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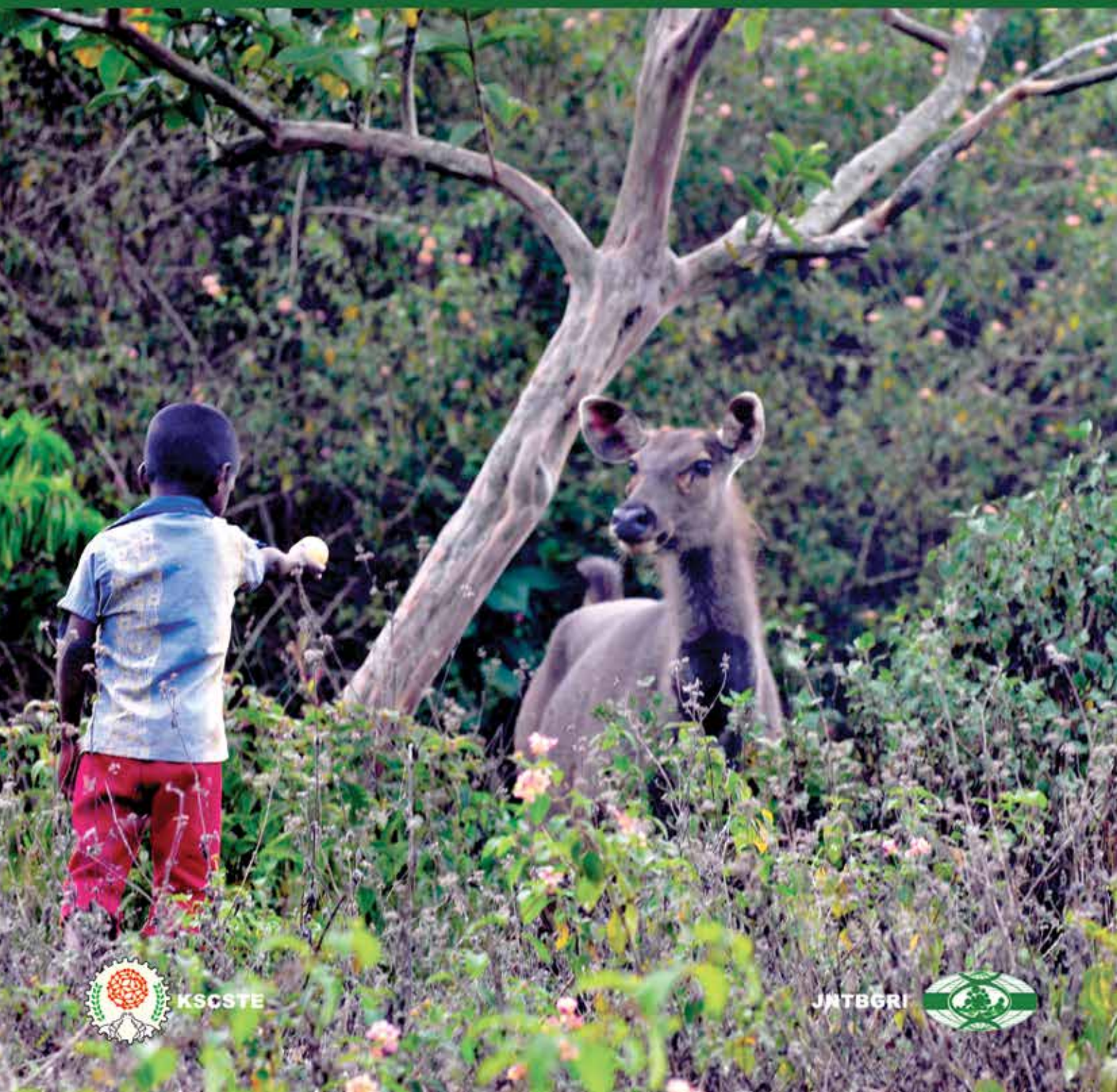

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Review on traditionally used botanical pesticides and pest management practices in Kerala

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Abstract

Kerala farming community possessed traditional skills and indigenous knowledge on pest control practices of various crops. Due to the emergence of modern agricultural practices the rich traditional knowledge systems gradually vanished. Negative impacts of modern pest control practices on human health and environment led to resurgence in the interest in botanical insecticides because of their minimal cost and least side effects. This reality provoked the agricultural community to return to the vanished traditional sustainable ways of cultivation, especially using bio-pesticides. The present study is aimed to collect and doccument such eroded knowledge from available sources. Detailed studies have found that about forty one (41) indigenous pest control practices were reported in Kerala for various crops. About fifty five (55) plant species were used in different regions of the state against various pests. Among the various plant parts used, leaf accounted the main allelochemical containing region, mostly used against pests. The study highlights the need to explore more locally available traditional botanicals having allelochemical potentiality to control various crop pests to save the crops and environment.

Keywords: Pest, Crop, Botanical pesticides, Traditional pest management

1. Introduction

Kerala has a glorious history of farming and the farming community possessed a stock of traditional skills and indigenous knowledge which got evolved through generations without the help of agricultural experts. They have rich indigenous knowledge in controlling various insects' pests in crops like rice, coconut, vegetables and stored grains. Crop pests were managed with the indigenous practices involving various plant species available locally and the other naturally available waste products. Over the years, these practices have gradually become more effective for sustainable crop protection. However, under the 'high yielding variety - fertilizer- pesticide pack' of Green revolution, farmer's traditional skills and knowledge were of least importance and they were vanished gradually. Inherent toxicities of chemical pesticides badly affect the health of consumers and the environment. Negative impacts on human health led to a resurgence in interest in botanical insecticides because of their minimal cost and lesser ecological side effects. Botanicals have advantages over broad spectrum conventional pesticides.They affect only target pests and closely related organisms and are effective in very small quantities, decompose quickly and provide the residue free food and a safe environment to live. This reality provoked the

agricultural community to return to this vanished, traditional and sustainable ways of cultivation especially the use of bio-pesticides. Consequent to this, a series of studies were carried out to ascertain the scientific basis of the action of certain products of plants and of natural origin against the pests. In a maiden study, tribal indigenous pest control practices of Tamil Nadu was documented and revalidated in certain crops (Purusottam *et al.,* 2009) and the impacts of phyto-chemical variability have been observed by many researchers testing botanicals against a range of target insect pest species, (Prakash and Rao, 1997; Satasook *et al.*, 1994; Marr and Tang, 1992). The plant kingdom is recognized as the most efficient producer of chemical compounds, synthesizing many products that are used to defend plants against different pests (Usman and Akhtar, 2007).

The bio-products from *Vitex negundo*, *Ferula assafoetida, Aloe barbadensis, Nicotiana tabacum*, hey and aged cow urine were found to be very effective against the insect pests of cabbage, wheat, peas, grains and other crops. Such an assessment was essential because these are the innovative and eco-friendly sprays, which are economically viable for small farmers and have already been adopted by the farmers in some locations. The choice of indigenous bio- insecticides have been found to be effective as well as eco-friendly. This will also help in reducing the load of insecticides on the ecosystem (Chaman Lal *et al.,* 2006).

Before the introduction of the chemical pesticides, traditional methods of pest control were practiced in Kerala. Most of the practices are extinct now. Considering their eco-friendliness, the current need is to identify and document such endangered and extinct methods especially botanicals used against specific pest in Kerala. In this perspective the present study is quite pertinent.

2. Materials and Methods

Secondary data were collected through referring relevant books of traditional farming practices in Kerala (Sujithkumar, 1999, Muraleedharan, 2001 and Harinarayanan, 2009) and the primary data was collected through personal interviews from 70 elderly farmers from different locations in Thiruvananthapuram district of Kerala. Reliable information on plants, plant parts used, vernacular names, occurrence, anti-insecticidal properties, detailed information about mode of preparation and form of usage were recorded. The collected vernacular names of plants were identified with their botanical names with the help of a Taxonomist of the Department of Botany, University of Kerala and through literature. The recorded data of such plants and their parts containing the pest killer allelochemical were tabulated.

3. Results and Discussion

From the collection of indigenous pest control knowledge, it became obvious that stock of knowledge existed in the farming system of Kerala. It was also observed from various documents that many varieties of plant species were used against crop pests. The name of different plant species and their parts carrying allelochemical were given in Table 1. Common name and scientific name of the plants, allelochemical containing plant parts and use against specific pests are also included in this table.

Table 1. Plants and plant part used against pests

Sl. No.	Common name	Plant name	Part used	Used against pest
1	Neem	*Azadirachta indica* (A.) Juss.	Seed, leaf	All pests
2	Jangli badam	*Hydnocarpus laurifolia* (Dennst.) Sleum.	Seed, leaf	Coconut, Rice pest
3	Birch tree	*Hibiscus populneus* L.	Leaf	Nematodes
4	Gliricidia	*Gliricidia sepium* (Jacq.) Walp	Leaf	Nematodes
5	Mango tree	*Mangifera indica* L.	Leaf	Rhizome pest
6	Poison nut tree	*Strychnos nux -vomica* L.	Leaf, seed	Coconut beetle

7	Wild arrowroot	*Curcuma angustifolia* Roxb.	Leaf	Leaf roller (ragi)
8	Persian lilac	*Ailanthus excelsa* Roxb.	Leaf, seed	Rhinoceros beetle
9	Castor oil plant	*Ricinus communis* L.	Seed, Leaf	All pests
10	Cashew nut tree	*Anacardium occidentale* L.	Leaf	Rice cafe worm
11	Leucas	*Leucas aspera* (Willd.) Link	Whole plant	Rice worm
12	Mark nut tree	*Semecarpus anacardium* L.f.	Leaf	Rice pest
13	Tobacco	*Nicotiana tabacum* L.	Leaf	All pests
14	Costus zingiber	*Costus speciosus* (J.Koenig) Sm.	Rhizome	All vegetable pests
15	Wood apple	*Aegle marmelos* L.	Leaf	Vegetable pests
16	Indian privet	*Vitex nigundo* L.	Leaf	Aphid, leaf eater, hoppers
17	Rubbish cassia	*Cassia tora* L.	Leaf, stem	Leaf eaters, hoppers
18	Negro coffee	*Cassia occidentalis* L.	Leaf, stem	Root eaters, nematode
19	Indian beech	*Pongamia pinnata* (L.) Pierre	Leaf	Rice nematode, worm
20	Alexandrian laural	*Calophyllum inophyllum* L.	Leaf	Rice pests
21	Indian gooseberry	*Phyllanthus emblica* L.	Leaf	-do-
22	Rain tree	*Albizia lebbeck* Benth.	Leaf	-do-
23	Malabar Kino	*Pterocarpus marsupium* Roxb.	Leaf	Nematode, worms
24	Alum	*Careya arborea* Roxb.	Leaf	-do-
25	Sweet flag root	*Acorus calamus* Linn.	Leaf, stem	Storage pests
26	Wild chilli	*Capsicum frutescens* L.	Fruit	All pests
27	Henna	*Lawsonia inermis* L.	Leaf	Vegetable pests
28	Pignut	*Hyptis suaveolens* (L.) Poit.	Leaf, stem	Pea aphids, thrips
29	Mexican poppy	*Argemone mexicana* L.	Leaf, stem	Rice leaf folder
30	Garlic	*Allium sativum* L.	Bulb	All pests
31	Onion	*Allium cepa* L.	Bulb	Beetle
32	Lemon grass	*Cymbopogon citratus* Spreng.	Leaf, tender stem	Banana pests
33	Turmeric	*Curcuma domestica* L.	Rhizome	Root eaters, storage pests
34	Holly basil or tulsi	*Ocimum sanctum* L.	Leaf	Pests, termites, Ants
35	Indian gentian	*Andrographis paniculata* (Burm. F) Wall ex Nees	Leaf, tender stem	Fruit fly
36	Betel vine	*Piper betle* L.	Fruit	Pea aphid, thrips
37	Cassava	*Manihot esculenta* Crantz	Leaf, tuber	Borers

38	Arrow root	*Maranta arundinacea* L.	Leaf	Lace bug, hoppers
39	Fenugreek	*Trigonella foenum-graecum* L.	Seed	Coconut
40	Betel nut palm	*Areca catechu* L.	Leaf	Beetle, termites
41	Mustard	*Brassica nigra* (L.)W.D.J. Koch	Seed	Banana pests
42	Asafoetida	*Ferula assa-foetida* L.	Resin	Mosquito larvae
43	Round zedori	*Curcuma zedoria* (Christm.) Roscoe	Rhizome, leaf	Pepper pest
44	Black cumin	*Carum carvi* L.	Seed	Vegetable pests
45	Golden trumpet	*Allamanda cathartica* L.	Leaf	Storage pests
46	Juniper berry	*Sphaeranthus indicus* L.	Leaf, tender stem	-do-
47	Wind killer	*Clerodendrum multiflorum* (Burm. f.)	Leaf	Leaf eaters
48	Lantana weed	*Lantana camera* L.	Leaf, stem	All veg. pests
49	Niepa bark tree	*Quassia indica* (Gaertn.)	Leaf	Lace bug
50	Edana	*Olea dioica* Roxb.	Leaf	Vegetable pests
51	Cycas	*Cycas circinalis* L.	Leaf, Stem	Termite, capsule borer
52	Vatta	*Macaranga indica* Wight	Leaf	Termite, storage pests
53	Paanal	*Glycosmis arborea* (Roxb.) DC.	Leaf	Rice Pests
54	Oduku	*Cleistanthus collinus* (Roxb.) Benth and hook.	Leaf, Bark	Nematodes
55	Terminalia	*Terminalia arjuna* (Roxb.) Wight and Arm.	Leaf	Rice pests, nematodes

While analyzing the data, about fifty five (55) plant species were used in different regions of the state against various pests. Among the plant parts used, leaf accounted the main allelochemical containing region, mostly used against pests. From the data it was found that, out of 55 plant species, leaf part of 45 plants were used for pest control. Other parts such as rhizomes, tender stems, bulbs, fruits and whole plant were also used as traditional pest control materials in Kerala. Besides the plants, natural products like cow dung, cow urine and ashes were also used as pest control materials in Kerala.

According to the collected data, about forty one (41) indigenous pest control practices were reported for various crops. A comprehensive listing of indigenous pest control practices of Kerala using plant products are listed in Table 2.

Table 2. Indigenous pest control practices of Kerala using plant products

Sl.No.	Pest control practices	Crop	Used against
1	Tobacco leaf soaked in water for 1 day + soap solution	All crops	Leaf eating insects
2	Neem leaf, seed paste + water	-do-	All pests
3	Indian gentian leaf, tender stem +soap solution + garlic paste	Vegetables	Sap feeders, Aphids, Thrips, Hoppers

4	Asafoeitida + water	-do-	Stem fly
5	Sand sprinkling at the crown region of coconut	Coconut	Red palm weevil and Rhinoceros beetle
6	Oduku leaf, bark paste + water	Rice	Stem borer
7	Cashew nut shell oil + water	-do-	Rice cafe worm
8	Garlic paste + water	All crops	All pests
9	Spreading of ash	Rice	Leaf folder
10	Spraying of cow dung + water	Vegetables	Defoliator
11	Dusting of cow dung ash mixture	-do-	Defoliator, Borers
12	Neem leaf + vitex leaf + water	Banana	All pests
13	Negro coffee leaf paste + water	Rice	Sap feeders, Hoppers
14	Lemon grass extract + water	-do-	Banana weevil, Aphids
15	Spraying wild arrow root paste +water	Vegetables	Brown hoppers
16	Rice seeds wrapped with arrow root leaf	-do-	Storage pests, Termites
17	Sprinkling of *Costus zingiber* rhizome, leaf paste + water	-do-	Fruit fly, Aphids
18	Cow urine + asafoeitida + wild chilli	Vegetable	Stem borers, Thrips, Sap Feeders
19	Garlic + rice water	-do-	Aphids, Leaf eaters
20	Garlic + neem oil	-do-	All pests
21	Jenny flower leaf -----+ soap solution	-do-	Pea aphid
22	Neem seed powder spreading	Banana	Banana aphid, Weevil
23	Garlic + mustard paste + water	Pepper	Gal thrips, Pollu beetles
24	Spraying of wild chilli paste + cow urine	Banana	Leaf eaters, Aphids
25	Spreading of turmeric powder	Coconut	Root eaters, Termites
26	Garlic, sweet flag root (dry)	Pulses	Storage pests
27	Wood apple leaf boiled in water then filtered + cow urine	Vegetable	All pests
28	Jangli badam leaf + seed powder spreading	Cocounut	Rhinoceros beetle
29	Persian lilac leaf powder	-do-	Rhincophorus
30	Onion paste -----+water	-do-	Rhincophorus
31	Cassava tuber, leaves boiled in water and spreading	-do-	Lace bug, Leaf eaters
32	Neem seed powder spreading	-do-	Coreed bugs, Beetles
33	Lantana leaf extract + water	Vegetable	All pests

34	Quassia leaf spreading	Rice	Storage pests ,Termite, Ants
35	Edana leaf	-	Houseflies
36	Turmeric powder	-do-	Termites, Ants, Capsule Borer
37	Cycus leaf	Rice	Plant hoppers
38	Wind killer leaf extracts + water		Bugs, House fly
39	Spreading of Arrowroot leaf, poison nut leaf powder	Coconut	Beetles
40	Henna leaf paste +Asafoeitida or Garlic paste + water	Vegetables	All pests
41	Leucas plant hanging and burning	Housefly	Mosquitos

While studying these practices, it was observed that varieties of crop pests were dealt with indigenous control methods. It was found that some practices or some materials were used against all pests or for all crops. For instance, tobacco leaf, soaked in water for 24 hours and mixed with soap solution was used for all crops against leaf eating insects. Similarly, neem leaf and seed paste with water and garlic paste with water were used for all crops and against all pests. While analyzing various products used in the pest control practices, a good number of plant species and an array of natural substances were observed. There were various control methods practiced for field crop pests, storage pests and house flies also. All the control materials were used in the form of crude preparation of plant parts like powders, paste, liquid extracts, etc.

Locally available plants have been used to control pest since pre-historic times all over the world. These traditional control practices were prepared from the cheapest materials available locally and are easy to prepare and eco-friendly (Naryanansamy *et al*., 2005, Naryanansamy, 2004). Present study shows that most of the crop pests in Kerala were managed with indigenous practices involving various plant species available locally and other naturally available products such as cow dung, cow urine and ash. These products are easily decomposed by variety of microbes commonly available in most soils and hence reduce environmental contamination.

A number of plant families are known to produce secondary metabolites such as alkaloids, phenolics, flavanoids, terpenoids and glucosinolates, which have been used for insect control since long time. These secondary metabolites having insecticidal/pesticidal properties are of several types *viz,.* repellants, anti-feedants, phago-stimulants and toxins (Maheswary *et al.,* 2005) are called allelochemicals, which are used by the plants for self defense from pests.

The secondary metabolites *viz*., karanjin, glabrin, karajae, pongapin, karanjone, pongallone, pongone, pongamol and ponga glabrone have been isolated from *Pongamia pinnata,* a traditionally used insecticide plant and all of them possess insecticidal activity (Rastogi and Mahrotra, 1993, 1995). In the present study the leaf of this plant used by traditional farmers in Kerala against rice pest such as root nematode and worm is documented.

Allelochemicals distribution can be very different, as different parts or tissues of plants have different physiological functions. Due to the inherent diversity of secondary metabolites in origin and structure of plant species can provide target specific, high volume and low margin products with least impact on ecology (Maheswary *et al.,* 2005). They also maintain the biological diversity of predators that are often killed by broad spectrum synthetic pesticides (Grange and Ahmed, 1998). It was supported by the study of crude leaf extract of *Adathoda vasica*, which was safe to grubs, pupae and adult stages of predators such as coccinellids, chrysopids and syrphid fly (Balikai and Lingappa, 2004). According to Dev and Koul (1997) over the 2000 plants belonging to some 60 plant families are known to exhibit different pesticide

activities. The current study conducted in Kerala recorded as much as 56 plant species having pest control properties in their allelochemical carrying plant parts.

Botanicals are well known to vary in the quality and quantity of active ingredient (Agerbirk *et al.,* 2001, Azerdo *et al*., 2001 and Isman, 1997). This active ingredients showed variability due to dependence on time and place which affect the potential changes in bioactivity. The impacts of Phyto-chemical variability have been observed by many researchers testing botanicals against a range of target insect pest species (Prakash and Rao, 1997, Satasook *et al*., 1994, Marr and Tang, 1992). Allelochemicals activity varies with temperature, photoperiod, water and soil, tissues and maturity within species (Peng *et al.,* 2004).

According to the study of Ben Hammoda *et al.,* in 2002 on auto toxicity of root, stem and leaf extractions from barley, the leaves were the most important source of allelopathic substance than stem and root. In the present study, it was observed that the leaves are the most widely used plant part in controlling various crop pests of Kerala. Moreover, maturity of plant tissues also affect the allelochemicals content and intensity. Some studies (Wang *et al*., 2001 and Hu and Kong, 2002) showed that the quantity and content of allelochemicals in soybean stubs were diverse in different decomposing time and growth stages. Sharma *et al.,* (2002) found that the allelopathic intensity increased by the age of *Populus deltoids*. This might be the scientific base behind the selection of plant parts in different stages used by traditional farmers. The present study observed that, tender stem of *Andrographis paniculata* was used to control fruit fly and lemon grass against the pests of plantain.

The plant kingdom is recognized as the most efficient producer of chemical compounds, synthesizing many products that are used to defend plants against different pests (Isman and Akhtar, 2007). In the present study, it can be seen that different combination of plants and their parts were used against different pests. Combination of garlic and mustard paste added with water was used to control pests of pepper plant. Leaf and seed paste of neem with water was used to control all pests. It might be due to the effect of different combination of allelochemicals produced by different plants and parts and their potency to control pests.

Plant based insecticides are not only toxic to pest, but can also deter and/or repel pest which attack at the pre as well as post harvest stages of the crop production and reduce transmission of disease to plants and animals including humans. Deterrent and repellent activities of botanicals are scientifically studied by several workers. Crushed *Allium cepa* bulb mixed with water showed repellent activity against *Reticulitermes virginicus* (Anon, 2004). *Azadiracta indica* seed kernel extract was a good repellent of *Spodoptera litura* (Joshi and Sita ramaiah, 1979 and Ayyangar and Rao, 1989). Leaf extract of *Vitex negundo* showed repellent activity against *Lasioderma serriicorne* (Ambadkar and Khan, 1994). Deterrent effect of *Cymbopogon citratus* (Boeke *et al.,* 2004) and *Eupatorium cannabinum* was found by Shukla *et al.,* in 2007. These scientific studies strongly support the effect of traditional botanical insecticides. Further, it provides sufficient scientific background to the plant materials used in Kerala as all plant materials matured were used in Kerala as traditional pest control materials.

According to the present study, some botanicals were used against mosquitoes, termites, ants and houseflies. Many studies were conducted by several workers on the effect of botanical insecticides against mosquitoes, which causes diseases such as Filariasis, Malaria, Yellow fever, Encephalitis, etc. Evans and Kaleysaraj in 1988 reported that after screening of 24 plants, 6 were found to be active against the larvae of *Culex quinquefasciatus*. Crude extracts of fruits and leaves of *Centratherum anthelminticum* showed larvicidal activity against *Anthrenus stephens* (Srivastava *et al.,* 2008). Petroleum ether extract of the leaves of *Eupatorium orodeatum* (Yankanchi and Patil, 2010) and areal part of *Cinnamomum rhynophyllum* (Komalamisra *et al.,* 2005) was studied to control larvae of *Aedes aegypti.* In the current study it is found that hanging or burning of *Leucas aspera* plant is useful to control mosquito and spreading of turmeric powder against termites and ants. This is because most tissues of plants, such a leaf, flower, fluid, stem, root and seed, even litter can release a certain amount of allelochemicals into the surrounding environment (Peng *et al.,* 2004). This might be the scientific aspect behind this hanging or burning or spreading of plants or plant materials to control mosquitoes, termites, ants and house flies.

Botanical insecticides were extensively used (1800 to 1940) until the discovery of synthetic insecticide, DDT. They may be crude preparations of plant parts such as powder or dusts, aqueous or organic solvent extracts, used as liquid concentrations or as dusts with carriers (Maheswary *et al.,* 2005). In the current study we can see that all traditional pest control practices were carried out with crude preparation of plant materials. One of the examples quoted from the list is crude paste of wild chilly mixed with cow urine that was used to control pests of Plantain. Several scientific studies were carried out on crude plant materials against insect pests. Boeke *et al.,* (2004) examined the toxicity of crude leaf powder of *Nicotiana tabacum* against *Callosobruchus maculatus*. Dry leaf powder of *Chenopodium ambrosioides* caused 100 percent oviposition inhibition against *Callosobruchus chinensis*, *Callosobruchus maculatus* and *Acanthoscelides obtectus* was studied by Tapondjou *et al.,* in 2002. Fruit powder of *Capsicum frutescens* showed ovipositor deterrent effect against *Callosobruchus maculatus* (Boek *et al.,* 2004). All these scientific studies pointed to the scientific background of traditional pest control materials and practices.

The present study revealed that, traditional farmers in Kerala had indepth indigenous knowledge on the insecticidal properties of plants; gained over several years through testing and conjecture and through observations and inference. It is a priceless legacy for agriculture. However, synthetic pesticides have emerged as one of the most powerful tools, to secure the provision of food and protect against pests that attack food crops. At the same time, it also causes considerable negative effects on biodiversity, environment, food quality and human health. Feeding the world without the use of pesticides remain almost impossible. However, intensification of agricultural production should be sustainable and should protect human health and environment. Therefore, sustainable agriculture is one of the greatest challenges that the world is facing now. In this situation, growing concern about protecting the environment, recognizing the importance of ecological balance and evidence of changes in the surroundings by extensive and indiscriminate use of pesticides with persistent residues has emphasized the need to review our existing strategies for insect pest control. Among several avenues explored for integrated insect pest control programmes, the use of plant insecticides, being safe, easily bio- degradable and practically innocuous to non- target species, has drawn attention all over the world (Ahmed and Chander, 1983).

At this juncture the importance of traditional information on botanicals is the promising tool for insect control. Knowledge on factors such as application concentration, method of application, preparation of botanicals and duration of control expected can be used to promote botanicals as a cost-effective and environmentally sustainable alternative to commercial synthetics. The choice of indigenous bio- insecticides has been found to be economically viable, effective and eco- friendly and it help in reducing the load of insecticides on the ecosystem (Chamanlal *et al.,* 2006).

However, the traditional knowledge of plant protection measures and procedures for preparation of plant based formulations has passed through generations orally, without proper documentation. Hence, they lack authenticity and may lead to failure, especially in case of large farmers who do not have access to actual preparation procedures related to traditional wisdom. It is desirable to have a detailed account of this traditional knowledge in a well documented form accompanied by testing the efficacy of these methods with respect to the present day crops and cropping pattern and standardize them to suit the present requirements.

4. Conclusion

It could be concluded that the traditional botanical pest control practices followed by the farming community of Kerala against various crop pests were safe and without having any adverse effect on the environment. These were cheap, locally available and easy to prepare and use. Hence, these practices can be very well preserved and engrossed into the plant protection schedule in a sustainable way. It is further envisioned that the collection of such, traditional knowledge based pest controls, being adopted in the traditional farming community in India must be documented systematically in a coordinated manner.

Therefore, it is the need of the hour to explore more locally available traditional botanicals having allelochemical potentiality. Moreover, it is also required to test the different plants and parts and their potency to control various crop pests. Intensive

studies and co-ordinated research is highly essential in this field, especially biotechnological and genetic engineering approaches for isolation, purification, characterizations, synthesis of standards and their screening for valuable biological effect(s) to save agricultural crops, human beings and environment.

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