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A review on biopesticidal activities of ethnobotanical plants

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Abstract
Harmful organism that harms vegetables, fruits, crops, grains and all types of food stuffs stored in houses and ware houses is called pest. For the management of pest number of synthetic pesticides are used more frequently on vegetables crops and stored grain pests. However, due to its side effects on target specific organisms and non-target specific organisms a sustainable approach was performed to produce biopesticides of plant origin and are isolated from ethnobotanical plants for protection of crops, for increasing production of yields, for maintaining health of domestic animals and human beings and for their possible incorporation into the Management of pest/insect.

In this review, bio-pesticidal activities of ethnobotanical plants were conducted by number of pioneer workers against number of pests by isolating its extract using soxhlation, cold percolation, vacuum evaporation, and by separating secondary metabolites of the extracts using thin layer and column chromatography. Obtained purified fractions of the ethnobotanical plant were applied on insect/pests for observing insecticidal / biopesticidal activities. From the results, it has been noticed that the extract and its fractions obtained from the ethnobotanical plants and their parts contain number of bioactive compounds including alkaloids, flavonoids, tannins, saponins, terpenoids that can be use as biopesticides and as an alternative source of synthetic pesticides/chemical pesticides. Biopesticides can be very cheap, easy and eco-friendly way of insect/pest management.

Keywords: Biopesticides, synthetic pesticides, integrated pest management

Introduction

The term “Biopesticides” refers to compounds obtained from organisms that are used to manage agricultural pests by means of specific biological effects rather than as broader chemical pesticides (Sporleder *et al.*, 2013) [102]. In the field of agriculture, one of the major problems is to protect crops from pests and/or insects. Mostafa (2012) [63] has reported that number of plants are being used as biopesticides or bioinsecticides because plants are a very good source of biologically active phytochemicals that can be an alternative source to replace presently using chemical insecticides/pesticides for the control of insects/pests. Pino *et al*. (2013) [75] have also reported that secondary metabolites isolated from plants can be an alternative source of synthetic pesticides. Therefore, the present review is based on the research work already conducted by the pioneer workers for the control of pest/insect of agricultural crops. The efficacy of synthetic pesticides has been reported by Gautam and Pareek (1991) [27] for controlling the pest of cabbage crops in the semi-arid zone of the Rajasthan state and observed that the efficacy of 0.01% cypermethrin against the aphids and larvae of diamond back moth was highest which was followed by 0.01% fenvalerate, 0.025% methyl demeton and 0.1% carbaryl, as compared to the least effective pesticides 0.03% dimethoate, 0.03% phosphamidon, 0.5% malathion and 0.025% carbosulfan, respectively and 2 chemical pesticides were found to be moderately effective *viz*. 0.035% endosulfan and 0.036% monocrotophos.

The efficacy of leaves and seed extract of *Azadirachta indica* against the pest *P. xylostella* of cabbage have been reported by Javaid *et al*. (2000) [39-40] and their results were compared with the synthetic pesticides *viz*. dimethoate and cypermethrin and found that *Azadirachta indica* extracts were most effective in controlling pest of cabbage as compared to the commonly available chemical pesticides pyrethroids. The study was also conducted by Krishnamoorthy and Kumar (2000) [44] on the seed kernel extract of *Azadirachta indica* against cabbage moth *P. xylostella* and leaf Webber *C. binotalis* with the efficacy of 4% concentration.

Significant efficacy of indoxacarb against larvae of cabbage moth diamond back was reported by Patel *et al*. (2005) [68]. They have tested number doses of indoxacarb and observed that 40gm a.i./ha was the highest dose of indoxacarb which was found to be effective significantly against the population of cabbage moth. In the experiment, it was also noticed that the 2nd highest dose 30gm a.i./ha was also found to be quite effective as compared to the 100gm a.i./ha dose of methyl demeton. However, 144gm a.i./ha highest dose of monocrotophos and 20gm a.i. / ha lowest dose of indoxacarb were also found to be effective against the population of cabbage moth *P. xylostella.*

The efficacy of few ethnic products and few synthetic insecticides were tested synergistically against the insect *P. xylostella* by Sewak *et al.* (2008) [89] and found that 5% extract of NSKE shows 58.02% larval mortality followed by the 5% extract of chili and garlic with 54.31% larval mortality.

Scientific approaches for the synergistic pest control have analyzed and developed by Ahuja *et al.* (2015) [4] for controlling the mustard/turnip aphid pest/insect *Lipaphis erysimi* and have reported the efficacy of biopesticide which is much safer in comparison with synthetic pesticides and for reducing the side effects of synthetic pesticides on crops and non-target organisms which are using crops.

Solangi *et al*. (2016) [99] have examined biopesticidal efficacy of number of plant extracts on cauliflower pests and observed its pre and post treatments effects. They have observed that 3 pests *viz*. diamondback moth, thrips and whitefly infest cauliflower crops. Their results showed that the mortality of cauliflower pest moth diamond back was 97.23% with *Azadirachta indica* extract, 95.39% with *Nicotiana tabacum* extract, 92.19% with Tooh extract, 89.79% with *Dhatura* extract and 80.98% with *Calotropis procera* extract, respectively. They have shown the results of mortality against the insect *Thrips* (Thunder flies) with the 78.42% efficacy of *Azadirachta indica* extract, followed by 72.33% *Nicotiana tabacum* extract, 69.51% *Tooh* extract, 65.55% *Calotropis procera* extract, respectively. Similarly, they have also tested plant extracts mortality against *Bemesia tabaci* whitefly insect with the efficacy of 83.81% *Tooh* extract followed by 78.14% efficacy of *Dhatura* extract.

Hassan *et al*. (2018) [32] have analyzed biopesticidal efficacy of *Azadirachta indica* extracts for the control of Lepidopteran pest *Plutella xylostella*. They have reported significant loss in weight of the larvae of this insect i.e. 56.43-68.20% after applying 0.31%, 0.5%, 0.6% and 1% concentration of azadirachtin and significant loss in weight of pupa i.e. 24.47 to 46.77% also after applying the same concentration of azadirachtin.

Since 20years researches in agriculture for controlling pest, number of chemical pesticides have already been used however, due to their hazardous effects on crops novel pesticides has now been discovered by the number researchers. Saxena *et al.* (1992) [86] have investigated insecticidal action of petroleum ether and MeOH extracts of *Lantana camara* at 1 to 5% concentration for controlling pest *Callosobruchus chinensis* with 10–43% mortality.

Regnault-Roger (1997) [83] has isolated essential oils from plants and reported its potential for insecticidal activities. They have noticed that aromatic plants gave an odor that is called aroma and has a characteristic flavor because of the presence of volatile compounds in the essential oils. Similarly, Dubey (1997) [26] has also reported the management of certain agricultural insect pest where he has isolated a compound Quercetin to control the pest of Okra.

Mahapatro and Gupta (1998) [52] have reviewed that the excess use of chemical pesticides and/or synthetic insecticides since last 50years brought to a number of complications including resistance of pest /insect to chemicals, the renaissance of insects/pests, remains of pesticides/ insecticides in soil and agricultural crops, the risk of side effects of insecticides/pesticides to the health of non-target organisms including human beings and livestock and also caused interruption in the food web and environmental pollution in ecosystem. Consequently, in the present scenario it has now became compulsory to find out some of the alternatives for controlling insects and pests that can reduce the excess use of synthetic insecticides and / or chemical pesticides. Phytopesticides are important alternatives to reduce and/or replace the excess use of chemical insecticides or synthetic pesticides which possess pesticidal, insecticidal, insect/pest repellent, anti-feedant, and insect/pest growth regulatory activities, as reported by Prakash *et al.* (1990) [77] and Prakash *et al.* (2003) [76], respectively. Presently, for the isolation of pure extracts from the plants, one of the known technique Super Critical Fluid (SCF) is being used that is a good alternative method of separation and is now called Green Technology of separation. In this perspective, Ghasemi *et al.* (2007) [30] have isolated *Artemisia sieberi* (Besser) extract using super critical fluid technique of extraction by applying 101_304bar pressure range, 34.85_64.85°C temperature range, 15_35 minutes dynamic extraction time, and 0_500micro liter a modifier volume. On the basis of observations, they have analyzed the maximum yields using super critical fluid extraction technique at 304bar pressure, 44.85°C temperature, 25minutes dynamic extraction time. Besides this, they have noticed that at 54.85°C temperature under same situations extraction of camphor can be done using super critical fluid extraction technique. The study revealed that components extracted under the supercritical fluid extraction conditions contain a wide range of compounds. Hence, super critical fluid extraction technique is more discriminating now-a-days in comparison to hydro distillation technique that is being used traditionally for the extraction of essential oil and its preservation.

Ajchariyapagorn *et al.* (2009) [5] have also isolated Nimbin extracts from *Azadirachta indica* seeds using supercritical CO_2 method and the impact of CO_2 with 0.24_1.24ml/min flow rate, at 34.85_59.85ºC temperature, at 100_260 bar pressure, 0.575_1.850 mm particle size and 1.0_2.5gm weight of *Azadirachta indica* kernel powder were investigated. Sapkale *et al.* (2010) [85] have also reported the most effective and efficient way to extract out precious phytoconstituents is supercritical fluid extraction. CO_2 is the king solvents for extraction of botanicals. The conditions for supercritical extraction using CO_2 solvent are above to 31ºC critical temperature and 74bar critical pressure. Chemically, CO_2 is a supercritical fluid which is highly compressed gas that releases pressure to separate analyte from mixture.

The extraction and chemical composition of the essential oils of Pipilongo (*Piper tuberculatum* Jacq) using supercritical $CO_2$was studied by Osorio *et al.* (2013) [86]. The extraction was performed as a function of particle size of the grinded seeds. The highest yield (2.812%) was obtained with the smallest particle size. The analysis of chemical composition of the oil by GCMS led to the identification of 15compounds, caryophyllene β-farnesene, neophytadiene and piperine among others.

The study by Scapinello *et al.* (2014) [87] evaluated the effects of supercritical CO_2 extracts obtained from the fruit of *M. azedarach* at 60°C and 200 bar on the development of *Spodoptera frugiperda* Smith from the larval period until the insect adulthood. Larval mortality was found to be increased by raising the extract concentration tested. The mortality was found to be 100.00 percent at the highest concentration (5000 mg/kg) with a minimum LC_{50} value (376.74 mg/kg). The extract exhibited insect growth inhibitory activity in the higher concentration (500, 1000 and 5000mg/kg) due to anti-feedant action which results in larvae and pupae with mass and body length significantly smaller than the control. At the lowest concentration (100mg/kg), a chronic toxicity effect was observed with low viability in pupal and adult stages.

Dreyer (1987) [25] carried out field and laboratory tests to determine the efficacy of simple neem products (aqueous extracts of neem kernel powder, neem oil and grounded neem kernels) for the control of the pests of various vegetables and field crops including *Plutella xylostella* (L.). The results revealed that good control of *P. xylostella* was achieved with weekly applications of 25 to 50gram neem powder/liter of water. The bio-efficacy of *Melia azedarach* leaves extract was investigated by Zhu (1989) against four lepidopteran cabbage pests namely *Pieris brassicae* (L.), *Pieris rapae* (L.), *P. xylostella*, *Mamestra brassicae* (L.) and concluded that the tested extracts caused inhibitory effect on larval metamorphosis at 0.05, 0.1, 0.5 and 1% concentration.

Klemm and Schmutterer (1993) [42] studied the effect of neem seed kernel water extract at 25 and 30-gram seed kernels/liter of water on the pest *P. xylostella* and its natural enemies. Under field conditions, the number of larvae was significantly reduced to 4.98 and 5.92 larvae per plant by the application of neem at the end of experiment compared to control (18.57 larvae/plant). It was also observed that development of pupae and adult was generally low to negligible on neem treated plants.

Patel *et al.* (1993a) [70] have evaluated antifeedant and insecticidal properties of plant materials for controlling the larvae of diamond back moth, mustard sawfly and army worm. They have reported that 5% suspension of seed kernel paste of *Azadirachta indica* was found to be effective against many pests, however, 5% suspension of leaf extract of *Azadirachta indica* was found to be less effective against pest *Plutella xylostella*. They have isolated a compound repelin which was reported to be a best repellent while, 1% Neem ark was reported at par with 5% suspension of *Azadirachta indica* kernel paste for controlling pest *Plutella xylostella*.

The insect growth controlling activities and field spraying efficacy of *Azadirachta indica* extract on pest *Plutella xylostella* and *Crocidolomia biontalis* (Zeller) of broccoli crops were studied by Prijano and Hasan (1993) [78]. They have sprayed 2.5%W/U azadirachtin oil at 1.8, 2.4, 3.0 liters/hectares on broccoli crops and reported complete protection of broccoli plants from the infestation by the pest *Plutella xylostella* as that with 50gm a.i./ha fenvalerate (Sumicidin 20EC). Sombatsiri (1996) [100] has reported the efficacy of *Azadirachta indica* seed kernel 2-4% alcoholic extract for controlling the larvae of *Plutella xylostella* and reported maximum yield of vegetable crops as compared to 0.05% spraying of mevinphos (0.05%) in those crops.

Dilawari *et al.* (1994) have tested the bioactivity of *Melia azedarach* on the pest *Plutella xylostella* and have reported that when *Plutella xylostella* female adults treated with methanolic extracts of *Melia azedarach* and exposed on the leaves of cabbage vegetables, *Plutella xylostella* female adults lay fewer eggs as compared to controlled. The efficacy of 7 insecticides for controlling the pests *Plutella xylostella* and *Lipaphis erysimi* of cabbage vegetable crops was studied by Patel *et al.* (1996) [69]. They have observed that 1:37.08 Endosulfan, 1:34.08 Chlorpyriphos and 1:27.58 suspension of seed kernel of *Azadirachta indica* were reported to be the most effective for controlling both pests *Plutella xylostella* and *Lipaphis erysimi* of cabbage crops. Seal (1996) [88] was also evaluated the efficacy of conventional bio-insecticides for controlling the cabbage pest *Plutella xylostella*. Seal has found that azadirachtin compound significantly controlled larvae of the pest *Plutella xylostella* and increased the production of cabbage crops. The efficacy of insecticides made-up of 4% aqueous neem seed kernel extract, lufenuron, *Bacillus thuringiensis*-based products, diafenthiuron and dichlorvos for controlling the pest *Plutella xylostellai* was also evaluated by Sannaveerappanavar and Viraktamath (1997) [84]. They have concluded that lufenuron is an excellent biopesticide for the pest control. Similarly, the seed kernel extract of *Azadirachta indica*, the product based on *Bacillus thuringiensis* and diafenthiuron also were also found as a good biopesticides for pest control. Dhaliwal *et al.* (1998) [22] have tested the efficacy of the compound Achook and Nimbecidine for controlling the cabbage pests. Different concentrations of *Azadirachta indica* extracts in the 1, 2, 4 kg/ha area were also tested for controlling pests which were compared with chemical pesticide endosulfan at 0.5 kg ai/ha area which was reported to be highly effective on all the pests followed by applying both the bioactive compound *viz*. Achook, Nimbecidine which showed highest pest mortality at 4 kg/ha area.

The seed kernel extract of *Azadirachta indica* were tested for controlling the pest diamond back by Moorthy *et al.* (1998) [61] who have also reported the population of *Plutella xylostella*. Narabenchi *et al.* (1998) [64] have also tested the efficacy of seed kernel aqueous extract of Neem for controlling the pest diamond back moth at various concentrations and have found that the aqueous seed kernel extract of Neem at 2-4% concentration shows pest control by reducing 1.30-3.70 larvae/plant after 2nd spray on 9.40 larvae in the untreated group.

The efficacy of 3 formulations of *Azadirachta indica* extract *viz*. Cuba Nim-t dry powder at 5kg/ha, Oleo Nim 80 CE water emulsion at 1.5 L/ha and Oleo Nim 50CE water emulsion at 3L/ha was evaluated by Perez *et al.* (1998) against the pest *Plutella xylostella* of cabbage crops and have reported 80% efficacy of Cuba Nim-t against the pest diamond back moth after 4 replicates and found statistically significant and similar to the commercial insecticide lambda-cyhalothrin (Karate 2.5EC). Meadow and Seljasen (1999) [54] have also tested neem extracts for their efficacy on the larvae of *Plutella xylostella* and have reported that above 2ppm concentration of azadirachtin prevented larval development while 8ppm concentration of azadirachtin prevented plants crops and after spraying, the plants were protected effectively from damage.

Javaid *et al.* (2000) [39-40] have evaluated the efficacy of leaf and seed aqueous extracts of Neem for controlling pest *Plutella xylostella* of cabbage and have compared it with dimethoate and cypermethrin parallelly under field conditions. Their results exposed that all the extracts of neem reported with significant marketable yield of cabbage heads and the good control of diamond back moth s compared to commonly utilized mixture of pyrethroids. Moorthy and Kumar (2000) [62] have also utilized 4% seed kernel extract of Neem for controlling cabbage diamond back moth *Plutella xylostella* and cabbage leaf Webber moth *Crocidolomia binotalis*.

Manjunatha *et al.* (2000) [53] have reported the efficacy of biopesticide made-up of 0.1%, 0.2%, and 0.4% concentration of Nivaar, 0.1% concentration of malathion, 0.05% concentration of monocrotophos and water as controlled sprayed for the management of cabbage pest *Plutella xylostella* and green peach aphid pest *Myzus persicae* on cabbage and have found that all concentrations of Nivaar was higher over the controlled and was also found at par along with malathion and monocrotophos after 1st and 2nd spraying and reported higher to both after 3rd spraying. Finally, they have found all the results after the spraying of Nivaar at par along with malathion and monocrotophos.

The effect of dosages of a bioactive compound azadirachtin on *Plutella xylostella* insect population dynamics under laboratory and field conditions was investigated by Hou *et al.* (2002) [33]. They have noticed that 0.0005% concentration spraying of azadirachtin on cabbage foliage pungently deterred the adults from egg laying and drastically inhibited feeding of larvae on the cabbage heads. The efficacy of 2.5% aqueous extract of Neem and 0.05% Di-Pel for controlling *Plutella xylostella* pest on cabbage was also evaluated and compared by Okoth *et al.* (2002) and have noticed that the Di-Pel-treated plants showed less infestation in larvae in comparison to the Neem extracts treated plants however, later treatment produced a better yield. The efficacy of certain biopesticides on diamond back moth of cabbage was also studied by Kamala *et al.* (2003). They have given the treatments of 5 sprays of Abamectin, seed kernel extract of Neem, Spinosad, Di-Pel and Neemajal on 10 days intervals and have observed that Abamectin, seed kernel extract of Neem and Spinosad produced the maximum number of profitable heads as well as yields, whereas Di-Pel and Neemajal were found at par however greater to the soap of Neem oil and soap of *Pongamia pinnata* oil.

Pandey and Raju (2003) [67] have conducted the experiments on biopesticidal efficacy of endosulfan, lufenuron, diafenthiuron and seed kernel extract of Neem on many instars of *Plutella xylostella* larvae and recorded mortality 80% to 97% within 96 to 120days of exposure. Similarly, the efficacy of phytoinsecticides on diamond back moth of cabbage was evaluated by Patil *et al*. (2003) [72] after the treatment of Azadirachtin, Carina i.e. Profenofos and Rocket i.e. Profenophos with cypermethrin which showed 100% efficacy after seven days of 4th spray.

Shankaara *et al.* (2003) [90] have evaluated bio-efficacy of a commercial neem product based on the formulations made up of 0.15% Solu Neem, 0.3% Eco-neem-plus, 0.3% Vijay Neem, 0.6% Neem Ark and 2 plant extracts at 10% concentration, 0.0075% indoxacarb, 0.01% fipronil and 4% Neem seed kernel extract on diamond back moth of cabbage. Their results revealed that indoxacarb and fipronil were reported to be the most effective bio-insecticide. Besides this, 4% Neem seed kernel extract was reported to be deliberate in its action however, it was found to be highly effective and at par along with two new insecticides for destroying the diamond back moth after third spray. During the study, commercial neem formulations *viz*. Solu Neem and Eco Neem plus both were found to be effective against diamond back insect moth of cabbage.

Singh *et al.* (2003) [96] have tested efficacy of 5 newly prepared insecticides, 4 insecticdes of conventional types and 4 insecticides based on Neem formulations for the control of early aged 3rd Instar larvae of *Plasmodiophora brassicae*. From the results, it was observed that Neem-based formulations including 0.5% Neemarin showed maximum 50% larval mortality. However, 0.5% Neem oil was observed to be least effective which showed 16.66% larval mortality after 72hrs of the treatment. Similarly, Sood *et al.* (2005) [1] have also carried out the studies on the toxicity of extracts of certain plants against *Plasmodiophora brassicae* and found the highest toxicity of extract of *Melia azedarach* with 30% to 93.3% mortality in different concentrations of extracts with solvent.

Sewak *et al.* (2008) [89] have also tested the efficacy of certain indigenous plants products and 3 chemical insecticides with their various combinations against *Plutella xylostella* and have noticed that among indigenous plants products, 5% seed kernel extract of neem was found to be highly effective with 58.02% larval mortality that was found to be at par with 5% extract of chili and garlic along with 54.31% mortality. Although, the chemical insecticide including 0.05% dichlorvos was proved to be highly toxic with 96.91% mortality which was also found to be at par with 0.07% endosulfan with 85.79% mortality. Moreover, the least effective mortality of indigenous plants products including 3% chili, 2% garlic and 10% cow dung with cattle urine in grouping with half dose of 0.25% dichlorvos and 0.035% endosulfan was proved to be highly effective as that of the chemical insecticide alone for the control of diamond back moth.

Rani and Jandial (2009) [80] have also reported the efficacy of 4 biopesticides based formulation including 2ml/liter azadirachtin, 1gm/liter *Bacillus thuringiensis* Kurstaki Berliner, 0.33ml/liter spinosad and $8x10^{12}$ conidia/g *Verticillium lecanii* Zimmerman for the management of pests *Plasmodiophora brassicae* and *Thysano plus iaorichalcea* (Fab.) and have observed that Spinosad reduces maximum population of *Plasmodiophora brassicae* in comparison to *Bacillus thuringiensis* Kurstaki while *Thysanoplusia orichalcea* polyphagous pest of vegetable crops both were found to equally effective for reducing population.

Sharma and Mehta (2009) [94] have studied the efficacy of *Melia azedarach* methanolic extracts, *Eupatorium adenophorum* and other plant extracts at 1.25%, 2.5% and 5.0% concentration against the pest cabbage aphid and revealed highest reduction in population of aphid after the treatment of *Melia azedarach*.

Sharma *et al*. (2009) [91-92] have tested the larvicidal activities of aqueous extract of 8 plants including *Lantana camara, Azadirachta indica*, *Melia azedarach*, *Nerium indicum*, *Cannabis sativa*, *Eucalyptus* species, *Solanum nigrum and Ricinus communis* against the pest *Spodoptera litura* and *Plasmodiophora brassicae*. They have observed that the aqueous extract of *Azadirachta indica* and *Melia* *azedarach* showed highest 20.90% and 19.20% larval mortality against *Spodoptera litura* and highest 18.50% and 19.60% larval mortality against *Plasmodiophora brassicae*, respectively as compared to the other plants extracts. They have also observed that seed kernel ethanolic extract of *Azadirachta indica* and *Melia azedarach* were found to be highly effective against *Spodoptera litura* and *Plasmodiophora brassicae* with significant larvicidal activities along with 22.20% to 25% and 13.20 to 50% and 10.50-39.50% mortalities, respectively, as compared to the other plant extracts.

Ahmad *et al.* (2010) [3] have screened the insecticidal activities of the crude methanolic extract of the aerial parts of *Sarcococca saligna* and purified fractions and their results revealed that purified fraction of n-hexane extract of *Sarcococca saligna* showed 60% insecticidal activity against *Callosobruchus analis* and 40% insecticidal activity against *Tribolium castaneum*. Mekuaninte *et al.* (2011) [58] have conducted laboratory studies for evaluating the efficacy of leaves and seeds extracts of *Melia azedarach* and *Mentha piperita* leaves extract against the pest aphid and tested 3 concentrations *viz.* 25%, 0.50% and 1.0% of methanol and aqueous extracts on aphids. They have noticed that among 3 extracts, *Mentha piperita* leaf extract and *Melia azedarach* seed extract showed promising insecticidal activities. Ghany *et al.* (2012) [29] have also tested ethyl acetate extract and purified fraction of *Melia azedarach* ripe fruits on 2nd and 4th instar larvae of *Spodoptera littoralis* and observed that the extract and the fraction of *Melia azedarach* showed significant insecticidal activities and significant loss in weight of larvae of *Spodoptera littoralis* at all concentrations with the LC_{50} values of the extract (4.10 and 16.04), although for the purified fractions of *Melia azedarach* the LC_{50} values were 1.19 and 2.01 against 2nd and 4th instar larvae of *Spodoptera littoralis*, respectively.

Razmjoo *et al.* (2013) [82] have studied the effect of plant extracts of *Melia azedarach* on the larval mortality of diamond back moth which was observed at a higher concentration of 10gm whereas lower at 3gm extract. Thakur and Sharma (2014) [105] have also conducted a study on the evaluation of organic inputs for the management of insect pests of cauliflower and cabbage. They have treated neonate larvae of *Plasmodiophora brassicae* through seven concentrations of the organic biopesticides extracts of the plants for observing mortality of the pest which was recorded at 24, 48 and 72 hours of exposure and it was observed that out of tested organic biopesticides, 0.30% neem oil showed 100% mortality, which was followed by 10% aqueous extract of *Eupatorium* with 81.10% mortality. Among all the treatments tested on *Plasmodiophora brassicae* neonate larvae using leaf dip technique, 16000IU/mg *Bacillus thuringiensis* showed 100% mortality which was followed by 0.30% neem oil with 66.70% mortality.

Gautam and Pareek (1991) [27] have studied the efficacy of 10 insecticides for the management of pest of cabbage vegetable crops in semi-arid zone of Rajasthan. They have reported that 0.01% cypermethrin was found to be highly effective for pesticidal activity which followed by 0.01% fenvalerate, 0.025% methyldemeton and 0.1% carbaryl whereas 0.03% dimethoate, 0.03% phosphamidon, 0.5% malathion and 0.025% carbosulfan were reported to be least effective and 0.035% endosulfan and 0.036% monocrotophos were reported to be moderately effective for controlling the pest/insect larvae of aphid and diamond back moth of cabbage crops. A field experiment was conducted by Kumar *et al.* (2006) [45] during the year 2005-06 for evaluating insecticidal activity of 10EW cypermethrin against pest *Plutella xylostella* on cabbage crops after 30 days of crops transplantation. Their study revealed that 10 EW cypermethrin when treated in 70-280gm a.i. per ha it was found to be highly effective to the other treatments, although 10 EW cypermethrin in 60 gm a.i. per ha was found to be least effective.

Liang *et al.* (2003) [48] have observed the effect of neem-based three insecticides including Neemix, Agroneem and Ecozin for observing oviposition deterrence activity and anti-feedant activity on larvae and for testing toxicity on eggs of insect *Plutella xylostella*. Their study revealed that all the three insecticides showed significant antifeedant activities. They have noticed that when larvae put on treated leaves they have stopped feeding and leaves were not found to be damaged. They have also noticed that 75.20%, 66.20% and 61.60% developments of *Plutella xylostella* eggs into neonates were observed, when treated with Neemix, Ecozin and Agroneem, respectively. The findings of Kouninki *et al.* (2006) [43] were observed for insecticidal activities of steam distillated extracts of essential oils of 7 plant species against *Sitophilus zeamats* (Motsch) found in Cameroon and for observing contact toxicity, formulations of 1% essential oils of *Xylopia aethiopica* and *Ocimum gratissimum* were applied which was found to be the highly toxic and 96-98% mortality were reported, respectively after 24 hours of exposure. The essential oil of *Hyptis spicigera* was also found to be highly fumigant after 48 hours of fumigation which was followed by the plant *Annona seregalensis* and *Xylopia aethiopica* with 96% and 95% of mortality, respectively after the treatment of the fumigation test.

The essential oil extracted from *Thymus persicus* was evaluated by Moharramipour *et al.* (2009) [60] for insect repellent and insecticidal activities against stored grain pests *Tribolium castaneum* (Herbst) and *Callosobruchus maculatus* (F.). Results of their studies revealed that *Callosobruchus maculatus* and *Tribolium* castaneum pests at 2ml/ml concentration of acetone showed 82.40% and 70.40%, insect repellency, respectively and *Callosobruchus maculatus* adults were found to be more susceptible with LC50: 2.39 ml/L air to the essential oil as compared to *Tribolium castaneum* adults with LC50: 234.42 µl/L air.

Sharma and Gupta (2009) [91-92] have evaluated antifeedant and insecticidal activities of aqueous extracts of *Azadirachta indica*, *Melia azedarach*., *Lantana camara*, *Cannabis sativa*, *Nerium indicum*, *Eucalyptus species*, *Ricinus communis* and *Solanum nigrum* against *Plasmodiophora brassicae*. The results of their studies showed that aqueous extract of *Azadirachta indica* and *Melia azedarach* showed repellency of maximum number of larvae consequently by protecting cabbage foliage 94.00% and 89.20%, respectively. Aqueous extract of *Melia azedarach*, *Nerium indicum* and *Azadirachta indica* showed 19.60%, 19.60% and 18.50% mortality of larvae, 19.60, 19.60 and 18.50%, respectively. The protection of the cabbage foliage was reported at 5% of concentration of *Melia azedarach* with 88.30% and *Azadirachta indica* with 82.50%. Abdel-Sattar (2010) [2] has seen insect repellent and insecticidal activities of essential oils of fruits and leaves of *Schinus molle* against *Trogoderma granarium* and *Tribolium castaneum* and has identified 65 compounds in these oils by GCMS analysis.

Hydrocarbons was found maximum 80.43% followed by monoterpenes 74.84% in essential oils of fruits and leaves. The highest yield and efficacy of essential oil of *S. mole* against *Trogoderma granarium* and *Tribolium castaneum* showed insecticidal properties.

Bullangpoti *et al.* (2012) [20] have evaluated the antifeedant activity of *Jatropha gossypifolia* and *Melia azedarach* leaves extracts on fall army worm *Spodoptera frugiperda*. They have observed that when, *Melia azedarach* added to the diet, it showed lower toxicity than *Jatropha gossypifolia*. However, *Melia azedarach* after two weeks found to be lethal to the larval population means it showed 100% mortality. Hence, it was observed that leaves extracts of both plants *Jatropha gossypifolia* and *Melia azedarach* when added with artificial diets showed significant anti-feedant activities for controlling armyworm larvae *Spodoptera frugiperda*. Michael and Raja (2012) [59] have evaluated individual and combined effect of aqueous extract of *Melia azedarach* seeds, *Croton macrostachys* leaves and *Schinus molle* extract against *Plasmodiophora brassicae* in the laboratory and field conditions as well for observing its bioactive potential. Both plant extracts showed insect repellent activity at 0.6%, 1.2%, 2.5%, 5% and 10% concentration using leaves disc no-choice method on insect. When field experiment was conducted of both plant extracts by spraying 5% concentration made-up of *Melia azedarach*, *Croton macrostachys* and *Schinus molle* and mixed forms of 2.5% *Melia azedarach* with 2.5% *Croton macrostachys,* 2.5% *Melia azedarach* with 2.5% *Schinus molle* and 2.5% *Croton macrostachys* with 2.5% *Schinus molle*, a significant reduction in a number of infested plants of cabbage crops and population of aphids was recorded.

Liu *et al*. (2013) [49] have investigated insecticidal activity of the essential oil of *Dipsacus japonicus* against maize weevil *Sitophilus zeamais* and wheat weevil *Tribolium castaneum.* The essential oil of *Dipsacus japonicus* contain 46 compounds with 96.76% of the total oil and showed contact toxicity against two stored grain insects maize weevil *Sitophilus zeamais* and wheat weevil *Tribolium castaneum* with mortality LD_{50}: 18.32, 13.45 mg/adult. The essential oil of *Dipsacus japonicus* also showed fumigant toxicity against *Sitphilus zeamais* with LC_{50}:10.11mg/L air and *Tribolium castaneum* adults with LC_{50}: 5.26 mg/L air. Sohani *et al.* (2013) [98] have also tested insecticidal and insect repellent activities of the essential oil of leaves extract of *Callistemon citrinus* (Curtis) by hydro distillation on female and male adults of *Callosobruchus maculatus.* Their study revealed that 34.20% 1,8-cineole and 29% α-pinene were the major compoound of the essential oil which possess insect repellent activities 86% and 94%, respectively after 2 and 4 hours of exposure of *Callosobruchus maculatus* at the 0.4µl/cm highest concentration.

Tarkeshwar *et al.* (2014) [104] have conducted the survivorship experimental bioassay with *Melia azedarach* fruit methanolic extracts on 1st instar larvae of *Spilosoma obliqua* Walker which showed toxicity. However, this extract when tested on 4th and 5th instar larvae of *Spilosoma obliqua* also showed significant antifeedant activity at all the applied concentrations. They have also observed strong larvicidal activity of methanolic extract of *Melia azedarach* on the neonate larvae that reflect the higher susceptibility to this extract while hexane extract when tested that shows less toxicity.

Wang *et al.* (2015) [108] have evaluated the insect fumigant, insect contact, and insect repellent activities of the bioactive compounds of 4 essential oils extracted from *Citrus limonum* leaves, *Cymbopogon citrates* leaves, *Litsea cubeba* leaves, and *Muristica fragrans* leaves against 10th instar larvae and adults of *Tenebrio molitor*. They have investigated two main bioactive compounds from *Citrus limonum* and *Cymbopogan citrates* which were 38.22% D-limonene and 26.21% 3,7-dimethyl-6-octenal. However, plants *L. cubeba* and *M. fragrans* were also possess compound 49.78% (E)-3,7-dimethyl-2,6-octadienal and 79.31% (E)-cinnamaldehyde, respectively. They have observed insect contact activities of *L. cubeba* and *C. limonum* with LC_{50}:21.2 and 13.9µg/cm^2 at 48hours and also observed insect repellent activities with >89.0% repellence indexes and significant value $P<0.05$ at 12hours on 10th instar larvae. However, the insect fumigation activities of *L. cubeba* on the 10th instar and adults with LC_{50}:2.7,3.7µl/L were found to be stronger and significant as compared to *C. limonum* with LC_{50}:10.9,12.096hours.

Sharma and Singh (1993) [93] have conducted studies on the remaining toxicity of insecticidal spray on 2nd instar larvae of *Plasmodiophora brassicae* of cauliflower heads. They have noticed that 0.01% cypermethrin showed 91.40%, 84.44%, 53.33%, 6.67% mortality; 0.05% malathion showed 86.67%, 77.78%, 53.33%, 6.67% mortality and 0.07% endosulfan showed 97.98%, 86.67%, 64.44%, 55.56%, 51.11% and 17.78% mortality on 0, 1st, 3rd, 5th, 7thand 10th day of spray of the insecticides, respectively.

Arora *et al.* (2003) [9] have conducted an experiment for observing the toxicity of few newly discovered and few commonly utilized insecticides against the 3rd instar larvae of *P. xylostella* for controlling insect pest of cauliflower heads. They have reported LC_{50} values of Spinosad 0.00033%, *B. thuringiensis kurstaki* 0.01493%, cartap hydrochloride 0.01758%, cypermethrin 0.02502%, dichlorvos 0.04530%, malathion 0.22310%, carbaryl 0.032265%, endosulfan 0.50192% and monocrotophos 1.36697%, respectively. They also reported the maximum persistent toxicity of spinosad 4151.42% times more toxic than monocrotophos.

Rai *et al.* (1986) have reported in their study about 0.0075% spraying of cypermethrin which showed an initial deposit of 0.35 ppm on crops cauliflower curds that fell in to 0.30ppm, 0.20ppm, 0.15ppm, 0.01ppm and 0.04ppm after the treatments of 1st, 3rd, 8th, 11th and 15th days. Awasthi (1987) [10] has also reported in their study about cypermethrin, when applied it at 0.01% and 0.015% concentrations which showed residues of 3.07ppm and 5.17ppm, respectively, on cabbage heads that showed 63.19% and 48.74% degeneracy within 3 days. Sharma and Singh (1993) [93] have also reported the application of 0.75% cypermethrin that showed 14.87 ppm of initial deposits on cauliflower heads that fallen below the detectable level on 10th day. Bhatia and Verma (1994) [19] have also reported about the cypermethrin, after 0.0075% spraying it, showed initial deposits of 1.33ppm and found continuing deterioration up to 0.66ppm, 0.21ppm and 0.08ppm concentration after 2nd, 4th and 7th days of spraying on heads of cabbage. Jaglan *et al.* (1995) [37] have recommended dosages of cypermethrin which showed initial deposits of 4.20ppm and 3.24 ppm on cabbage heads and when prepared formulations were tested at 0.01% concentration, after 3rd days of testing, the remains degenerate up to 2.33ppm and 1.88 ppm and exercising up to 44.52% and 41.98% degeneracy in case of formulated and proprietary cypermethrin, separately.

Jain and Gupta (1999) [38] have observed that synthetic pyrethroids when tested for the management of diamond back moth on cabbage heads at the two doses provided the residue of permethrin 1.39 to 2.59ppm, cypermethrin 1.48 to 2.70ppm, fenvalerate 1.60 to 2.81ppm and deltamethrin 0.39 to 0.69ppm. They have also observed that permethrin, cypermethrin, and fenvalerate persevered for 15th days, whereas, decamethrin persevered for 7th days and the waiting periods for permethrin were worked out to be 1.91days and 6.68 days, for cypermethrin 3.99days and 5.83days, for fenvalerate 8.14days and 9.28 days and for decamethrin 0 and 0.60 days. In this context, Babu *et al.* (2001) [11] found that cypermethrin when tested at 0.01% concentration on cabbage heads provided initial residues of 0.02ppm. Initially, the residues degenerate deliberately up to 3 days with 16.67% and consequently degeneracy was fast. After 5 days of spraying, the residues were found to be lower the measurable level. The residue and degeneracy of some pesticides were assessed in cabbage heads as reported by Patidar and Dadheech (2005) [71] in their findings which exposed that the spraying of profenofos, Rocket (40% Profenofos and 4% cypermethrin) and cypermethrin at diverse doses to manage the insect-pest of cabbage heads showed the residue of profenofos 1.85ppm to 5.88 ppm, Rocket 1.91ppm to 3.08ppm and cypermethrin 0.80 ppm. Profenofos, Rocket and cypermethrin persevered for 11th, 9th and 5th days, correspondingly. Based on remains degenerate beyond the patience limit, the waiting times were worked out for profenofos 1.74 days to 6.85 days, for Rocket 2.27days to 4.08 days and for cypermethrin 0.86 days. The proportional and remaining toxicity of some newest pesticides including 10AF cypermethrin, 14.5SC indoxacarb and 20SP acetamiprid along with standard controlled 10EC cypermethrin was reported by Meena *et al.* (2007) [57] against *Plutella xylostella*. The LC_{50} values of toxicity of 10AF cypermethrin > 14.5SC indoxacarb > 20SP acetamiprid were tested on 6 days old larvae of *Plutella xylostella*. The remaining toxicity on the cabbage vegetable crops was tested on the basis of LT_{50} and persistent toxicity values which exposed that all the insecticides sprayed in the field persevered for 22 days on the crop and remaining toxicity was reported as 10AF cypermethrin > 14.5SC indoxacarb > 20SP acetamiprid, respectively.

Lowery and Isman (1995) [51] have tested seed oil of Neem at 3 different concentrations including 0.50%, 1.00% and 2.00% on preserved plants infested with *Myzus persicae* which entirely prohibited adult eclosion of *Coccinella septempunctata* and reduced adult eclosion of *Eupeodes fumipennis* to the modify of 0 to 11%. Banken and Stark (1997) [16] have conducted the studies on the susceptibility of *Coccinella septempunctata* after direct contact to the 4.5EC Neemix and found that development and survivorship of the larvae were reported to be affected in a dose-dependent manner. The LC_{50} values of azadirachtin for the 1st and 4th instar larvae were assessed to be 1 ppm, 120 ppm and 520 ppm, respectively which were found to be very much higher as compared to the recommended values 20ppm for the management of aphids in 3 weeks. This study suggests that Neemix can be very useful pesticide for the management of integrated pest.

Dhingra and Dhingra (1999) have also tested the toxicity of 24 insecticides on the adults of aphid predator *Coccinella septempunctata* and on the basis of LC_{50} values, the relative toxicity of different insecticides were calculated as shown in descending order: 0.0009212 lambda cyhalothrin > 0.00219 decamethrin > 0.002548 alphamethrin > 0.00424 dimethoate > 0.005367 cypermethrin > 0.00755 monocrotophos > 0.007875 phosphamidon > 0.0129 fenitrothion > 0.01329 fenpropathrin > 0.01419 methyl parathion > 0.01616 dichlorvos > 0.02376 malathion > 0.02595 carbaryl > 0.02667 polytrin cypermethrin > 0.0335 fenvalerate > 0.03352 quinalphos > 0.03372 profenofos > 0.07183 pyrethrin and 0.1226 methyldemeton.

Gesraha *et al.* (2000) [28] have also tested the mortality of the 2nd instar larvae of the predator *Coccinella undecimpunctata* consumed on *Aphis durantii* treated with certain plant extracts including *Stachys aegyptiaca*, *Tagetes erecta*, *Tagetes patula*, *Lavandula coronopifolia*, *Melia azedarac*h and *Azadirachta indica* and reported mortality not more than 20% in case of 1% concentration that provoked 100% mortality in aphids within 1 to 2.3 days. Meena *et al.* (2002) [56] have tested insecticides toxicity on lady bird beetle predating on fenugreek aphid and have observed that 1% *Pongamia pinnata* seed extract, 0.5% Neem guard, 0.5% malathion and 0.07% endosulfan were reported to be comparatively safe to lady bird beetle, while, 0.03% phosphamide was reported to be highly toxic. Similarly, Rathod and Bapodra (2002) [81] have also studied relative toxicity of many insecticides to coccinellid predators in cotton and 0.07% endosulfan and 0.03% dimethoate found to be significantly safer as compared to coccinellids while 0.04% Polytrin and 0.03% phosphamidon found comparatively more toxic as compared to both the stages of coccinellid predators.

Loknath and Singh (2003) [50] have tested four plant extracts with one neem formulation and with a synthetic pesticide dimethoate on the lady bird beetle *Coccinella septempunctata* and syrphid flies Syrphidae for predating on *Hyadaphus coriandri* and infesting *Coriandrum sativum*. They have observed that *Lagerstroemia indica* seed kernel extract was found to be the safest to both predators one day after spraying, which was followed by *Pongamia glabra* seed kernel extract 1%, *Azadirachta indica* seed kernel extract 1.00% and Neemarin 1.00% whereas dimethoate 0.03% was reported to extremely toxic on lady bird beetle and syrphid larvae and a similar result was reported at 3rd, 5th and 7th days after spraying.

Balikai and Lingappa (2004) [15] have reported the toxic effect of the aqueous extracts of the plants: *Vitex negundo, Catharanthus rosea, Azadirachta indica, Pongamia pinnata, Datura metel, Prosopis juliflora, Parthenium hysterophorus, Argemone mexicana, Ricinus communis* and *Adhatoda vasica* with 0.07% spraying of 35 EC endosulfan and 5% dust of malathion against predators of aphids including *Menochilus sexmaculatus, Coccinella septempunctata, Chrysoperla carnea, Syrphus species* and *Ischiodons cutellaris* during 1996 to 1997 and 1997 to 1998 at Bijapur, Karnataka. They have found plant products 2-3 times fewer toxic than malathion. The plant products 5% *Vitex negundo* leaves, 5% *Catharanthus rosea* leaves, 5% *Azadirachta indica* kernels, 5% *Pongamia pinnata* leaves and 5% *Adhatoda vasica* leaves were reported to be safe to natural enemies.

Gour and Pareek (2005) also evaluated toxicity of 9 pesticides against grubs and adults of *Coccinella septempunctata* and reported cypermethrin to be the highly toxic on grubs and adults of predators which was followed by dimethoate and endosulfan, respectively. They have observed the toxicity on grubs in the order: cypermethrin > dimethoate > ethofenprox > malathion > imidachloprid > acephate > cartaphydrochloride > endosulphan > neem extract while the order for adult is: cypermethrin > dimethoate > imidachloprid > ethofenprox > malathion > acephate > cartap hydrochloride > endosulfan > Neem extract. Finally, azadirachtin was found to be quite safe on *Menochilus sexmaculatus* and *Coccinella septempunctata* as reported by Indumathi and Savithri (2006) [34]. They have also reported that endosulfan was found to be comparatively nontoxic to coccinellid beetles while, cypermethrin needed an adverse effect on the population coccinellid beetle.

Singh *et al.* (2007) [97] have also compared efficacy of 4 Neem plant based products including 1000 ml/ha Achook, 1000 ml/ha Nivaar, 1000 ml/ha Rakshak and 1500 ml/ha Nimbecidine and 6 conventional pesticides including 700gm a.i./ha 35EC Hildan, 25gm a.i./ha EC Karate 5, 440gm a.i./ha 50EC Anaconda, 440gm a.i./ha 44EC Polytrin, 500gm a.i./ha 36SL Nuvacron and 200gm a.i./ha 10EC super killer to *Coccinella septempunctata*. The results described that population of *Coccinella septempunctata* was reported to greater in the plots when treated with Achook, Nivaar and Nimbecidine products, respectively. Seven spotted lady bird beetle larvae were also treated with 0.0036 to 0.3% concentrations of compound Nimbokill60EC i.e. azadirachtin, Tracer 480SC i.e. Spinosad and Sure1.8EC i.e. abamectin and their effect on hemogram which was examined for 1, 30 and 60 minutes after the treatment as reported by Suhail *et al.* (2007) [103].

Vanlaldiki *et al.* (2013) [107] have conducted field experiment for evaluating relative effects of 4 different eco-friendly insecticides products made up of Neem including Nimbecidine, Agrineem, Vijayneem and Neemark, two products of *Bacillus thuringiensis* including Di-Pel and Delfin), one product Biorin of an entomopathogenic fungus *Beauveria bassiana* and one product Nuvan of a chemical insecticide on the predatory coccinellid *Coccinella septempunctata*. Amongst all the examined compounds, Agri-neem and Delfin shown to be the best insecticide to the voracious beetle with the maximum population of 1.20/plant against 1.28/plant in untouched check. The lowest beetle population 0.87/plant was documented in Nuvan preserved plots. Although, all the insecticides were discovered to be nontoxic for the predator as there was no significant alteration with untouched check after post application counts.

Pereira *et al.* (2001) [73] have evaluated periodic change in the amounts of secondary metabolites including terpenes, sterols, alkaloids and α-tocopherol in *Croton hemiargyreus* and *Croton echinocarpus*. Their results revealed that the amounts of triterpenes were found to be maximum in most of the samples in the tropical summer and the major sesquiterpene compound was characterized as caryophyllene. The maximum periodic change in amounts of the compound glaucine was reported between June and October for *Croton hemiargyreus,* and was existing only in January and June for *Croton echinocarpus*.

Angioni *et al.* (2006) [7] have isolated essential oils from the leaves, stems and flowers of *Lavandula stoechas* using hydro-distillation technique of extraction and has analyzed it by Gas Chromatography. The major compound reported in the essential oils was fenchone which was found 52.60% in leaves and 66.20%in flowers, followed by another compound camphor 13.13% in leaves and 27.08% in flowers.

Batish *et al.* (2006) [17] have evaluated the chemical composition and phytotoxicity of essential oil isolated from the leaves of *Eucalyptus citriodora* and obatined 23 volatile compounds analyzed by Gas Chromatography and mass spectrometry. Citronellal is a monoterpene compound of the essential oil found to be 77-78% in the juvenile and senescent leaves.

Lago *et al.* (2006) [46] have conducted GC and GC MS analysis of the volatile oils isolated from the plant *Guarea macrophylla* of family Meliaceae and a compound sesquiterpenes was obtained in the leaf oil. They have identified 5 compounds *viz.* ledol, 1- cubenol, guai-6-en-beta-ol, 1-epi-cubenol and taumurolol. Their studies revealed that these compounds can be attractant of *Hypsipyla grandella* to *Gentiana macrophylla.*

Singh *et al.* (2006) [95] have also noticed lethal and sub-lethal impacts of different ecotypes of *Melia azedarach* against *Plutella xylostella* and powdered drupes of *Melia azedarach* were designated from Rajasthan, Punjab and Himachal Pradesh. These drupes were extracted in chloroform and methanol in the ratio of 9:1 and tested on 2nd instar larvae of *Plutella xylostella* by applying leaf-disc dip method of bioassay. The ecotype obtained from the arid region of Rajasthan yielded the lowermost LC_{50} value with 1.47%, followed by that from the open plains area of Punjab with 1.79% However, the hilly areas of Himachal Pradesh yielded the highest value of LC_{50} with 2.29%. The extracts produced from these trees in the arid region of Rajasthan produced both lethal and sub-lethal effects on 1.0% of adults as compared to 3.5% and 5.5% adult survival in the extracts from the open plains area and hilly area, correspondingly.

Cheng *et al.* (2008) [21] have reported larvicidal activities of the essential oils isolated from the leaves of *Cryptomeria japonica* and tested against 2 species of mosquitoes *viz. Aedes aegypti* and *Aedes albopictus*. Their study revealed that essential oil extracted from the leaves of *Cryptomeria japonica* was reported to be highly effective against both *Aedes aegypti* and *Aedes albopictus* larvae. Besides this, they have isolated 11 pure compounds from the essential oils of leaves of *Cryptomeria japonica* which were also tested separately against both the species of mosquito larvae. Out of 11 bio-active compounds alpha-terpinene, gamma-terpinene, p-cymene, 3-carene, terpinolene, and beta-myrcene exhibited strong larvicidal activities against both the species of mosquito larvae and 3-carene exhibited the larvicidal activity against *Aedes aegypti* and terpinolene showed an excellent inhibitory action against *A. albopictus albopictus* larvae.

Trindade *et al.* (2013) [106] have tested larval mortality of an ethanolic extract of leaves of *Annona muricata* against the larval and pupal development of insect pest *Plutella xylostella*. Their results showed that at the 5 mg/ml concentration of the extract produced 100% larval mortality however, the pupal stage was found to be less affected on exposure to the extracts.

Ben-Jemaa *et al.* (2012) [18] have investigated seasonal variation in chemical composition of essential oils obtained from the leaf's extracts of 5 species of *Eucalyptus viz. Eucalyptus camaldulensis, Eucalyptus astringens, Eucalyptus leucoxylon, Eucalyptus lehmannii* and

Eucalyptus rudis. They have observed fumigant activities of these essential oils against 3 stored grain insect pests including *Ephestia kuehniella*, *Ephestia cautella* and *Ectomyelois ceratoniae* and noticed that chemical composition and oil yields were found to be varied with *Eucalyptus* species and in seasons. Highest oil yields were found maximum in toxic compounds during the summer season and 5 essential oils *viz.* 1, 8-cineole, a-pinene, and a-terpineol were reported as major compounds. The have concluded that the fumigant toxicity was varied with seasons, insect species, concentration of essential oil and time of exposure. Finally, they have found that for all insect pest species, fumigant activity of essential was reported to be greatest in the summer season and *Ephestia cautella* was reported to be the most sensitive species.

Lakusic *et al.* (2013) [47] have also noticed seasonal variations in the chemical composition of the essential oils isolated from Rosemary plants as determined by gas chromatography and mass spectrometry. They have obtained number of bioactive compounds in essential oil including 18.2-28.1% Camphor, 6.4-18.0% 1,8-cineole, 9.7-13.5% alpha-pinene, 4.4-9.5% borneol, 5.1-8.7% camphene, 2.1-8.1% beta-pinene, 4.6-6.5% beta-phellandrene, 3.4-5.9% myrcene and 0.2-7.9% bornyl acetate. Zhang *et al.* (2014) have also conducted studied on the extraction process and seasonal variation of *Melia azedarach* and noted optimum parameters of extraction in petroleum ether (1:24g:ml) and in ethanol (1:34g:ml) followed by extraction with in ethanol and in ethyl acetate in the 1:8 ratio.

Conclusion

This review is based on the fact that *Spodoptera exigua* (Hubner) is a damaging insect/pest of cauliflower vegetable crops. Looking to the economic importance of the host plant *Brassica oleracea as* edible vegetable crops which is being destroyed by the larvae of *Spodoptera exigua* pest and the excess use of chemical based synthetic pesticides for the management of target organism (pest) and their side effects on non-target organisms. It was thought important to discover a new mode of pesticides. Therefore, the present study was conducted on vegetable crops of cauliflower for economic as well as agricultural purposes that suits to the present-day national context of biopesticides.

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