been the most used control option as it is readily available, long lasting in its effects and more drastic in keeping insect pest population below the economic injury threshold.

Synthetic Insecticide Use and Resistance
The introduction of insecticide brought a lot of relieve to human as a means to overcome the numerous challenges of pest insects. Van Emden *et al*. (2006) attributed the increase in agricultural productivity in the 20th century to insecticide use. The United States Environmental Protection Agency (2016) described insecticides as chemicals used in the control of insects by killing them or preventing them from engaging in behaviours deemed undesirable or destructive. These encompass chemicals such as the insect growth regulators which do not kill outrightly, but hamper their development and some other insecticides which act as repellants and feeding deterrents. The growth of synthetic insecticides accelerated with the discovery of DDT (Dichlorodiphenyl trichloroethane) by Paul Müller in 1939, an organo chlorine which was later replaced by the organo phosphates and the carbamates as a result of their persistence in the environment.

The benefits of Insecticides use cannot be over emphasized but, these benefits come with a cost as these insecticides, particularly the synthetic ones which are not easily degraded persists in the environment thus, acting as a selection pressure on the insect population. Subsequently, new biotypes that can survive insecticide exposure evolve due to natural selection as proposed by Darwin. From the time Melander reported the first case of resistance by scale insects in 1914; over 500 pests have been reported to have developed resistance to one or more insecticides worldwide. Emmanouil*et al.* (2015) reported resistance of the destructive tomato borer *Tutaabsoluta* to diamide insecticides which were highly effective in the control of lepidopteran pests, and to other insecticides, including methamidophos (organ phosphate), permethrin (Pyrethroid), cartap (organsulfur). In the western world, cotton production have been greatly hampered by insect pest attacks one of which is the bud worm *Heliothisvirescens* and have been an issue of global concern as it has evolved resistance to almost all insecticide used leading to the introduction and commercialization of transgenic plants (Bt) in 1996 but the success of Bt toxins were also short lived because just as the persistence of synthetic insecticides encouraged resistance, the round the clock protection provided by Bt technology also fostered resistance as resistance have been recorded (Tabashnik *et al*., 2013, 2014;Farias *et al*., 2015; Jakka *et al*., 2015; Monnerat *et al*., 2015;Oceloti *et al.*, 2015); Santos-Amaya *et al.* (2016).Similarly, in the health sector, the WHO malaria eradication programme have been seriously hampered due to malaria parasite and mosquito resistance to almost all drugs and insecticides introduced (WHO 2016). The mechanisms of resistance employed by these insects include behavioural, penetration, metabolic and target site alteration resistance mechanisms.

Health and Environmental Impact of Synthethic Insecticide

Insecticides use have undoubtedly improved insect vectors and pests management with attending improvement in human and livestock wellbeing as well as increase in agricultural productivity. More so, its uses has become a common practice in the world today as the usage is not restricted to agriculture alone but abound everywhere in homes, offices, schools, parks etc. Thus, can be found in foods, air, water, soil and insecticides been toxic can result to serious health issues when exposed to enough of it. Moreover, most insecticides are persistent and have been listed as part of the "Persistent Organic Pollutants" (POPs) and Gilden *et al.* (2010) reported that nine of the twelve initially recorded most dangerous and persistent chemicals are pesticides causing several environmental issues.

Persistent organic pollutants (POPs) as defined by *Ritter et al,(2007) are* compounds that are resistant to environmental degradation by chemical, biological, and photolytic processes thus, are persistent in the environment and often linger years after restriction. Because of their persistence, POPs tend to bio accumulate in the fatty tissues of organisms and are also capable of long range transports which are potentially detrimental to human and the environment. These effects were the bane of discussion at the 'Stockholm Convention on Persistent Organic Pollutants' in 2001 aimed at regulating the production of these chemicals. The presence of POPs even in places where they have never been used like in the Arctic Circle and Antarctica, as reported by Beyer *et al.,* in 2000 confirms the long range transport ability of these chemical and Kelly *et al.*(2007)describing this phenomena said that the POPs under certain environmental conditions volatilize from soils, water bodies and vegetations into the atmosphere, resisting breakdown in the air, to travel long distances before they are re-deposited.

Several health problems have been attributed to insecticide exposure, among the most reported include leukemia and other types of cancers (Gilden *et al.,* 2010;*Chenet al., 2015*), fetal defect and death Winchester *et al. (*2009), neurological disorders Baldi *et al.* (2011), asthma Amaral, (2014), among others. These health effects are dependent on the toxicity of the insecticide, amount, and duration of exposure and the general health status of an individual as certain individuals like children, pregnant women, sick and the aging populations may be more sensitive to the effects of insecticide than others NPIC (2015). Insecticides use also raises a number of environmental concerns as over 98% of sprayed insecticides reach a destination other than their target species and this includes non-target species, water, soil and air causing varying degrees of contamination Miller, (2004). These environmental concerns include; decline in biodiversity, biological magnification and global distillation (Castro *et al.* 2010; Quinn, 2012; Schenker *et al.,*2014) among others.

Botanical Insecticides, Panacea to Our Fast Degerading Environment

In recent years, with emphasis on sustainable environment, advocacy for organic farming system and integrated pest management approach which encourages the use of ecologically based pest control options in response to the negative impacts of synthetic insecticides on our environment have been on EPA, (2016). More so, with the requirement of some countries for no pesticide residues in agricultural products, Coulibaly, *et al.* (2007) opined that safer alternatives to managing pests should be encouraged. Therefore, an ideal insecticide which will meet the current need and that of the foreseeable future must be specific, non-toxic to mammals, biodegradable, less disposed to insect pest resistance and comparatively less expensive. The use botanical insecticides from crude extract of plants with insecticidal potentials as safer alternative to managing pests problems have been proposed as plants contain several allelo chemicals that have been proven effective in insect pest control (Amoabeng et al., 2013; Silva Diniz *et al*., 2014; Esmaeiliand Asgari, 2015).

Botanical insecticides are organic pesticides derived from plants and minerals that have naturally occurring defensive properties. They have proven to be more useful than conventional insecticides and better for the environment as they are biodegradable. The half-life of neem in the soil and water is 3-44days and 48hours -2.5 days respectively Bond *et al.(*2012) as opposed to 7-120 days in the soil reported for chlorpyrifos Christensen *et al.* (2009). Thus, have little lasting effects as they are easily degraded into harmless compounds naturally or by UV exposure. Use of plant parts with insecticidal properties have been reported from all over the world and their effectiveness cuts across insects of public health importance, field as well as stored products pests. In Nigeria, botanical insecticides have been extracted from various plants including *Azadiractaindica*, *Chrysanthemum cinarariaefoliun*, *Nicotianatobacum*, *Carica papaya,Lycopersiconesculentum*, *Anarcardiumoccidentale*, *Allium sativum*, *Aframomummelegueta*, *Hyptissauvolens*, *Allium cepa*, *Ocimumbasilicum*,*Zinigiberofficinale*, *Vernoniaamygdalina*, *Chromolaenaodorata*, *Uvariaafzelli* just to mention a few Iyang and Asemota, (2015) and their biological properties tested and found to include insecticidal, repellent,antifeedant, growth regulatory, oviposition inhibitory, and sterility inducing effects against insect pest War *et al*. (2014).

The most reported botanicals in pest management include *Jathrophacurcus*(Umoetok *et al*., 2015; Ojiako *et. al*., 2015;Jyothna *et. al.,* 2015; Negbenebor *et al*., 2015).*Azadirachtaindica* (Ileke and Ogungbite2014; Nwankwo *et al.,* 2016),*Tithonia diversifolia*(Odeyemi*et al*. 2014; Wachira*et al*. 2014;Wanzala*et al.,* 2014; Onekutu *et. al.,* 2015;Pitan *et. al.,* 2015; Popoola *et. al.,* 2018) and *Chromolaenaodorata* (Lawal *et. al.,*2015; Udebuani *et. al.,* 2015; Ezena, 2016; Afolayan *et. al.,*2016). Several studies have also compared them to conventional insecticides and have reported them as effective substitute to conventional insecticides Hameed *et. al.*, (2011); Ojiako *et. al*. (2015).

Conclusion

In spite of the wide-spread recognition of insecticidal properties of plants, few commercial products obtained from plants are in use and botanicals used as insecticides presently constitute only 1% of the world insecticide market Rozman *et. al.(* 2007). Commercial availability of these environmentally friendly alternatives will help phase out the unfriendly ones. Thus, government and stake holders should ensure that researches on the effectiveness of these botanical insecticides do not end up on library shelves but transformed into ecofriendly products on supermarket shelves. More so, more stringent laws must be promulgated to help rid our environment of these toxic chemicals.

References

Amoabeng,B.W., Gurr, G.M., Gitau, C.W., Nicol, H.I., Munyakazi, L., Stevenson, P. C. (2013). Tri-Trophic Insecticidal Effects of African Plants against Cabbage Pests.*PLoS ONE* 8(10): e78651.

Amaral, André F. S. (2014). "Pesticides and Asthma: Challenges for Epidemiology". *Frontiers in Public* Health2.doi:10.3389/fpubh.2014.00006.

Baldi, I., Gruber, A., Rondeau, V., Lebailly, P., Brochard, P., Fabrigoule, C. (2011). "Neurobehavioral effects of long-term exposure to pesticides: results from the 4-year follow-up of the PHYTONER Study". *Occupational and Environmental Medicine,*68 (2): 108–115.

Beyer, A., Mackay, D., Matthies, M., Wania, F., Webster, E. (2000).Assessing Long-Range Transport Potential of Persistent Organic Pollutants. *Environmental Sciences & Technology*.34:699-703.

Bond, C., Buhl, K., Stone, D. (2012). *Neem oil general fact sheet*; National Pesticide Information centre, Oregon State University Service.

Castro, Peter and Michael E. Huber (2010).*Marine Biology*. 8th edition, New York: McGraw-Hill Companies Incorporated., 2010. Print.

Chen, M., Chang, C.H., Tao, L., Lu, C. (2015). "Residential Exposure to Pesticide During Childhood and Childhood Cancers: A Meta-Analysis.". Pediatrics 136 (4): 719–29.

Christensen, K., Harper, B., Luukinen, B., Buhl, K., Stone, D. (2009). Chlorpyrifos Technical Fact Sheet; National Pesticide Information centre, Oregon State University Service.

Coulibaly, O., Cherry, A.J., Nouhoheflin, T., Aitchedji, C.C., Al-Hassan, R., (2007).Vegetable producer perceptions and willingness to pay for biopesticides. *Journal of Vegetable Science*. 12, 27e42.

Emmanouil, R.., Emmanouil, V., Maria, G., Marianna, S., Ralf, N., Magali, G., Andrea, B. (2015).First report of *Tutaabsoluta* to diamide insecticides.*Journal of pest science* 88 (1) 9-16.

EPA (2016).*Integrated Pest Management (IPM) Principles*. Available at: https: //www.epa.gov/safepestcontrol/integrated-pest-management-ipm-principles (accessed August 26, 2016).

Esmaeili, A., and Asgari, A. (2015).Invitro release and biological activities of *Carumcopticum* essential oil (CEO) loaded chitosan nanoparticles. *International Journal of Biolological Macromolecules* 81, 283–290.

Ezena, G.N., Akotsen-Mensah C., Fening K.O. (2016) Exploiting the Insecticidal Potential of the Invasive Siam Weed, *Chromolaenaodorata* L. (Asteraceae) in the Management of the Major Pests of Cabbage and their Natural Enemies in Southern Ghana. *Advances in Crop Science and Technology* 4:230.

Farias, J.R., Andow, D.A., Horikoshi, R.J., Sorgatto, R.J., Dos Santos, A.C., Omoto C. (2015). Dominance of Cry1F resistance in Spodopterafrugiperda (Lepidoptera: Noctuidae) on TC1507 Bt maize in Brazil. *Pest Management Science* 72(5):974-979.

Gilden, R.C., Huffling, K., Sattler, B. (2010). "Pesticides and health risks".Journal of Obstetrics, Gynecology and Neonatal Nursery (Review) 39 (1): 103–10.

Hameed, A., Freed, S., Hussain, A., Iqbal, M., Hussain, M., Naeem, M., Sajad, A., Hussnain, H., Sadiq, M. A. and Tipu, A. L. (2012). Toxicological effects of neem (*Azadirachtaindica*), kanair (*Nerium oleander*) and spinosad (Tracer 240 SC) on the red flour beetle (*Triboliumcasteneum*) (Herbst.). *African Journal of Agricultural Research*, **7**(4): 555-560.

Ileke, K.D. and Ogungbite, O.C. (2014).Entomocidal Activity of Powders and Extracts of Four Medicinal Plants Against *Sitophilusoryzae* (L), *Oryza ephilusmercator* (Faur) and *Ryzoperthadominica* (Fabr.). *Jordan Journal of Biological Sciences*. **7**: 57-62.

Ilondu, E.M., Ojeifo, I.M., Emosairue, S.O. (2014). Evaluation of Antifungal Properties Of *Ageratum conyzoides, Spilanthe sfilicaulis* and *Tithonia diversifolia* Leaf extracts and search for their Compounds Using Gas Chromatography - Mass Spectrum: ARPN *Journal of Agricultural and Biological Science* VOL. 9, NO. 11, NOVEMBER 2014; ISSN 1990-6145.

Iyang, I.J. andAsemota, E. (2015).A review of the Nigerian challenge, benefits and applicability of biopesticides. *Journal of Biopesticides and Agriculture*, 1: 128-133.

Jakka, S.R., Gong, L., Hasler, J., Banerjee R., Sheets, J.J., Narva, K., Blanco, C.A., Jurat-Fuentes, J.L. (2015). Field-evolved Mode 1 fall armyworm resistance to Bt corn associated with reduced Cry1Fa toxin binding and midgut alkaline phosphatase expression. *Applied Environmental Microbiology* AEM-02871.

Juno, F. Silva Diniz, Paulo R. da Silva, Marcelo R. dos Reis, Ricardo T. Endo, Rodrigo S. Ramos, Flávio L. Fernandes, Ítalo W. da Silva (2014). Insecticide Activity of Weeds to Pests of Stored Product and Crops; *Journal of Agricultural Science*; Vol. 6, No. 7; 2014, ISSN 1916-9752 E-ISSN 1916-9760.

Jyothna, B., Rajaram, V., Manivannan, S., Somashekar, D. (2015). Feeding deterrence and insecticidal activity of phorbol esters in *Jatropha curcas* seed oil against *Dinoderusminutus* (Coleoptera: Bostrychidae): *Journal of Entomology and Zoology Studies* 3 (6): 257-261.

Kelly, B.C., Ikonomou, M.G., Blair, J.D., Morin, A.E., Gobas, F.A.P.C. (2007). Food Web-Specific Biomagnification of Persistent Organic Pollutants.*Science* 317, 236–239.

Melander, A.L. (1914). Can Insects become resistant to spray? *Journal of Economic Entomology 7:167-173*

Merriam-Webster dictionary, accessed 22 August 2012.

Miller, G.T. (2004). *Sustaining the Earth*, 6th edition. Thompson Learning, Incoporated. Pacific Grove, California. Chapter 9, Pages 211-216.

Monnerat, R., Martins, E., Macedo, C., Queiroz, P., Praça, L., Soares, C. M., Moreira, H., Grisi, I., Silva, J., Soberon, M. (2015). Evidence of Field Evolved Resistance of *Spodoptera frugiperda* to Bt Corn Expressing Cry1F in Brazil That Is Still Sensitive to Modified Bt Toxins. *PLoS One* 10:e0119544.

Negbenebor, H.E., Makanjuola, W.A. &Denloye, A.A. (2015). Toxicity of seed powder and extracts of *Jatropha curcas* to three storage beetles - *Callosobruchusmaculatus* F. (Bruchidae), *Rhizopert hadominica* F. (Bostrichidae) and *Sitophiluszeamais*Motsch. (Curculionidae).*Entomogical Society of Nigeria Publications*, 013/2015: 54-55.

NPIC, National Pesticide Information Center.“*Pesticide and human health*” November 2015.

Nwankwo, E.N., Onuseleogu, D.C., Ogbonna, C.U. & Okorocha, A.O.E. (2016). Effect of neem leaf extracts (*Azardirachtaindica*) and synthetic pesticide (Carbofuran) on the rot knot nematode (*Melodoigyne spp*.) of cowpea (*Vignaun guiculata* L. Walp). *International Journal of Entomology Research*, 1(3): 01-06.

Oceloti, J., Sánchez, J., Arroyo, R., García-Gómez, B.I., Gómez, I., Unnithan, G.C., Tabashnik, B.E., Bravo, A., Soberón, M. (2015). Binding and Oligomerization of Modified and Native Bt Toxins in Resistant and Susceptible Pink Bollworm. *PLoS One* 10:e0144086.

Odeyemi, I.S., Afolami, S.O., Daramola, F.Y. (2014). Evaluation of *Tithonia diversifolia* and *Chromolaenaodorata* residues as potential organic compost materials for the management of *Meloidogyne incognita* on cowpea (*Vignaunguiculata* L. WALP).*Journal of AgriculturalScience & Environment*, 14: 73-81.

Ojiako, F.O., Dialoke, S.A., Ihejirika, G.O. and Aguwa, U.O. (2015). Comparative contact, fumigant and repellent activities of different solvent extracts of the roots and seeds of *Jatropha curcas* L. and *Chlorpyrifos* against tailor ants, *Oecophyll alonginoda*Latrielle (Hymenoptera: Formicidae). *Entomological Society of Nigeria Publications*, 157/2015: 62-63.

Onekutu A., Nwosu, L.C., Abakpa, R.E. (2015). Comparative efficacy of aqueous extracts of *Tithonia diversifolia* (Asteraceae) and *Vernonia amygdalina* (Asteraceae) leaves in the management of *Sitophiluszeamais* infestation in stored maize: *Journal of Pharmacy and Biological Sciences* 10(3): 66-70.

Pitan, Olufemi R., Kehinde, Adesoji T., Osipitan, Adebola A., Ademolu, A. A., Lawal, Oluwasegun A. (2015). Laboratory Evaluation of Insecticidal Activities of Some Botanicals against Four Insect Pests of Honey Bees (*Apismellifera* L.) : *International Journal of Applied Agricultural and Apicultural Research*; IJAAAR 11 (1&2): 172-182, 2015.

Popoola, K.O.K., George- Onaho, J.A., Alamu, O.T., Ayandokun, A.E. (2018). Insecticidal activities of three weed varieties against the bamboo powder post beetle *Dinoder usminutus* Fabricius (Coleoptera: Bostrichidae). *The Zoologist*, 16: 31-35

Quinn, L. Amie. (2012). "*The impacts of agriculture and temperature on the physiological stress response in fish.*"Uleth.University of Lethbridge, n.d. Web. 20 Nov 2012.

Ritter, L., Solomon, K.R., Forget, J., Stemeroff, M., O'Leary, C.(2007). "Persistent organic pollutants" (PDF). United Nations Environment Programme. Retrieved 2007-09-16.

Santos-Amaya, O.F., Tavares, C.S., Monteiro, H.M., Teixeira, T.P., Guedes, R.N., Alves, A. P., Pereira, E.J. (2016). Genetic basis of Cry1F resistance in two Brazilian populations of fall armyworm, Spodoptera frugiperda.*Crop Protection* 81:154-162.

Schenker, Scheringer, Hungerbühler (2014). Do Persistent Organic Pollutants reach a thermodynamic equilibrium in the global environment? Environmental Science & Technology, 2014, doi:10.1021/es405545w.

Tabashnik, B.E., Brévault, T., Carrière, Y. (2013). Insect resistance to Bt crops: lessons from the first billion acres. *National Biotechnology* 31:510-521.

Tabashnik, B.E., Mota-Sanchez, D., Whalon, M.E., Hollingworth, R.M., Carrière, Y. (2014). Defining terms for proactive management of resistance to Bt crops and pesticides. *Journal of Economic Entomology* 107:496-507.

Udebuani, A.C, Abara, P.C., Obasi, K.O., Okuh, S.U. (2015). Studies on the insecticidal properties of *Chromolaenaodorata* (Asteraceae) against adult stage of *Periplaneta americana*: *Journal of Entomology and Zoology Studies,* 2015; 3 (1): 318-321.

Umoetok, S.B.A., Musa, I.D. &Okweche, S.I. (2015).The mode of action of *Jatropha curcas* seed oil on *Sitophiluszeamais*. *Entomological Society of Nigeria Publication*, 061/2015: 33-34.

UNEP, (2015). Ridding the world of POPs: A guide to the Stockholm Convention on Persistent Organic Pollutants" (PDF).United Nations Environment Programme. Retrieved 2008-06-06.

U. S. Environmental Protection Agency, CADDIS Volume 2: Sources, Stressors & Responses Plant Incorporated Protectants.

Van Emden, H.F. and Service, M.W. (2006). Pest and Vector control. *Journal of Agricultural Science*, 144:183-186.

Wachira, S.W., Omar, S., Jacob, J.W., Wahome, M., Alborn, H.T., Spring, D.R., Masiga, D.K. &Torto, B. (2014). Toxicity of six plant extracts and two pyridine
alkaloids from *Ricinuscommunis* against malaria vector *Anopheles gambiae*. *Parasites and Vectors*, 7(1): 312.

War, A.R., Pauwraj, M.G., Hussain, B., Ahmad, T., War, M.Y. &Ignacimuthu, S. (2014). Efficacy of a combined treatment of neem oil formulation and endosulfan against *Helicover paarmigera* Hubner (Lepidoptera: Noctuidae). *International Journal of Insect Science*, 6: 1-7.

Winchester, D., Huskins, J., Ying, J. (2009). "Agrichemicals in surface water and birth defects in the United States".*Actapaediatrica* (Oslo, Norway : 1992) 98 (4): 664–669.

World Health Organization, (2016). Monitoring health for the SDGs, Sustainable development goals. ISBN 978 92 41565264.