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REVIEW ARTICLE

PESTICIDAL POTENTIAL OF ETHNOBOTANICALLY IMPORTANT PLANTS IN NEPAL – A REVIEW

Pravin Budhathoki*, Pushpa Gnawali, Divya Baral, Amita Gyawali

Institute of Agriculture and Animal Science, Paklihawa Campus, Tribhuvan University, Nepal
****Corresponding Author Email: pravinbudhathoki522@gmail.com***

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ABSTRACT

Pests are considered a major problem in agriculture as they cause a various degree of losses. The use of synthetic pesticides to control these pests has resulted in pest resurgences, pest resistance, environmental degradation and lethal effect to non-target organisms in the agro-ecosystems. To minimize or replace the use of synthetic pesticides, botanical pesticides are important alternatives. They possess a toxic effect against pest including repellent, antifeedant and antibiosis effect against insect growth. In Nepal, among 5,345 species of flowering plants, 324 species have pesticidal properties. Some of the botanicals like Neem, Tobacco, Sweet flag, Garlic, Mint, Ginger, Artemisia, Sichuan pepper, Adhatoda, Basil, Drum-stick, Jatropha, Polygonum, Lantana, Chinaberry etc are widely used in pest management and many types of research have been done to explore the potential of these botanicals. This study aims to review the insecticidal potential of these important ethnobotanical plants. The biopesticides made from these botanicals were found to be effective against various pests. However, efficacy was found to be variable and often lower than that of synthetic pesticides.

KEYWORDS

Ethnobotanicals, Bio-pesticides, Pest-control.

1. INTRODUCTION

Nepal's agriculture sector is the most significant contributor to National GDP, engaging 2/3rd of its total population. A large number of crops are grown for food, fiber, shelter, fuel, animal feed, fodder, medicine, and so on. Infestations of insect pests are one of the major challenges in agriculture. Different kinds of pests (insects, mites, rodents, birds, slugs, snails, etc.) and disease causal organisms (bacteria, fungi, viruses, nematodes, etc.) attack all types of crops which leads in various degrees of loss (Neupane, 2004). Globally, it is estimated that yield loss due to arthropods, diseases, and weeds account for about 35% significant crops, which may exceed 50% when pest control options are limited (Oerke et al., 2012). And in some cases, there may be higher losses up to total crop failure (Abate et al., 2000).

The application of pesticides has rapidly increased for control of pests in agriculture after their introduction in Nepal in the early sixties. The largest quantity of pesticides is used in rice (40-50%) followed by grain legumes (14-20%), fiber crops (13-15%), and vegetables and fruits (10-20%) (Manandhar & Palikhe, 1999). The annual import of pesticides in Nepal is about 211 mt. a.i. with 29.19% insecticides, 61.38% fungicides, 7.43% herbicides, and 2% others, and the average amount of pesticide used in Nepal is 142 g a.i./ha, which is very low as compared to other Asian counties (Sharma et al., 2012). Chemical pesticides are economical, reliable, and easy to use and have a high and instant effect against pests**.** These chemicals not only control the target pests but also control other non-target organisms (parasitoids, predators, plant pollinators, soil microorganisms, aquatic organisms, etc.) and wild animals. Such chemicals, when used repeatedly at high doses, lead to pest outbreaks, resistance, and resurgence. In the long run, insects develop resistance to insecticides.

Synthetic pesticides have serious health issues among workers during manufacture, formulation, and field applications. Most of the Nepalese farmers are unaware of pesticide types, level of poisoning, safety precautions, and potential hazards on health and environment. High amount of pesticidal residue in vegetable crops is sold in the market. The growers don't follow the certified waiting periods (time between the last application of pesticide and harvest of a crop) for several pesticides on vegetable crops (Shrestha & Neupane, 2002). They can create hormonal imbalance and have high and acute residual toxicity (Pretty, 2012).

Biopesticides were developed as self-alternative for synthetic pesticides. According to Mazid et al.,2011 "Bio-pesticides are naturally occurring substances from living organisms (natural enemies) or their products (microbial products, phytochemicals) or their by-products (semiochemicals) that can control pest by nontoxic mechanisms" (Mazid et al., 2011).

Biopesticides fall into three major categories (Gupta & Dikshit, 2010):

1) Microbial pesticides

2) Plant-pesticides

3) Biochemical pesticides

In Nepal, the use of locally available plants for pest control is one of the traditional methods. Our farmers have been using such plants since

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ancient times. Most of the Ayurvedic plants also possess pesticidal properties (Neupane, 2004). Botanical pesticides are easy to grow and are easily found in our surroundings. Besides low cost, less toxicity, and environmentally friendly characteristics of these pesticides make them more preferable (Palikhe, 2002). Botanical pesticides do not pollute the environment as they are easily decomposed by microorganisms (Dubey et al., 2010). The study aims to know the pesticidal potential of the ethnobotanicals found in Nepal. The specific objectives of this study is to access the effectiveness of those ethnobotanicals against various pests.

2. Review Methodology

A rigorous desk study was done to collect and synthesize information in line with the topic of study. Various research papers, review articles, commentaries, and reports were earnestly read and screened for data compilation and its subsequent analysis. Scientific databases referred for the purpose included Scopus, Sciencedirect, Pubmed, Scifinder, ResearchGate, academia.edu, and Google scholar.

3. Result and Discussion

3.1 Pesticides in Nepal

In Nepal, total 170 different pesticides (by common name) have been registered under various trade names (3035). Most pesticides used in Nepal are imported from India, some from China and Japan, and other countries based on registration. The distribution of pesticides in Nepal is conducted only in the form of finished products. In Nepal, 3035 types of pesticides by the trade name and 170 common names have been registered up to 2018 for use under Pesticides Act and Rules.

Table 1: Summary of registered pesticides in Nepal till 2018

S. N	Pesticides	Trade name	Common name
1	Insecticide	1635	60
2	Fungicide	746	42
3	Herbicide	436	30
4	Biopesticide	113	14
5	Rodenticide	38	2
6	Acaricide	28	6
7	Bactericide	17	1
8	Molluscicide	2	1
9	Nematicide	1	1
10	Herbal	19	13
	Total	3035	170

Source: (PQPMC, 2018)

3.2 Opportunities of Biopesticides in Nepal

The demand of biopesticides is rising steadily with organic crop cultivation and increasing health consciousness among people in all parts of the world as they are safe, do not have application restriction, are easily degradable and possess superior residue and resistance management potential. When used in Integrated Pest Management systems, biopesticides efficacy can be equal to or better than conventional products.

Bio pesticide sector has huge scope in Nepal. Due to its rich biodiversity, Nepal offers plenty of scope for biopesticides. The rich traditional knowledge base available with the highly diverse indigenous communities in Nepal may provide valuable clues for developing newer and effective biopesticide. The increasing awareness on organic and residue free food would certainly warrant increased adoption of bio pesticides by the farmers.

3.3 Trend of Bio-pesticide Import

The negative impacts of synthetic pyrethroids and increasing pesticide resistance have increased the interest in alternative control methods, with emphasis being placed on botanical pesticides and biological control. Bio-pesticides help farmer's transition away from highly toxic conventional chemical pesticides. The data shows that the import of Bio-pesticide is increasing rapidly from 147.02 a.i.(Kg) in 2012/13 to 866.56 a.i.(Kg) in 2017/18 (Table 2). As reported on The Kathmandu Post : To reduce pesticide use Plant Protection Directorate (PPD) has been running the program by setting up Integrated Pest Management Resources Centres in seven districts- Kavre, Tanahun, Kapilvastu, Chitwan, Jhapa, Nepalgunj and Kailali and farmers in these districts are producing biopesticides for their use and sales among local groups of farmers (The Kathmandu Post, 2018).

Table 2: Trend of Bio-pesticide Import (a.i. Kg)

Year		Import	
	Qty.(kg)	a.i.(kg)	Rupees (Nrs)
2012/13	10375.00	147.02	4041700.00
2013/14	6277.50	71.74	3724273.00
2014/15	7287.5	51.778	3141760.3
2015/16	8424.00	63.33	2226917.20
2016/17	20448.25	1125.25	6575182.02
2017/18	11865.00	866.56	2260388.00

Source: (PQPMC, 2018)

3.4 Demerits of using botanicals

Less toxic or nontoxic compounds makes it less harmful for human and environment but also to target organism. Botanical pesticides may require frequent applications and pesticides instead of synthetic chemical pesticides (Dodia et al., 2010).

Botanical pesticides are naturally derived from plants that have been formulated specifically for their ability to control insects. They are not true insecticides since many are merely feeding deterrents and their effect is slow. Botanical insecticides are easily degraded by sunlight, air, and moisture. They lack persistence and wide spectrum activity. They are not necessarily available season long. Most of them have no established residue tolerance. All plant products applied by growers have not been scientifically verified. Botanicals cannot kill insect immediately but are quickly to stop its feeding. Botanicals tend to be less expensive but are not widely available. Also, the potency of some botanicals may differ from one source or batch to the next. Also, they have poor water solubility and are not generally systemic, which is very important for effective control of sucking pests. The phytotoxicity is also problem of botanical pesticides such as neem oil based is often phytotoxic to tomato, brinjal and ornamental plants at high oil levels (Nawaz et al., 2016).

3.5 Commonly used botanicals in Nepal

In Nepal, around 324 species of botanicals are found and among them, in Asian farming system 23 species are of special value. The most common Nepal's indigenous plants used as pesticides are Neem (*Azadirachta indica*), Bojho (*Acorus calamus*), Garlic (*Allium sativum*), Pudina *(Mentha arvensis*), Ginger (*Zingiber officinalis*), Turmeric (*Curcuma domestica*) , Tite pati (*Artemesia vulgaris*), Marigold (*Tagetes patula*), Timur (*Xanthoxylum alatum*), Asuro (*Adhatoda visica*), Tulasi (*Ocimum sanctum*), Bakaino (*Melia azedarach*), Papaya (*Carica papaya*), Sisnu (*Urtica dioica*), Tobacco (*Nicotiana tabacum*), Pire Ghas (*Polygonum hydropeper*), Sarifa (*Annonaa squamosa*), Drum stick (*Moringa oleifera*), Onion (*Allium cepa*), Siundi (*Euphorbia royaleana*), Sajiwan (*Jatropha curcus*), Simali *(Vitex nigundo*) (Shrestha, 2006).

3.5.1 Neem (Azadirachta indica)

The neem tree (*Azadirachta indica*) is indigenous to India, it belongs to the family Maliaceae. Neem is rich in various phytochemicals such as alkaloids, steroids, flavonoids, terpenoids, fatty acids, and carbohydrates (Arulkumar et al., 2016). Neem is popular for its pharmacological attributes like antioxidant, hypolipidemic, microbicidal, anti-inflammatory, hepatoprotective, antipyretic, hypoglycemic, insecticidal, antifertility, nematicidal, antiulcer, neuroprotective, cardioprotective, anti-leishmaniasis properties due to its chemical constituents such as bitter fixed oil, nimbidin, Nimbin, nimbinin and nimbidol, tannin etc (Saleem et al., 2018).

Mode and specificity of action of Neem as bio-pesticide

- Oviposition deterrence

Azadirachtin blocks the neuro-secretory cells, which disrupts adult maturation and egg production and egg deposition of aphids.(Vijayalakshmi et al., 1985; Vimala et al., 2010) observed that the reproductive potential of *Myzus persicae* fed on a diet containing azadirachtin was less than half the other that fed on control diet within the first 26 hours.

- Repellant

According to (Shannag et al., 2015) the three products Azatrol, Triple Action Neem Oil, Pure Neem Oil at higher concentrations were able to repel aphids feeding on sweet pepper plants.

- Antifeedant

When *Spodoptera litura* infested crops were treated to neem products, due to presence of azadirachtin, salanin, and melandriol, it cause vomiting like sensation and the insect does not feed on the neem-treated surface (Jeyasankar et al., 2010; Vijayalakshmi et al., 1985).

- Growth Regulation

The neem components, azadirachtin, suppresses the activity of ecdysone so that the larva fails to molt and ultimately dies. It also causes malformation and sterility in emerging adult or inhibition of chitin formation (Vijayalakshmi et al. 1985).

Effectiveness of neem products

Neem products are found effective against more than 350 species of arthropods, 12 species of nematodes, 15 species of fungi, 3 viruses, and two species of snails and one crustacean species (Nigam et al., 1994), 200 species of insects (Uchegbu et al., 2011).

Neem leaf extracts, seed extract (seed cake), bark extract, neem oil can be used widely to control Blattodea pests (Ibrahim & Demisse, 2013) Hemipteran pests (Degri et al., 2013) Lepidopteran pests (Okrikata et al., 2016), Thysanopteran pests (Dougoud et al., 2019) and Coleopteran insect in storage condition (Kemabonta & Falodu, 2013; Khan et al., 2016)

Neem products have low toxicity to mammals (Boeke et al., 2004; El-Wakeil, 2013) although some non-target species may be particularly susceptible.

Neem products were found profitable(benefit/cost) for the control of the green leafhopper *Nephotettix virescens* in rice (Rajappan et al., 2000) , the aphid *Lipaphis erysimi* in mustard (Gupta, 2005) , the whitefly *Bemisia tabaci* and the pod borer *Maruca testulalis* in black gram (Gupta & Pathak, 2009) ,the pod bug *Clavigralla gibbosa* in pigeon pea (Narasimhamurthy & Keval, 2013), and the *Sesamia calamistis* stem borers in sorghum (Okrikata & Anaso, 2016).

A study on the effect of Azatrol 1.2% (Azadiractin A and B) and triple action neem oil (70% neem oil) and pure neem oil against aphid in greenhouse condition showed that aphid colonization is reduced by 50-75% after 1 week of application and 2nd application at 1 week of 1st application cause total elimination of aphid. It has shown that Feeding was suppressed but Neem couldn't achieve complete inhibition of food intake (Shannag et al., 2015). The cold extract after soaking of leaves for 1 week is found to have effective insecticidal properties against the storage insect pests (Vimala et al., 2010) . Neem seed kernel powder mixture can be used for the control of Okra Cotton leafhopper (Neupane, 2000).

3.5.2 Asuro (Justicia adhatoda)

Justicia adhatoda linn is a shrub widespread throughout the tropical regions of Southeast Asia (Chakraborty & Brantner, 2001). It was found that the leaves and flowers of Asuro contain a significant amount of phenols, flavonoids, and alkaloids in addition to protein and carbohydrate. The presence of these bioactive secondary metabolites in the leaves and flower of *Justicia adhatoda* Linn are correlated with their medicinal applications (Sarangthem, 2014).

Extracts of Asuro showed antifeedant (76.33), larvicidal (62.33%), pupicidal (22.05%), and ovicidal (58.86%) effect. On the contrary, the extracts of *Vitex negundo* and *Justicia adhatoda* prolonged the larval and pupal duration of *S. litura*. This indicates that the selected medicinal plants may be a potent source of natural antifeedant, ovicidal and larvicidal activities against selected important agricultural lepidopteran polyphagous field pest *Spodoptera litura*. *Justicia adhatoda* was found to be effective in reducing the feeding rate of larvae of *Spodoptera litura* with maximum antifeedant activity in ethanol extracts of *Justicia adhatoda* at 5% extract concentration (Sukanya Rajput, 2018).

Sadek (2003) reported the extract of Asuro leaves to exhibit feeding deterrent properties when applied on the leaf disc method against *Spodoptera littoralis* (Sadek, 2003). Anuradha et al. (2010) reported the deterrent effect of Asuro leaves extract on the last instar of *Spodoptera litura* at various concentrations (25, 50, 75 and 100%). Due to the toxic effect of plant extracts, the maximum number of treated larvae died in spite of less food consumption (Anuradha, 2010).

3.5.3 Tobacco (Nicotiana tabacum)

Tobacco (*Nicotiana tabacum*) contain nicotine and other alkaloids which are synaptic poisons, they mimic neurotransmitter acetylcholine and exhibits agonistic effects on most nicotinic acetylcholine receptors (Brack, 2018). Rizvi and his team concluded that tobacco extract @ 2 % showed the control of cotton mealybug when the infestation is at the initial stage (Rizvi et al., 2015). Tobacco decoction (@250 g tobacco + 30 g liquid soap + 4 liters of water boiled for 30 minutes), sprayed @ 1:4 parts water was found effective to control Tobacco caterpillar(*Spodoptera litura F.*), mustard sawfly(*Athalia lugens proxima*) and leaf miners(*Phytomyza horticola*) on vegetable crops (Mainali et al.). According to Ubina et al. (1994) Tobacco spray reduced bean fly and bean aphid population by 89% and 97% , respectively. Tobacco dust reduced tomato cutworm and bean fly populations by 89% and 79%, respectively. Leafhopper, thrips and corn earworm were also reduced by 50-69%.

3.5.4 Sweet flag (Acorus calamus)

Sweet flag *(Acorus calamus),* native to India, central Asia, and Eastern Europe is found today in many temperate and sub-temperate areas of the globe. In Nepal, the herb is available up to 2000-meter altitude. Bojho are found in sedge meadows that are prone to flooding, edges of small lakes and ponds, marshes, swamps, seeps and springs, and wetland restorations. The plant contains β-asarone in stolons which is considered the main substance that acts as an insecticide (Giri et al., 2013). Acorus calamus stolon dust at 5 g/kg of potato tubers showed high efficacy to protect potato tubers against potato tuber moth for about three to four months in farmer's rustic potato stores (Giri et al., 2013). Bulb of the sweet flag can be used as an insecticide, insect repellent, and contact poison (Dahal, 1995).

3.5.5 Garlic (Aliium sativum)

Garlic (*Aliium sativum*) is herb that contains numerous vitamins, minerals, and trace elements. Many research have shown that garlic can be used as repellent to some plant pests and diseases (Ramasasa, 1991). Sulfur compounds such as DAS, DADS, DATS, methylallyl disulfide, methylallyl trisulfide, 2-vinyl-4H-1, 3-dithinin, and (E, Z)-aioenes are present in essential garlic oil (Aggarwal et al., 2013). These constituents could be used for the control of serious fruit and vegetable pests (Upadhyay, 2016). Two of the major constituent's methyl allyl disulfide and DATS, were found against Motschulsky and *Tribolium castaneum* (Herbst). Similarly, essential oils of garlic repelled and caused lethality in *Sitophilus zeamais* L. (Coleoptera) adults and also reduced their progeny production (Meriga et al., 2012).

3.5.6 Ginger (Zingiber officinale)

Ginger (*Zingiber officinale*) is one of the most common herbs used as pesticides. Prophylactic and therapeutic cadmium detoxification effects of ginger have been reported in many studies (Egwurugwu et al., 2007). 6-dehydroshogaol, zingerone, and 3-hydroxy-1-(4-hydroxy-3-methoxyphenyl)butane extracted from ginger showed moderate insect growth regulatory (IGR) and antifeedant activity against *Spilosoma obliqua* , and significant antifungal activity against *Rhizoctonia solani* (Agarwal et al., 2001). Extract of ginger can help in the control of American bollworm, aphids, planthoppers, thrips, whitefly, root-knot nematodes, brown leaf spot on rice, mango anthracnose, and yellow vein mosaic (Sridhar et al., 2002). Higher concentrations of ginger residue were found effective for the protection of crops against *C. maculatus* adult emergence (Amuji et al., 2012).

3.5.7 Sichuan pepper (Xanthoxylum armatum.)

Timur (*Zanthoxylum armatum*) is commonly used in daily life for condiments and therapeutic remedies. Different plant parts of the *Z. armatum* also has insecticidal potential. However, potential has not been yet determined against many agricultural pests, including leaf worm. In study done by (Kaleeswaran et al., 2018), n-hexane pericarp extract of *Z. armatum* has strong antifeedent, ovicidal and larvicidal properties against *Spodoptera litura*. Some research shows that it have insecticidal properties against *Plutella xylostella* (Kumar et al., 2016) and *Pieris brassicae* (Kaleeswaran et al., 2019). In a case study made in some parts of the country, Timur was found to be used by farmers for the preparation of botanical pesticides (Kaphle & Bastakoti, 2016).

3.5.8 Chinaberry (Melia azedarach)

Chinaberry (*Melia azedarach*) is highly recognized for its insecticidal properties. Biologically active triterpenoids with an alimentary effect are responsible for this property. They inhibit the feeding and also cause death and malformations of subsequent generations (Vergara et al., 1997). *M. azedarach* senescent leaf extract proved to be lethal to 100% of the larval population of *Spodoptera frugiperda* (Bullangpoti et al., 2012). Similarly in a study conducted on Diamond Black Moth extracts of chinaberry was found to be toxic to larvae they died due to failure in molting (Chen et al., 1996).

3.5.9 Lantana (Lantana camara L.)

Lantana Camara L. is a perennial shrub, exotic to Nepal, due to its adverse growth it is also called unwanted shrub (Vaidya et al., 2005). In Nepal, *Lantana Camara* extract and its powder widely used to check the plant diseases whether it is bacterial or fungal as well as to increase the fertility of the soil and also used to cure human diseases (Vaidya & Bhattarai, 2009). Lantanolic acid and Lantic acid are the active principles present in Lantana, which shows growth inhibition and repellent activity against insect pests (Nirmal et al.). Chopped leaves and tender stem of *Lantana camara* mixed with potato tubers @ 300-330 gm/8 kg was found effective to control potato tuber moth in storage(Pradhan, 1987). It contains a variety of chemical substances such as triterpenes, iridoid, and phenylethanoid, glycosides, naphthoquinones, and flavonoids (Ghisalberti, 2000). (Rajashekar et al., 2014) reported lantana to be effective against storage pests, while (Muzemu et al., 2011) reported that different plant extracts are biopesticidal against rape aphids(*Brassica napus*). *L. camara* contains camaric acid and olenolic acids which may have larvicidal or ovicidal properties (Ghimire et al., 2015). Research of Ghimire found that 50% concentration of *L. camara* leaf extract at 48 hrs and above was found deleterious to root-knot nematode (Ghimire et al., 2015).

3.5.10 Basil (Ocimum tenuiflorum)

More than 200 chemicals in basil oil have been reported. The chemical constituents include monoterpenes, sesquiterpenes, triterpenes, flavonoids, and aromatic compounds. Major components in basil oil include linalool, estragole (methyl chavicol), anethole, eugenol, and methyl eugenol (Li & Chang, 2016). Tulasi leaf extract is used as a seed treatment(10 ml/kg) along with foliar sprays(10ml/lit) thrice at tillering, booting and panicle initiation stage was found effective in reducing rice blast (Hossain, 2000). 2.5 gm of Tulasi leaf powder showed high repellency against post-harvest pests *Sitophilus zeamais L.* and *Callosobruchus macullatus L.* (Iloba & Ekrakene, 2006). Basil oil at 2% showed significant mortality, repellency, and anti-reproductive effects to rice weevil (Popović et al., 2006). Basil leaf powder @0.5gm/100g of cowpea was found effective to control *Callosobruchus maculates* on cowpea and chickpea (Paneru & Shivakoti, 2001).

3.5.11 Titepati (Artemisia Vulgaris)

It is distributed throughout Nepal at 300 - 2500 m, common along sideways and in margins of cleared forest (Rai et al., 2012). *Artemisia vulgaris L.*, a perennial aromatic shrub with a bitter taste, is considered as a medicinal plant and water extract of it consists of active components like psilostachyin A, psilostachy C, Exiguaflavanone A, Maackiain, fernenol with both anti-bacterial and medicinal value (Rai et al., 2012). *Artemisia vulgaris* leaves chopped pieces (20 g /kg potato) were also effective in reducing potato tuber moth damage levels (Giri et al., 2013). Fresh leaves extract of artemisia kept in water for one hour (1:4 parts) and sprayed @ 25,50, and 100g/liter water was found effective to control red pumpkin beetle in summer squash (Neupane, 1993). Chopped foliage of Titepati @ 5 mt/ha mixed in soil controlled red ant in potato field (Gc et al., 1997).

3.5.12 Mint (Mentha arvensis)

Essential oils and chemical constituents derived from different species of the *Mentha* were found to be effective against fungal and bacterial plant pathogens including storage insects like Callosobruchus and Tribolium species (Singh & Pandey, 2018). An aqueous extract of Mentha arvensis @2oo gm/ 1.33 liter of water applied on cauliflower foliage prevents the attack of mustard aphid (*Lipaphis erysimi*) (K Vaidya, 2000). Vaidya, (2000) found that field intercropped with Mentha arvensis effectively control Red ant (*Dorylus orientalis*) problem (Kaminee Vaidya, 2000). Chopped and shade dried Mentha leaves with stem @ 300-330 g/8 kg of Potato controlled Potato tuber moth(*Pthoremia operculella*) on storage (Pradhan, 1987).

3.5.13 Pire ghas (Polygonum sps.)

Pire ghas (*Polygonum sps.*) is one of the most common weeds of Nepal. Traditionally it is used to cure gastrointestinal diseases, neurological disorders, diarrhea (Sharma, 2003) and leaf paste is used to cure swelling (Parihaar et al., 2014), According to Ayaz et al. (2016), in addition to the medicinal property, 124 compounds were identified among which several bioactive antibacterial, antifungal, and insecticidal compounds were found.

3.5.14 Sajiwan (Jatropha curcas)

Sjiwan (*Jatropha curcas)* is considered a multipurpose plant because of its multiple uses. It is used as live fences as it can prevent or control erosion and also reclaim land (Openshaw, 2000). Seed oil is used to make biodiesel while Twigs are used to brush teeth to cure gum problems and latex are mixed with mustard oil and used for itches in the body. Along with other uses, sajiwan can also be used as biopesticides and in laboratory insecticidal activity of seed extracts of *Jatropha curcas* against Homopteran (peach aphid), Lepidopteran (cabbage butterfly), and Coleopteran (rice weevil) insect pests were observed (Li et al., 2006).

3.5.15 Drum-stick (Moringa Oleifera)

Moringa Oleifera belongs to the family Moringaceae which possesses an additional 13 species. Moringa, considered as one of the world's most useful trees (Ojiako et al., 2012). According to Fugile (2000), the many uses for *M. Oleifera* include fertilizer, biopesticide, medicine, etc., (Fuglie, 2000). Prabhu et al. (2011) had recorded that the phytochemicals derived from *M. oleifera* seeds extracts are effective mosquito vector control agents (Prabhu et al., 2011). Also, Ojiako et al., (2013) had found that *M. oleifera* seed extracts reduced the number of *Megalurothrips sjostedti* and *A crassivora* (Frank et al., 2013*).* Also, *M. oleifera* extracts had a 62 % reduction of *Phyllotreta Cruciferae* (Alao et al., 2015). Methanolic extracts of aqueous extract of moringa seeds exhibited larvicidal action against *Aedes aegypti* (Kamaraj & Rahuman, 2010).

4. Conclusions

Traditionally, farmers have identified and used variety of the plant products and extracts for pest control. As an alternative to synthetic pesticides, ecologically safe methods must be developed to control insect pests of field crops and stored food products. Organic pest management appears to be a more attractive alternative with lower economic costs. Combined use of botanicals with microbial pesticides increases efficacy and reduces cost per application and delays the development of resistance. Although botanical pesticides are safe to the environment, human health and natural enemies, they can't completely replace the synthetic pesticides. It will be quite logical to use existing technical knowledge and skill with scientific technologies. In several research, botanical pesticides have shown better activity than synthetic pesticides. Such many studies should be done on various effects of these botanicals against several harmful insect pests. To make botanicals more versatile, more formulations should be developed. Identification, documentation, conservation, and promotion of the existing indigenous knowledge and skill should be done to protect the intellectual right and put them into formal research for effective technology development. Networking and coordinated effort of all stakeholders is a crucial need to harness the abundant in-house resources available on pest management.

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Abbreviations

DADS- Diallyl Disulphide

DAS- Diallyl Sulphide

DATS- Diallyl Trisulphide

GDP- Gross Domestic Product

IGR- Insect Growth Regulatory

IPM- Integrated Pest Management

PPD- Plant Protection Directorate

PQPMC- Plant Quarantine and Pesticide Management Center

PRMD- Pesticide Registration and. Management Division

UNEP- United Nations Environment Programme

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