World Journal of Pharmaceutical and Life Sciences
WJPLS
www.wjpls.org
SJIF Impact Factor: 4.223

SEED OILS ARE NATURAL SOURCE OF BIO PESTICIDES

Raj Mani Prajapati[1], Akriti Agarwal[2], L. K. Thakur[2] and Dr. Upma Singh*[1]

[1]School of Vocational Studies and Applied Sciences. Gautam Buddha University, Greater Noida (UP) – 201308.
[2]Institute of Pesticide Formulation Technology, Gurgaon (HR)-122016.

***Corresponding Author: Dr. Upma Singh**
School of Vocational Studies and Applied Sciences. Gautam Buddha University, Greater Noida (UP) – 201308.

Article Received on 20/08/2017 **Article Revised on 10/09/2017** **Article Accepted on 01/10/2017**

ABSTRACT

In present time mainly chemical pesticides are used for pest management but the major drawback of their persistence, caused adverse effect on human health and environment. Botanical pesticides are usually safer to humans and the environment than conventional pesticides. Seed oils are plant origin, which is the important group of naturally occurring, often slow-acting crop protectants with minimal residual effects. Seed oils are used against home and garden pests, these "green pesticides" can also found effective in agricultural situations, particularly for organic food production. In this review, pesticidal activities of seed oil documented against various insect and focous on role of seed oils in pest management.

KEYWORDS: Seed oil; Botanical pesticide; Agriculture; Insecticidal activity; Pest management.

INTRODUCTION

Insect, nematodes and pathogenic microorganisms such as viruses, bacteria, fungi, protozoa that cause disease and damaging of plants resulted yield loss. Due to plant diseases, insects and weeds annually interfere with the production that resulted 36.5% average of total losses, 14%, 10.2% and 12.2% are caused by diseases, insects and by weeds respectively.[1] The total annual worldwide crop loss from plant diseases is about $ 220 billion.[2] Pests are constantly being introduced to new areas either naturally or accidentally, or, in some cases, organisms that are intentionally introduced.[3] Ecological backlash is often produced due to top rsistent of chemical insecticides in environment, which is a counter-response of the ecosystem, specifically with insect pest populations. It expresses in forms of resistance which makes less susceptible against chemical pesticides, resulting pest population is difficult to control.[4]

Botanical pesticides possess a number of usefull properties like low mammalian toxicity, no health hazards, less hazards to non-target organisms, no adverse effect on plant growth. It is less expensive and easily available because of their natural occurrence.[5] Due to minimal residual effects, these crop protectants are an important group of naturally occurring, slow acting botanical pesticides, that are usually safer to humans and the environment than chemical pesticides. Injudicious uses of synthetic pesticides to control agricultural pests has created numerous problems such as poisoning of farm workers, consumers and wildlife, resistance to pesticides in pest populations and negative environmental impacts. These adverse effects have provided the impetus for the development of alternatives to chemical pesticides for pest management. Natural products derived from plants have been shown to be promising alternatives.[6,7] A review on that locally available plants extracts of Africa can be effective in controlling pest which can be used alone or in mixtures with conventional insecticides at reduced rates and suggested that botanical insecticides should prove most beneficial to consumers in developing countries has been documented.[8] Plant extracts and phytochemicals have long been a subject of research to develop alternatives to conventional insecticides.[9] Nicotine, sabadilla, rotenone, neem and pyrethrum/pyrethrins are well stabilized botanical pesticide. In present, there are more than 2000 plant species known to have insecticidal properties, where the *Euphorbiaceae*, *Asteraceae*, *Labiatae*, *Fabaceae*, *Meliaceae* and *Solanaceae* families have notable insecticidal activities.[10] In present time, these botanical pesticides play only a minor role in pest management. The focus on biodegradable that are less persistent and suitable for use in integrated pest management are becoming more important for the safety of the environment and society.[11]

Seeds are produced by plants, and they can be distinguish as angiosperms (enclosed seeds) and gymnosperms (naked seeds) on the basis of manner of their production. Seed oils commonly referred to as non-volatile plant secondary metabolites are byproducts of plant and produced during metabolism. Seed oils are

reported as controlling agent to control wide range of insects, fungi, bacteria. An ideal insecticidal plant should be perennial with wide distribution and abundantly present in nature. The active ingredient should be effective even at lower concentration.[12] Many developing countries are promoting botanical pesticides as an alternatives to synthetic organic insecticides. Botanical pesticides are naturally occurring and renewable ideal pest control agents. Effectiveness of botanical insecticides from seed oil of *P. Pinnata, A. indica* and *Chrysanthemum cinerariifolium* emulsion against various insect *Spodoptera littoralis, Myzus persicae,* and *Tetranychus urticae* has been reported.[13]

The aim of this study is focous on insecticidal, antifeedant, larvicidal, repellent and fungicidal activities of seed oil which play an important role in development of safe, ecofriendly and environmentfriendly botanical pesticides. Seed oils and their secondary metabolites are an important source for biopesticides that can be used for development of new pesticides.

Bioactivity

Insecticidal activity

Annona Squamosa (Sugar apple) plant belongs to *Annonaceae* family have a broad range of insecticidal bioactivities. This family have been extensively tested in recent years against pest insects and related arthropods.[14] A review article by[12] has been described biopesticidal activity of various parts which make this plant for potential alternatives to chemical pesticides in Agriculture. The toxicity of seed oil of *A.squamosa* plant was due to the malathion and two isolated compounds (annonastion and squamozin) which were found active against adult, egg and larval stages of the FSS2 and CTC 12 strains of *Tribolium castaneum* (red flour beetle), silver leaf white fly (*Bemisia argentifolii*), cotton aphid, (*Aphis gossypii Glover*), Kanzawa spider mite (*Tetranychus kanzawai)*.[15] The seed oil extract of petroleum spirit, ethyl acetate, acetone and methanol showing strong insecticidal activity against four strains Raj, CR 1, FSS II and CTC-12 larvae and adults of the *T. castaneum*, among these extract, the highest toxicity was recorded in petroleum spirit extract and lowest toxicity was for methanol extract in case larval bioassay while in adults, the lowest toxicity was observed in acetone extract.[16]

R.comminis and *Jatropha curcas* are important plants of *Euphorbiaceae* family having bioactive compounds. It has been found that castor oil from *R.comminis* has insecticidal activity against *C. maculates* which affect yield loses during storage and field crop and diamond back moth insect (*Plutellaxy lostella*) pests of brassicas.[17-18] The biopesticidal potential of this seed oil was evaluated against termite and cockroach and it has been found that Castor 10% oil caused 100% mortality in 60 hrs. and 72 hrs. against termite and cockroach, respectively.[19] The castor oil having limited toxic effect but it reduced oviposition of *Cosmopolites sordidus* banana insect.[20]

J. curcas (physic nut) is a drought- resistant multipurpose shrub or a small tree native of tropical America, popularized as a biofuel crop but in addition to this it has many more uses.[21] The insecticidal effect of this seed oil has been evaluated against on black bean aphid and *Vigna unguiculata* insect cow pea crops and it was effective at 5 and 7.5% concentrations.[22] This seed oil effective against *Sitophilus granaries* (wheat grain pest) and author concluded that this oil act as insecticide and germination promoter.[23] Biopesticidal activity of this seed oil has been investigated against two insect *Cnaphalocrosis medinalis* and *Halicoverpa armigera.*[24] Insecticidal effect of seed oil against *C. maculatus* and *Dinarmus basalis* insect have been reported that eggs were more susceptible as compared to pre adult stages.[25-27] Seed oil extract showed insecticidal efficacy against the *Schistocerca gregaria* desert locust insect at different concentration.[28] Insecticidal activities i.e. contact toxicity, eggs mortality, Anti oviposition and ovicidal effects, feeding deterrency, repellency and egg toxicity, insect growth regulatory effect and reduction of development/fertility of progeny of this seed oil against various insects have been reported.[29] Insecticidal activity of seed oil has been reported against two bruchid beetle *C. maculatus* and *Bruchidius atrolineatus* at different concentration, results shows that oil reduced population of both species but *B. atrolineatus* was found more susceptible than *C. maculates.* With treatment at 10% jatropha seed oil caused 100% mortality in 48hrs and 72hrs against termites (*Odontotermes obesus*) and Cockroach (*Blattela germanica*) respectively.[30] Bioassay study showed that oil have great pottencial[31] (Demissie and Asnake 2013). Treatment with 100 ppm concentration this seed oil was effective against *Sitophilus zeamais* on maize weevil grain.[32]

A. indica and *Melia azaderatch* are important members of *Meliaceae* is family beceause a number of bioactive constituents isolated which have pesticidal activities. Azadirachtin molecule is an limonoid reported as natural insecticides, found in both member. *A. indica* (Neem) is recognized as a natural product which has much to offer in solving global agricultural, environmental and public health problems. Natural properties of neem do not have any toxic reactions.[33] The bioactivity of crude or commercial pesticides from the seeds, twigs and stem barks of neem trees against over 700 pests and disease pathogens has been documented. *A. indica* and *Carapa procera* seed oils have same promising termiticidal and preventive activities on wood.[33] The larvae of *Microtheca punctigera* beetle which affect chinese cabbage and mustard crop, showed mortality after treatment with neem seed oil at different concentration during *in- vitro* test.[34] Comparative insecticidal effects of seed oil obtained from neem berries stored for one to seven years under normal room conditions, against the 3rd instars larvae of *Trogoderma granarium* insect, the

results indicating significant reductions in activities were reported in oil treatments prepared from the oldest fruits of eight years old but though the newest products of one to four years old were relatively the best.[35] Insecticidal activity of neem oil (0.5, 1.0 and 2.0%), neem cake extract (1.0, 3.0 and 5.0%) along with monocrotophos 0.05% were evaluated and results incated that all test solutions, 2.0% oil showed maximum larval mortality followed by neeem cake extract found effective against fourth instar larvae of *H. armigera* under laboratory conditions.[36] Comparative efficacy of neem oil with synthetic insecticides has been found effective against management of thrips of mungbean avigna radiate wilezek.[37] Seed oil was found more effective followed by leaves and stem bark powder against adults *C. maculatus* insect.[38] *Lutzomyia longipalpis* is the main vector of visceral leishmaniasis, seed oil was effective in reducing the population on eggs, larvae and adult.[39]

Ripe fruits oil from *M. azedarach* seed was found effective to control at various concentration against the 2nd and 4th instar larvae of *S. littoralis* insect.[40] Emulsion developed from *P. pinnata* seed oil in alone and with combination with other oil and plant extract has been carried out against green peach aphid (*Myzus persicae)* insect and result showed that at 3%concentration almost all formulations, gave 90% or above mortality of treated females.[41]

Papaver somniferum seed oil at 2, 4, 6, 8 and 10ml/kg concentration was investigated against *C. maculatus* insect and it reduced population signicantly at all concentration.[42] 1% cotton seed oil+1% nirma as emulsifier agent was effective as phosphamidon 85 WSC against cotton aphid (*Aphis Gossypii)* without phytotoxic effect.[43] On collard and tomato crop,10 mL and 5 mL/Litre concentration of cotton seed oil and vegetable oil have been showed insecticidal efficacy for control of *Bemisia argentifolii* insect.[44] Seed oil of *Hura crepitans* (Sandbox tree), showed insecticidal activity at 0.1% concentration on oviposition, adult emergence, mortality of immature stages and reproductive competitiveness against *C. maculates.*[45] *Moringa oleifera* and *Alium sativum* (garlic) seed oil at 0.4% and 0.6% and 0.1, 0.2,0.4 and 0.6% concentration were found effective against *C. maculatus.*[46,47] Treatment with Cassava (*Manihot esculenta*) seed oil at 1% and 0.5% against aphids (*Aphis craccivora*) on cowpea and ivy gourd showed 100% mortality of the pest within 24 and 48 hours respectively.[48] 10% jojoba oil was found effective in controlling the *Schistocerca gregeria* insect.[49]

Vegetable oils are important part of seed oil and they are reportd as insecticides. A review articles on vegetable oils like sunflower, mustard, groundnut, sesame, soybean, olive, palm, castor oil has been protected legume-pulses from insects.[50] Three vegetables oils (corn, sunflower and sesame) either alone or combined with pyridalyl or /and spinosadat mixing ratios of 99/1, 95/5 and 90/10 (insecticide /oil), result showed that activity these combined ratios was significantly increased insecticidal activity against *C. maculates* insect.[51] Four vegetable oils (olive oil, groundnut oil, soybean oil and palm kernel oil) showed that these oils suppressed the development of *C. maculatus* to some extent in stored cowpea seed after treatment with 0.2 ml oil per 50gm.[52] Seed oils of bitter gourd, small bitter gourd, bottle gourd and ridge gourd has been found effective in controlling mustard aphid (*Lipaphiserysimi*), under field trial at 6% concentration all oils showed 100% mortality.[53]

Antifeedant activity

Antifeedant efficacy of *Jatropha curacus* seed oil extract at different concentration has been reported against *S. gregaria* insect.[28] The authors isolated 11 limonoids from *A. indica* seed oil by HPLC and evaluated antifeedant activity against *Reticulitermes speratus* (termite). Among 11 compounds in which deacetylgedunin was found the most active compound as antifeedant.[54] *Oebalus poecilus* most important pest of rice in South America, both males and females showed mortality after treatment commercial neem oil formulation.[55] Antifeedant activities of various isolated limonoid compounds from neem seed oil reduced significantly population of larvae of *S. litura* insect.[56] Antifeedant effect of neem seed oil was observed against *M. punctigera* insect at 0.25, 0.50 and 1% level. Maximum antifeedant activity reported at 1%.[57] Antifeedent insect growth regulator and sterilant activity of isolated azaderachtin compound has been reviewed and author concluded that azaderachtin is a safe insecticide.[58]

Seeds of *M. azedarach* were showing, antifeeding effects due to presence of biologically active group of triterpenoids.[59] Antifeedant effect of methanolic fraction of seed oil of *P. pinnata* was reported against the larvae of *S. litura* and *T. Granarium* insect.[60]

Larvicidal activity

Comparative Larvicidal activity of seed oil, root and leaves from three species of Jatropha i.e. *J. nana, J. gossypifolia* and *J. glandulifera* were evaluated against *S. litura* insect, after 24 h of exposure, these seed oils were showed larval mortality.[61] The effect of vector borne diseases is a major threat to human survival, mosquitoes are important insect to spread disease. *J. curacus* seed oil showed larvicidal activity against the fourth-instar larvae of *A. aegypti* and author suggested that it can be effectively used as potential candidates for controlling and can be considered for eco-friendly vector control programs [62]. With treatment of 5% *J. curacus* seed oil showed significant antifeedant effect on the treated nymphs instar of *S. gregaria.*[28] Larvicidal efficacy of seed oil of neem cake, karanja (individualy and combination) and Pine were studied against larvae of *Cx. quinquefasciatus, A. Aegypti* and *Anopheles stephensi* mosquito species, study results showed that these oils showed larvicidal effect, combination of neem

and karanja oil cakes have better effect than the individual treatments.[63,64] Seed oil of *cedrus libani* shown larvicidal efficacy against third and fourth star larvae of mosquito *culex pipiens.*[65]

Repellent activity

Repellent activities of various seed oil have been documented against various pests. The seed oil of neem showed repellent activity against *M. punctigera* beetle and termite.[57,34] Neem seed oil showed significant repellent activity against *Cx. Quinquefasciatus* mosquito, is vector of filariasis disease.[66] At laboratory conditions, the repellent activities of neem and *P. pinnata* seed oil (separately and mixed oil) have been reported against mosquito vector *A. aegypti*. Results showed that combination of oil increased repellent activity as compared to single oil.[67] The seed oil of *P. pinnata* showed maximum repellent activity against *T. granarium* at 0.2 mg/cm^2 concentration.[60] Seed oil of jatropha, Canola and Jojoba, showed repellent activity against two insect, *C.maculates* and*C. Chinensis*.[68] Pine oil is reported as strong repellent which provide 100% protection against *Anopheles culicifacies* for 11 h and 97% protection against *Cx. quinquefasciatus* for 9 hours respectively.[64]

Antifungal activity

Ten annonaceous acetogenins (AAs) were isolated from *A. squamosa* seeds in which eight compounds were showing *in-vitro* and *in-vivo* antifungal activities against *P. infestans* and *P. Recondite* fungi causing tomato late blight and wheat leaf rust respectively.[69] Jojoba and jatropha seed oil extract were found most effective than castor oil against 13 species of plant pathogenic fungi.[70] *J. curacus* seed oil showed antifungal activity against six seed borne plant pathogenic fungi i.e *Alternaria alternate, Aspergilius flavus, Aspergilius fumigates, Aspergilius niger, penicellium glaburam* and *Fusarium Chlamydosporum* in which *P. glaburam* and *A. niger*fungi were found more susceptible than others.[71] Endophytic fungi were isolated from *J.curcas* and identified as *Colletotrichum truncatum, Nigrospora oryzae, Fusarium proliferatum, Guignardia cammillae, Alternaria destruens* and *C.truncatum* were found effective against *Fusarium oxysporum* and *Sclerotiniasclerotiorum* plant pathogenic fungi.[72] Mycelia growth and rot development of yam caused by *Fusarium verticilliodes* and *Aspergillus flavus* has been controlled by *J. curcas* and *R. cumunis* seed oil in *in-vitro* and *in-vivo* conditions.[73] Seed oil from jatropha species i.e. *J. curcas, J. gossypifolia, J glandulifera, J.Integerrima* showed satisfactory results against four plant pathogenic fungi *A. alternata, A. flavus, A.niger,F. oxysporum,* and *Rhizoctonia solani.*[74] Extracted curcin from *J. curcas* seeds showed antifungal activity against plant pathogenic fungi i.e. *Pyricularia oryzae, Pestalotiopsis funerea, R. solani* and *S. sclerotiorum* at 50 µg/ml concentration.[75]

Neem oil inhibits 100% growth of *Fusarium moniliforme, A. niger, Drechslera rostrata* and *Macrophomina phaseolina* fungi at 10%.[76] 2% neem oil was found effective for controlling *Botrytis cinerea* and *Penicillium expansum* plant pathogens causing gray mold disease in apple during post harvest.[77] Mustard, neem, karanj, cedar, apricot and olive vegetable oils were found effective to control mycoflora of pea which is caused by *Aspergillus* sp, *Alternaria* sp and *Mucor* sp during germination. Neem and karanj oil provided maximum protection against fungal pathogens while apricot oil was found least effective.[78] Antifungal activity of seed oil of *Citrus sinensis* has beern reported against *Lentinus sajor-caju* (saprophytic mushroom) at *in-vitro* scale.[79]

Chemical Constituents

Different plant seed extract/oil obtained from the *Annonaceae, Meliaceae, Euphorbiaceae* and *Solanaceae* contains secondary metabolites which are reported as insecticides. The *Meliaceae* family is the most studied one, with azadirachtin as the most important active compound. The azadirachtin molecule which is reported as active ingredient was isolated from seeds o by.[80] The insecticidal properties of neem oil are mainly due to presences limonoids,among these limonoids, deacetylgedunin have potent antifeedant against *Reticulitermessperatus* termites.[54] T. R. Govindachari et al. in 2000[56] isolated limonoids from neem seed oil by preparative HPLC.analysis was carried out in two E-2-A and E-2-S fractions in which E-2-A fraction showed presence of azadirachtins A and B isomers as the major constituents and azadirachtins D, H and I as minor constituents.In E-2-S showed presence of salannin, nimbin, azadiradione and desacetylnimbin as major constituents andthese compounds responsile for antifeedant and groth regulating activities. Meliartenin and its interchangeable isomer 12-hydroxiamoorastatin were isolated from fruit extract of *M. Azedarach* and identified as antifeedant against *Epilachna paenulata* larvae.[81] 7-(3'-furyl)-benzo[3,4-c]-7H-oxol-2-one compound was isolated from fruit extract of *M. azaderatch* which was reported as insecticide and fungicide against *S. littoralis* 4th larval instar and plant pathogenic fungi such as *R. solani, Macrofomina phaseoli, Pythium debarianum* and *Fusarium calmorum* repectively.[82] Two compounds, 1-cinnamoylmelianolone and 1-cinnamoyl-3,11-dihydroxymeliacarpin, were isolated from the fruit of *M.azedarach* responsible for insecticidal activity.[83] Acetogenins, squamocyn and annonacyn phytochemicals were identified from*Annonaceae* family which were repoted as bioactive compounds.[84] 11 compounds known as squamocenin, annotemoyin-2, reticulatain-2, squamocin-I, squamocin-B, squamocin, motrilin, squamostatin-D, squamostatin-E, cherimolin-1, and cherimolin-2 were isolated and identified as annonaceousacetogenins from*A. squamosa* seed extracts.[86] Two compound were isolated and identified from seed extract of hexane and ethyl acetate identifiedas

annonin (squamocin) and the other was characterized as a novel dihydroxy-bistetrahydrofuran fattyacid lactone (acetogenin) showed insecticidal activity against eggs, larvae and adults of *Drosophila melanogaster*.[87]

The phorbol ester fraction from seed oil of *J.curcas* analysed by HPLC which reported as a promising candidate for use as a plant-derived protectant of a variety of crops, from a range of pre-harvest and post-harvest insect pests.[88,89] Six unstable intramolecularditerpene esters were isolated from the seed oil of *J.curcas* known as 12-deoxy-16-hydroxyphorbol which were having insecticidal activities.[90] Two glucosides, simmondsin and simmondsin 2-ferulate were isolated from jojoba seedwhich was reported insecticide, antifeedant and antifungal agents.[91] The Carotol, daucol and β-caryophyllene were isolated from carrot seed oil showed strong antifungal activity *A. alternate* pathogen.[92]

DISCUSSION

A no of products were developed from seed oil and other botanicals. Three newly developed botanical insecticides and novel formulation (*PONNEEM*) from pongamia oil were found effective to control *P. xylostella*, *S. litura* and *H. armigera* insects.[93,94] *M. azaderatch* seed oil-based formulations were developed as insecticides against *A. Gossypii* and *Cavariellam aegopodii*.[95] Natural pyrethrum extract blended with cotton seed oil was the most potent insecticide against maize weevils insect and also found that Cotton seed and neem seed oils enhanced the stabilization of the natural pyrethrum insecticide.[96]

Botanicals i.e. essential oils, seed oils and extracts have potential for development of eco- friendly products for crop protection in future. Bio-pesticides which were derived from botanicals are necessary to charcterize their potency for revolution. For this necessity to be used by applying available modern biotechnological tools, to develop low cost technology for compound isolation, formulation and commercial scale establishment of plant resource. Botanical pesticides are the best option for organic food production and post harvest protection of food in developing countries in pest management. For development of biopesticide biocontrol agents reuired sophisticated procedure like packaging, storage and marketing strategies and eventual registration of formulated product for producing commercial botanical based pesticides.[97] The major problems are costly toxicology testing for new products which may have limited Intellectual Property (IP) protection, relatively small market size, economical supply of plant product, quality control and lack of stability of product.[98] Authors found that for optimization, environmental sustainability of natural pesticides must be evaluated for their environmental impact in the context of an integrated approach, policy decisions must be based on empirical data and objective risk-benefit analysis and not arbitrary classifications.[99] Developing countries, research and practices are needed to develop and evaluate IPM concepts without companion efforts in extension and training. Most of the academic research is perhaps incomplete because of its short term goals.[100] For commercialization of new botanical insecticides i.e. scarcity of the natural resources, registration, standardisation and quality control are principal barriers in commercialization of botanical pesticides.[101] Botanical pesticides and pollution prevention division which was established in 1994 to facilitate the registration and promoting in safer use of botanical pesticides for encouraging the IPM programme. Most oil based products sold as pesticides are regulated by the Environmental Protection Agency (EPA) under the Federal Insecticide, Fungicide and Rodenticide Act, which granted some exemptions are to be edible oils and other specific ingredients that are considered to pose minimum risk to humans. Many plant oils are exempt from EPA regulations and some are sold for organic production. Commercialization of botanical pesticides have to be great challenge due to various factor like identification, phenotypic and genetic variability, extract variability and unstable nature for longer time span, toxic components and contaminants.

CONCLUSION

Seed oils have been used as pesticides for centuries which is effective and safe alternatives to synthetic insecticides and fungicides.Due to health concern issues, botanical pesticides is now fast growing and wider acceptance among farmers.For commercialization of botanical pesticides needs more work on formulation, to make easy registration, fundamental political approach, financial support and field trials are required.There should be an organizational infrastructure to plan, foster, facilitate and coordinate research so that current gap or imbalance in scientific research findings.In this paprer authors have been made efforts to document the pesticidal activities of seed oils that play scientificant role in botanical formulation. Seed oils will play a significant role in integrated pest management in the future for pest control in both industrialized and developing countries.

REFERENCES

1. Dang QL, Lim CH, Kim JC. Current Status of Botanical Pesticides for Crop Protection. Res. Plant Dis, 2012; 18(3): 175−185.
2. Agrios GN. Plant Pathology. 5th ed. Elsevier Academic Press, Burlington, Mass., USA, 2005.
3. Mazid S, Kalita JC, Rajkhowa RC. A review on the use of biopesticides in insect pest management. Int. j. sci. adv. Technol, 2011; (1): 169-178.
4. Travis LM Ken M. Evaluation of *melia azedarach* as a botanical pesticide against beet armyworm (Spodopteraexigua). ARPN Journal of Agricultural and Biological Science, 2012; 7(11): 962-967.
5. Prakash A. Rao J, Nandagopal V. Future of Botanical Pesticides in rice, wheat, pulses and

vegetables pest management. Journal of Biopesticides, 2008; 1(2): 154 –169.
6. Isman MB. Botanical insecticides, deterrents, and repellents in modern agriculture and an increasingly regulated world. Annu Rev Entomol, 2006; 51: 45-66.
7. Copping LG, Duke SO. Natural products that have been used commercially as crop protection agents. Pest Manag Sci, 2007; 63: 524-554.
8. Isman MB. Perspective Botanical insecticides: for richer, for poorer. Pest Manag Sci, 2008; 64: 8–11.
9. Akhtar YYR, Yeoung AE, Isman MB. Comparative bioactivity of selected extracts from *Meliaceae* and some commercial botanical insecticides against two noctuid caterpillars, *Trichoplusia ni* and *Pseudaletia unipuncta*. Phytochem Rev, 2008; 7: 77–88.
10. García-Mateos R, Pérez PR, Rodríguez HC, Soto HM. Toxicidad de alcaloides de *Eythrina Americana* en larvas de mosquito *Culex quinquefasciatus*. Fitotecnia Mexicana, 2004; 27: 297-303.
11. Klocke JA, Kubo I. Defense of Plants through Regulation of Insect Feeding Behavior. The Florida Entomologist, 1991; 74(1): 18-23.
12. Begum N, Sharma B, Pandey RS. *Calotropis procera* and *Annona squamosa:* potential alternatives to chemical pesticides. British journal of applied science & technology, 2013; 3(2): 254-267.
13. Pavela R. Effectiveness of some botanical insecticides against *Spodoptera littoralis* Boisduvala (Lepidoptera: Noctudiae), Myzus persicae Sulzer (Hemiptera: Aphididae) andTetranychusurticae Koch (Acari: Tetranychidae). Plant Protect. Sci, 2009; 45(4): 161–167.
14. Isman MB, Seffrin R. Natural Insecticides from the *Annonaceae*: A Unique example for developing biopesticides. Advances in Plant Biopesticides, 2014; 21-33.
15. Chin L, Wu DC, Jih-zu YU, Chen BH, Wang CL, Ko WH. Control of silver leaf whitefly, cotton aphid and kanzawa spider mite with oil and extracts from seeds of sugar apple Neo-tropical. Entomology. 2009; 38(4): 531-536.
16. Khalequzzaman M. Sultana S. Insecticidal activity of *Annona squamosa* l. seed extracts against the red flour beetle, *tribolium castaneum* (herbst). J. bio-sci, 2006; 14: 107-112.
17. Hughtalab N, Shyshteh N, Aramideh S. Insecticidal efficacy of castor oil and hazelnut oil against stored cowpea *callosobruchus maculatus* (coloepetra: bruchidae). Journal of biological sciences, 2009; 9(2): 175-179.
18. Rondelli VM, Pratissoli D, Santos JHJ, Zago HB, Machado LC, Rodrigues HD, Valbon WR. Insecticide activity of *beauveria bassiana* and castor bean oil against *Plutella xylostella* under greenhouse. Biosci. J.Uberlândia, 2013; 29(5): 1187-1193.
19. Asnake GE, Demissie AG. Comparative bio-activity guided characterization of biocide from *jatropha curcas* and *Ricinus communis* L seeds oil. J Pharmacogn Phytochem., 2013; 2 (3): 176-181.
20. Tinzaara W, Tushemereirwe W, Nankinga CK, Gold CS, Kashaija I. The potential of using botanical insecticides for the control of the banana weevil, *Cosmopolites sordidus* (Coleoptera: Curculionidae) Afr J of Biotech, 2006; 5(20): 1994-1998.
21. Gübitz GM, Mittelbach M, Trabi M. Exploitation of the tropical oil seed plant. *Jatropha curcas*. Bioresource Technol, 1999; 67: 73–82.
22. Habou1 ZA, Haougui A, Mergeai G, Haubruge E, Toudou A, Verheggen FJ. Insecticidal effect of *jatropha curcas* oil on the Aphid Aphis fabae (Hemiptera: Aphididae) and on the main insect pests associated with cowpeas (*Vigna unguiculata*) in Niger. Tropicultura, 2011; 29(4): 225-229.
23. Nabil A, Azzaz-Yasser E, Khalifa AM. *Jatropha curcas* oil as insecticide and germination promoter. J Appl Sci Res, 2012; 8(2): 668-675.
24. Dowlathabad MR, sreeyapureddy A, Adhikari A, bezawada K, Nayakanti D. Pharmaceutical investigation and biopesticidal activity of *jatropha cucuras* seed oil on digestive enzymic profiles of *cnaphalocrosis medinalis* (rice leaf folder) and *halicoverpa armigera* (cotton boll worm) IRJP., 2010; 1(1): 194-200.
25. Kshirsagar RV. Insecticidal activity of jatropha seed oil against *callosobruchus maculatus* (fabricius) infesting phaseolus aconitifolius jacq. The bioscan, 2010; 5(3): 415-418.
26. Adebowale KO, Adedire CO. Chemical composition and insecticidal properties of the underutilized *Jatropha curcas* seed oil Afr. J. Biotechnol, 2006; 5(10): 901-906.
27. Boateng BA, Kusi F. Toxicity of jatropha seed oil to *Callosobruchus maculatus* (Coleoptera: Bruchidae) and its parasitoid, *Dinarmus basalis* (Hymenoptera: Pteromalidae J Appl Sci Res, 2008; 4(8): 945-951.
28. Bashir EM, Hamadttu AFE. Insecticidal and antifeedant efficacy of jatropha oil extract against the desert locust, *Schistocerca gregaria* (Forskal) (Orthoptera: Acrididae) Agric. Biol. J. N. Am., 2013; 4(3): 260-267.
29. Alain R, Michael W. The phorbol ester fraction from *Jatropha curcas* seed oil: potential and limits for crop protection against insect pests, Int. J. Mol. Sci., 2012; 13: 16157-16171.
30. Haboul ZA, Haougui A, Basso A. adam T, Haubruge E, Verheggen FJ. Insecticidal effect of *Jatropha curcas* oil *callosobruchus maculatus* and *bruchidius atrolineatus* fab (coleopetra: bruchidae) on store cowpea seeds (*vigna unguiculata*). Afr. J. Agric. Res, 2014; 9(32): 2506-2510.
31. Demissie AG, Ede AG. Bio-activity guided studies of biocides and biodyes from Jatropha (*Jatropha curcas* L.) seed oil. Journal of Scientific and Innovative Research, 2013; 2(5): 938-942.
32. Jide-Ojo CC, Daniel TG, Ojo OO. Extracts of *Jatropha curcas* L. exhibit significant insecticidal and grain protectant effects against maize weevil,

Sitophilus zeamais (Coleoptera: Curculionidae). J. Stored Prod Postharvest Res, 2013; 4(3): 44-50.
33. Lokanadhan S, Muthukrishnan P, Jeyaraman S. Neem products and their agricultural applications. J Biopest, 5 (Supplementary): 2012; 72-76.
34. Mikami, AY, Ventura MU. Repellent, antifeedant and insecticidal effects of neem oil on *Microtheca punctigera*. Braz. arch. biol. Technol, 2008; 51(6): 1121-1126.
35. Tindo DS, Amusant N, Dangou J, Wotto DV, Avlessi F, Dahouénon-Ahoussi E, Lozano P, Pioch D. Sohounhloué KCD. Screening of repellent, termiticidal and preventive activities on wood, of *Azadirachta indica* and *Carapa procera* (*meliaceae*) seeds oils; ISCA Journal of Biological Sciences., 2012; 1(3): 25-29.
36. Abdelrahim AS, Elamin MM, Futuwi AI. Insecticidal effects of need (*azadirachta indica* a. juss) oils obtained from neem berries stored at different periods. The Experiment, 2013; 6(2): 330-337.
37. Kavitha E, Kingsley S, Revathi N, Sathivel M. Insecticidal activity of neem derivatives against okra fruit borer *Helicoverpa armigera* Hubner. International Journal of Agricultural Sciences, 2009; 5(2): 528-530.
38. Azam MG, Bhuyain MMH, Uddin MN, Islam MT, Kabir KH. Efficacy of some synthetic insecticides and neem seed oil for the management of thrips of mungbean vigna radiata (l.) wilezek J. bio-sci, 2008; 16: 105-108.
39. Kabir HY, Muhammad S. Comparative studies of seed oil extract, leaves and stem bark powders of *Azadirachta indica Linn (Meliaceae*) on adults *Callosobruchus maculatus* (Coleoptera *Bruchidae*). Bioscience Research Communications, 2010; 22(6): 345-350.
40. Maciel MV, Morais SM, Bevilaqua CM, Silva RA, Barros RS, Sousa RN, Sousa LC, Machado LK, Brito ES, Souza-Neto MA. *In-vitro* insecticidal activity of seed neem oil on lutzomyialongipalpis (Diptera: Psychodidae). Rev Bras Parasitol Vet, 2010; 19(1): 7-11.
41. Mohamed F, Ahmed MHM, Yousefa H, Rahman AHA. Repellent and insecticidal activities of *Melia azedarach* L. Against cotton leaf worm, *Spodoptera littoralis* (Boisd.) Z. Naturforsch, 2011; 66: 129-135.
42. Stepanycheva EA, Maria OP, Taisiya DC, Pavela R. Prospects for the use of *Pongamia pinnata* oil-based products against the green peach aphid *Myzuspersicae* (Sulzer) (Hemiptera: Aphididae). Hindawi- Psyche, 2014; 1- 5.
43. Hamid SC, Khashaveh A. Insecticidal activity of poppy (*Papaver somniferum* L.) seed oil against cowpea weevil (*Callosobruchus maculatus* F.) in stored cowpea. Archives of Phytopathology and Plant Protection, 2013; 6: 2314-2322.
44. Gopali JB, Patil BV, Hanumaratti GN. Use of cotton seed oil in management of cotton aphid *Aphis Gossypii*(Glover). Karnataka J. of Agri. Sci, 1996; 8(3): 308-311.
45. Liu XT, Stansly PA. Insecticidal activity of surfactants and oils against silverleaf whitefly (*bemisiaar gentifolii*) on collard and tomato. Pest Manag Sci, 2000; 56: 861-866.
46. Adedire CO, Ajayi OE. Potential of sandbox, *Hura crepitans* L. seed oil for protection of cowpea seeds from *Callosobruchu smaculatus* Fabricius (Coleoptera: Bruchidae) infestation, J Plant Dis Prot, 2003; 110(6): 602–610.
47. Dauda Z, Mailafiya DM, Simon LD. Protective bioactivity of moringa (*Moringa oleifera*lam.) seed oil against *callosobrochus maculates* (f.) infestation in stored cowpea (*vigna unguiculata*) Insects Review, 2014; 1(2): 20-25.
48. Dauda Z, Maina YT, Richard BI. Insecticidal activity of garlic (aliumsativum (l.)) oil on *Callosobruchus maculatus* (f.) in post-harvest cowpea (*vigna unguiculata* (l.) walp.) Journal of Biology, Agriculture and Healthcare. 2012; 2(3): 28-35.
49. Jayaprakas CA, Ratheesh S. Rajeswari L.S. Biopesticidal activity of cassava *(Manihotesculenta* Crantz). seed oil against bihar hairy caterpillar (*Spilarctia obliqua*) and cowpea aphid (*Aphis craccivora*). Journal of Root Crops, 2013; 39(1): 73-77.
50. Halawa SM, Kamel AM, Abd EI, Hamid SR. Chemical constituents of jojoba oil and insecticidal activity against *Schistocerca gregeria* and biochemical effect on albino effect on rats. J. Egypt. Soc. and Toxicol, 2007; 36: 77-87.
51. Singh A, Khare A, Singh AP. Use of Vegetable Oils as Bio-pesticide in Grain Protection -A Review. J Biofertil Biopestici, 2012; 3(1): 1-9.
52. Manal AAA, Rashwan MH, Zidan-Lobna, TM. Insecticidal activity of pyridalyl, spinosad alone and combined with vegetable oils on growth development and reproductive performance of *Callosobruchus maculates* (F.). Nature and Science, 2013; 11(4): 118-127.
53. Uddin RO, Sanusi SA. Efficacy of olive oil, groundnut oil, soybean oil and palm kernel oil in the control of *callosobruchus maculatus*(f.) In stored cowpea (*vigna unguiculata* l. Walp). Agrosearch, 2013; 13(2): 67-72.
54. Mishra D, Shukla AK, Dubey AK, Dixit AK, Singh K. Insecticidal efficacy of vegetable oil against mustard aphid *Lipaphis erysimi* (kalt), under field condition. j. of oleo Sci, 2006; 55(5): 227-231.
55. Ishida M, Serit M, Nakata K, Juneja, LR, Kim M, Takahashi S. Several antifeedants from neem oil, *Azadirachta indica* A. Juss., against *Reticulitermes speratus* Kolbe (Isoptera: Rhinotermitidae). Biosci. Biotech. Biochem, 1992; 56(11): 1835-1838.
56. Pinheiro PV, Quintela ED. Neem oil antifeedant and insecticidal effects on oebaluspoecilus (hemiptera: pentatomidae) males and females. Pesq. Agropec. Trop. Goiânia, 2010; 40(4): 394-400.

57. Govindachari TR, Suresh G, Gopalakrishnan G, Wesley SD. Insect antifeedant and growth regulating activities of neem seed oil the role of major tetranortriterpenoids. J. Appl. Ent, 2000; 124: 287-291
58. Mikani AY, Ventura MU. Repellent, antifeedant and insecticidal effects of neem oil on *Microtheca punctigera*. Braz. arch. biol. Technol, 2008; 51(6): 121-126.
59. Mordue AJL, Nisbet AJ. Azadirachtin from the neem tree *Azadirachta indica*:its action against insects dezembro. An. Soc. Entomol. Brasil, 2000; 29(4): 615-621.
60. Valladares G, Defagó MT, Palacios SM, Carpinella MC. Laboratory evaluation of *Melia azedarach* (*Meliaceae*) extracts against the elm leaf beetle (Coleoptera: Chrysomelidae). Journal of Economic Entomology, 1997; 90: 747-750.
61. Kumar V, Chandrashekar K, Sidhu OP. Efficacy of karanjin and different extracts of *Pongamia pinnata* against selected insect pests. J. ent. Res, 2006; 30(2): 103-108
62. Bhagat RB, Kulkarni DK. Evaluation of larvicidal and antifeedant potential of three Jatropha species against *Spodopteralitura* (Lepidoptera: Noctuidae) and two predators (Coleoptera: Coccinellidae). Ann Biol Res, 2012; 3(6): 2911-2916.
63. Ojha K, Pattabhiramaiah M. Evaluation of phytochemicals, larvicidal activity of *Jatropha curcas* seed oil against *Aedes aegypti*. IJARS, 2013; 2(12): 2278-9480.
64. Shanmugasundaram R, Jeyalakshmi T, Dutt MS, Murthy PB. larvicidal activity of neem and karanja oil cakes against mosquito vectors, *Culex quinquefasciatus* (Say), *Aedes aegypti* (L.) and *Anopheles stephensi* (L.). J. Env. Biol, 2008; 29(1): 43-45.
65. Ansaria MA, Mittalb PK, Razdana RK, Sreeharia U. Larvicidal and mosquito repellent activities of Pine (*Pinu slongifolia*, Family: *Pinaceae*) oil. J Vect Borne Dis, 2005; 42: 95–99.
66. Huseyin C, KaniIsik KY, Yanikoglu A. Larvicidal effect of *Cedrus libani* seed oils on mosquito *Culex pipien.* Pharm. Biol, 2009; 47(8): 665–668.
67. Mandal S. Repellent activity of Eucalyptus and *Azadirachta indica* seed oil against the filarial mosquito *Culex quinquefasciatus* Say (Diptera: Culicidae) in India. Asian Pac J Trop Biomed, 2011; 109-112.
68. Yadav M, Savitri P, Kaushik R, Singh NP. Studies on repellent activity of seed oils alone and in combination on mosquito, *Aedes aegypti*. J. Env. Biol, 2014; 35: 917-922,
69. Sabbour MM, Abd-El-Raheem MA. Repellent Effects of *Jatropha curcas*, canola and jojoba seed oil, against *Callosobruchus maculates* (F.) and *Callosobruchus chinensis* (L.). J Appl Sci Res, 9(8): 2013; 4678-4682.
70. Daang QL, Ki-won K, Mai NC, Ho CY, Ja CG, Soo JK, Soo PM, Hwan LC, Hoang LN, Cheol KJ. Nematicidal and antifungal activities of annonaceousacetogenins from *Annona squamosa* against various plant pathogens *J. Agric. Food Chem*, 2011; 59(20): 1160–1116.
71. Sabbour MM, Sahab AF, Hussein MM. Evaluation of the fungicidal and insecticidal activity of three seed oil extracts against some phytopathogenic fungi and tomato insects. IJSR, 2014; 3(9): 1377-1384.
72. Srivastav S, Kumar R, Sinha A. Antifungal activity of *Jatropha cucarus* seed oil against seed borne fungi. Plant Pathol J, 2012; 11(4); 120-123.
73. Kumar S, Kaushik N. Endophytic fungi isolated from oil-seed crop j*atropha curcas* produces oil and exhibit antifungal activity. PLOS ONE, 2013; 8(2): 1-8.
74. Makun HA, Anjorin ST, Adeniran LA, Onakpa MM, Muhammad HL, Obu OR, Agbofode YV. Antifungal activities of *Jatropha curcas* and *Ricinus cumunis* seeds on *Fusarium verticilliodes* and *Aspergillus flavus* in yam. ARPN. Journal of Agricultural and Biological Science, 2011; 6(6): 22-27.
75. Gaikwad RS, Kakde RB, Kulkarni AU, Gaikwad DR, Panchal VH. *In-vitro* antimicrobial activity of crude extracts of Jatropha species, Current Botany, 2012; 3(3): 9-15.
76. Qin W, Yi L, Li-Jun J, JinXia Z, SH, Chen F. Antifungal activity of curcin from *Jatropha curcas* seeds. Chinese Journal of Oil Crop Sciences, 2004; 26(3): 71-75.
77. Vir D, Sharma RK. Studies on the fungicidal properties of Neem oil. Indian Journal of Plant Pathology, 1985; 3(2): 241-242.
78. Moline HE, Locke JC. Comparing neem seed oil with calcium chloride and fungicides for controlling postharvest apple decay. Hortscience, 1993; 28(7): 719–720.
79. Bhardwaj A, Verma SC, Bharat NK Thakur M. Effect of vegetable oil seed treatment on seed mycoflora of pea, *Pisum sativum* L. International Journal of Farm Sciences, 2013; 3(2): 46-51.
80. Yekeen MO, Ajala OO, Alarape AB. Antifungal activities of *Citrus sinensis* seed oil against Lentinussajor-caju. Advances in Applied Science Research, 2014; 5(3): 109-113.
81. Butterworth JH, Morgan ED. Isolation of a substance that suppresses feeding in locusts. J. Chem. Soc., Chem. Commun, 1968; 1: 23-24.
82. Carpinella MC, Defago MT, Valladares G, Palacios SM. Antifeedant and insecticide properties of a limonoid from *Melia azedarach* (*Meliaceae*) with potential use for pest management, 2003; 15; 51(2): 369-374.
83. Ahmed SA, Megeed AA. Pesticidal activity of an isolated limonoid from *Melia azedarach* fruits. J Anim Plant Sci, 2015; 25(2): 519-527.
84. Mark LS, Klocke JA, Barnby MA, Yamasaki RB, Balandrin FM. Insecticidal constituents of *Azadirachta indica* and *Melia azedarach*

(Meliaceae). Phytochemistry, 1999; 50 (6): 977–982.
85. Castillo SE, Jiménez-Osornio JJ, Delgado-Herrera MA. Secondary metabolites of the *annonaceae, solanaceae* and *meliaceae* families used as biological control of insects. Tropical and Subtropical Agroecosystems, 2010; 12: 445-462.
86. Yu JG, Luo XZ, Sun L, Li DY, Huang WH, Liu CY. Chemical constituents from the seeds of *Annona squamosa*. Yao XueXueBao, 2005; 40(2): 153-158.
87. Kawazu K, Alcantara JP, Kobayashii A. Isolation and structure of neoannonin, a novel insecticidal compound from the seeds of *Annona squamosa*. Agric. Bioi. Chern, 1989; 53(10): 2719-2722.
88. Makkar HPS, Becker K, Sporer F, Wink M. Studies on nutritive potential and toxic constituents of different provenances of *Jatropha curcas*. J. Agric. Food Chem, 1997; 45: 3152–3157.
89. Ratnadass A, Michael W. The Phorbol Ester Fraction from *Jatropha curcas* seed oil: potential and limits for crop protection against Insect Pests. Int. J. Mol. Sci, 2012; 13: 1615-1617.
90. Haas W, Sterk H, Mittelbach M. Novel 12-deoxy-16-hydroxyphorbol diesters isolated from the seed oil of *Jatropha curcas*. J Nat Prod, 2002; 65(10): 1434-1440.
91. Moustafa AA, Abdelgaleil SAM, Belal AH, Abdel M, Rasoul AA. Insecticidal, antifeedant and antifungal activities of two glucosides isolated from the seeds of *Simmondsia chinensis*. doi:10.1016/j.indcrop.2007.04.005.
92. Misiaka IJ, Lipoka J, Ewa MN, Wieczoreka PP, Piotr M, Kafarski P. Antifungal activity of the carrot seed oil and its major sesquiterpene compounds Z. Naturforsch, 2004; 59: 791-796.
93. Bajpai NK, Sehgal VK. Effect of neem products, nicotine and karanj on survival and biology of pod borer, *Helicoverpa armigera* Hubn. of chickpea. Proc. II azra conference on recent trends in plant, animal and human pest management: Impact on Environment, 48. Madras Christian College, Madras, 1994.
94. Packiam SM, Anbalagan V, Ignacimuthu S, Vendan ES. Formulation of a novel phytopesticide ponneem and its potentiality to control generalist herbivorous lepidopteran insect pests, *Spodoptera litura* (Fabricius) and *Helicoverpa armiger*a (Hübner) (Lepidoptera: Noctuidae). Asian Pac J Trop Dis, 2012; 2(2): 720–723.
95. Ascher KRS, Schmutterer H, Zebitz CPW, Naqvi SNH. The persian lilac or chinaberry tree: *Melia azedarach* L. In: The need tree. Federal Republic of Germany, 1995; 605-642.
96. Wanyika HN, Kareru1 PG, Keriko JM, Gachanja AN, Kenji GM, Mukiira NJ. Contact toxicity of some fixed plant oils and stabilized natural pyrethrum extracts against adult maize weevils (Sitophilus zeamais motschulsky). AJPP, 2009; 3(2): 66-69.
97. Ezekiel AS, Anjorin ST, Garba CD, Omolohunnu EB. A review of need biopesticide utilization and challenges in Central Northern Nigeria, Afr J of Biotech, 2008; 7(25): 4758-4764.
98. Arnason J, Sims TSR, Scott IM. Natural products from plants as insecticides phytochemistry and pharmacognosy, encyclopedia of life support system, 2011; EOLSS. http://www.eolss.net/outlinecomponents/Phytochemistry Pharmacognosy.aspx.
99. Cavoski I, Caboni P, MianoT. Natural Pesticides and Future Perspectives ISBN: 2011; 978- 953-169-190.
100 Isman M B. Neem and other Botanical insecticides: barriers to commercialization. Phytoparasitica, 1997; 25(4): 339-344.
101 Sarkar M, Kshirsagar R. Botanical Pesticides: Current challenges and reverse pharmacological approach for future discoveries. J Biofertil Biopestici, 2014; 5(2): 1-2.