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Review paper

# Indigenous knowledge using medicinal plants to control the Pests and Diseases in Crop Cultivation in Sri Lanka and its scientific basis

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**ABSTRACT**

***Context:*** Approximately 60% of the rural population is involved in agricultural production as their livelihood in Sri Lanka. Agricultural productivity was sufficient during ancient times, and the traditional knowledge of the control of pests and diseases was successful. Even today, some of the rural farming communities use traditional knowledge in agricultural production. With the introduction of the green revolution in the 1960s, pesticides and insecticides became an integral part of insect and pest control. However, most of the chemical pesticides and insecticides lead to health hazards in human and environmental pollution. Furthermore, many of the insects and pests become resistant to chemical pesticides and have a serious impact on their productivity. ***Objectives:*** The aim of this study is to re-introduce the traditional knowledge-based *kem* methods to control pests and diseases with scientific basis for sustainable agricultural productivity. ***Methods:*** Extensive research findings were gathered from journal articles and reports using Google Scholar and other reputed search engines. Furthermore, the informal discussions with rural communities were too gathered on *kem* methods. ***Results:*** Several *kem* methods using medicinal plants to control insects' pests and diseases in paddy and other field crops were adapted by ancient farmers. All these methods and the medicinal plants used have a scientific basis to prove the respective *kem* methods. ***Conclusions:*** It is time to return to these traditional knowledge-based *kem* methods to mitigate pests and diseases in paddy and field crops, and it may contribute to a beneficial influence on agriculture, environment, human health and wellbeing.

***Keywords:*** crop diseases, medicinal plants, pest, traditional knowledge

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## INTRODUCTION

Agriculture is contributing to Sri Lanka's economy for over thousands of years. However, many of the indigenous practices with regard to cultivation have been neglected or forgotten by the majority of the farming community with technological advancements. Serious health hazards to humans as well as the environment were created due to the use of chemicals in agricultural practices. Sri Lanka has a rich biodiversity and cultural diversity. According to Senanayake (2006), the ancient hydraulic civilization of Sri Lanka dates back to the third century BC and possesses a rich heritage of Indigenous knowledge. Rice cultivation was the basis of civilization for over two thousand years (Mahawansa, 1912, Deraniyagala, 1992) and Sri Lankan history provides ample evidence of the use of indigenous techniques in rice cultivation. These techniques have traditionally played an important role in generating household income, providing healthy and nutrient-rich foods and ensuring the country's food security (Irangani and Shiratake, 2013). Indigenous knowledge is considered as the main social asset of the farming communities (Ryser, 2011), making the farmers self-reliant by non-dependency on market-oriented inputs (Irangani and Shiratake, 2013). Indigenous knowledge means the knowledge developed in local communities since ancient times about healing systems, biological diversity and agriculture and disseminated by the word of mouth across and within generations (Irangani and Shiratake, 2013).

Indigenous knowledge consists of the skills, innovations, beliefs, experiences and insights of the people in their respective natural and cultural environments, accumulated over the years and applied to maintain their livelihood (Dei, 1993). Indigenous knowledge is also identified as a unique local knowledge existing within and developed around the rural communities (Warren, 1991). It is generated through a systematic process of observing local conditions, experimenting with solutions and readapting previously identified solutions to modified environmental, socio-economic and technological situations (Brouwers, 1993). When referring to Indigenous knowledge, the term "traditional knowledge" appears to be more appropriated and justifiable for the Sri Lankan context because of the age-long history, culture and traditions (Karunaratna, 2010).

According to Dharmasena (2010), the farming system comprising chena, paddy and home garden cultivation has evolved with the interaction of man and the environment and developed in harmony with natural ecosystems, their experience, observations on rainfall patterns, wind, temperature, humidity and soil behaviors. Traditional agricultural practices such as eco-friendly crop protection measures, biological control methods, *kems*, rituals and the use of plants or plant extracts have shown promise in pests and disease management in the rice fields of the country. Weeramunda and Damayanthi (2011) state that *kems* methods used in indigenous knowledge-based agriculture reduce costs of cultivation and thereby result in increasing the profit margin of traditional varieties which have low yield compared to newly improved varieties. However, according to Dharmasena (2010), Indigenous knowledge is tacit or embedded in the practices and experiences and hence a vast amount of true Indigenous knowledge of the country, especially oral knowledge, has diminished over the years. Therefore, it is of timely importance to study the scientific justification of these indigenous practices, such as *kems*, as they are eco-friendly and

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sustainably sound to encourage the younger generation to preserve and use this traditional knowledge in the present context of Sri Lankan agriculture. This paper especially looks into the *kems* methods used by ancient Sri Lankan farmers in paddy cultivation for insect and pest control and their scientific justification.

## METHODS

The literature has been gathered from search engines like Google Scholar and PubMed on traditional and indigenous knowledge in the various modern textbooks, journals and authentic websites. Furthermore, several journal articles were studied and extracted information for the control of plant diseases and pests. Additional information regarding various aspects, such as the constitution of plants, diseases of the plants and the organic remedies that were used to cure plant diseases were collected from several journal articles. The properties of such organic material, plants used in treatments and their medicinal and pharmacological properties were collected from reputed journals and ancient treatises of *Vrkshayurveda.* Traditional *kem* methods are practiced in pest management systems; the rituals and recommendations attached to each method in various parts of Sri Lanka were recorded in focus group interviews with farmers. Furthermore, the firsthand experiences of the farmers, the effectiveness of traditional pest control methods as is perceived by the farmers and the success of those methods were also recorded. Further research findings on the phytochemical properties of medicinal plants used in *kem* methods were collected from reputed journals to justify the *kem* methods used by ancient farmers.

## RESULTS

The *kem* methods are a kind of practice, technique or custom used commonly in rural areas in Sri Lanka in order to obtain some favorable effect such as relief from a specific illness (Deraniyagala,1992). Some *kems* combine the use of astrology and mantras with the use of certain medicinal plants and herbs. These practices have survived to date because they are effective and if they were not effective, they would have disappeared long ago (Deraniyagala,1992). The chemical compounds of the plants used in *kem* methods and their pesticidal and insecticidal properties were recorded from the literature and recent scientific research findings to justify the *kem* methods used based on traditional knowledge.

### Kem methods to control insects in paddy and other field crops

*Sour orange treatment*

In this method, three paddy bugs are collected from a field and killed and inserted into three sour oranges (ඇඹුල් දෙහිඹ) (*Citrus aurantium* L. Family Rutacea*e*) by making holes in each orange. Each orange, with a paddy bug, is kept on a stick split into three from one of its tips. Three such sticks are planted at the starting, middle and the terminal end of the paddy field. When oranges start rotting, they release a very bad smell which keeps paddy bugs away from the field (Irangani and Shiratake, 2013). This can be due to individual sensitivity to certain compounds in citrus peel oils, such

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as limonene, which can have a very strong, sharp scent. Changbunjong et al. (2022) found *C. aurantium* essential oil exhibits insecticidal activity. Therefore, it can be used as an alternative to synthetic insecticides.

*Bataleegaama*

According to Irangani and Shiratake (2013), the *kem* method is *bataleegaama* which means dragging bamboo sticks. A 7-8-foot bamboo stick is wrapped with cloth ribbons. The cloth ribbon is applied with *dorana* (දොරණ) (*Dipterocarpus scabridus* Thwaites - Family Dipterocarpaceae), oil and jackfruit latex. The bamboo stick is then drawn on the paddy field, so that it touches plants and files get trapped on the stick. *Dorana* oil is used extensively for painting murals in ancient temples. *Dorana* oil with jack fruit latex is sticky, and the files are physically removed from the paddy fields (Ranawaka, 2021).

*Bokugaama*

*Bokugaama* means dragging a window. Before doing this, neem (කොහොඹ) (*Azadirachta indica* A. Juss. Family Meliaceae) or citrus oil is applied to the lower side of a wind. The lower side of the Winnow is then gently drawn, allowing it to touch the panicles (Jayatisa et al, 2019). When the wind is drawn, flies are trapped in the oil. The neem oil is poisonous to insects, providing a natural alternative to synthetic pesticides. Margosa does not directly kill insects. It acts as an antifeedant, repellent, and egg-laying deterrent and thus protects the crop from damage. The insects starve and die within a few days. Margosa also suppresses the subsequent hatching of their eggs (Srivastava et al., 2013).

*Daluk leaf and latex treatment*

Bundles of tender leaves of *daluk* (දළුක්) (*Euphorbia antiquorum* L. Family Euphorbiaceae) are hung at different locations in a paddy field at a pre-decided auspicious time and when rotting of *Daluk* leaves releases a very bad smell and this smell distracts insects attacking the paddy crop (Irangani and Shiratake, 2013). A mixture of latex of *daluk* bark of Gajamarana (Sinhala) and Lakada (sealing wax) used to spread or applied on a rope across the field at a previously decided auspicious time as the sticky traps (Jayatissa et al., 2019). When those ropes were moved along the field, the insects were trapped in the glue. To prepare this sticky mixture, the latex of *warā* (වරා) (*Calotropis gigantea* (L.) R. Br., family Apocynaceae) is also used with *daluk*. The *warā* plant contains calotropeol and beta-amyrin (De Silva et al., 2008). Also, the latex of *daluk* has been found to be very successful in terms of pest control (De Silva et al., 2008).

*Hanging kapparawalli leaves*

*Kapparawalli* (කප්පරවල්ලිය) (*Plectranthus amboinicus* (Lour.) Spreng. -Family Lamiaceae) leaves and branches are collected and hung on sticks at various places of the field without talking to others to control paddy bugs (Jayatissa et al., 2019). The multiple potentials of the *Kapparawalli* herb extracts, such as allelopathic potential, antibacterial properties, antimicrobial activity, insecticidal properties, free radical scavenging and radio-protective components have been reported (Wadikar and Patki,

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2016). The leaf oil of *Coleus amboinicus* Lour. from India is rich in thymol and is a potent insecticide against *Odonto termesobesus*, a pest of sugarcane fields (Gurdip Singh et al., 2002).

*Pandamkariya*

*Pandamkariya* means lighting torches in the field using demata (ඉඳුමට) (*Gmelina asiatica L.* Family Lamiaceae) and wild grapes (*Vitis vinifera* L.-Family Vitaceae) branches which are made to brush by repeatedly striking branches on a stone. These brush-like branches are erected randomly in the field and torched. This process has to be repeated on three consecutive days for effective results. Insects get trapped and burnt in the flames (Irangani and Shiratake, 2013). *Gmelina arborea* L. product extracts have the insecticidal efficacy of controlling the legume pod borer (*Maruca vitrata*) and the pod-sucking bug (*Clavigrallato mentosicollis*) on cowpeas (Oparaeke, 2005). Also, it was discovered that leaf and stem bark powder both of Demata (*G. arborea*) had strong insecticidal effects on weevils (Olanrewaju et al., 2023). In contrast to synthetic chemical insecticides that pose risks to the environment's health and expose people to lethal doses, stem bark powders proved to be the most effective throughout the experiment, followed by leaf and stem bark powders, respectively (Olanrewaju et al., 2023).

*Keppetiya branches treatment*

*Kappettiya* (කැප්පිටියා) (*Croton laccifer* L. -Family Euphorbiaceae) is a common plant species with a strong odor, found in deserted lands of Sri Lanka. When the paddy field is under attack by paddy bugs, the farmer performs *Kappettiya* sweeping on the paddy field, to control the problem. Early in the morning, some *Kappettiya* branches are detached from the plant and tied to a bunch. Then this bunch is taken near the paddy field and beaten with a stick to damage the leaves (Irangani and Shiratake, 2013). The farmer then goes around the field, sweeping the paddy plants with this bunch of leaves. This is followed by placing *kappetiya* branches on both sides of the bunds. It is believed it is good if the farmer makes sure no one crosses/jumps over the *Keppetiya* branches (Irangani and Shiratake, 2013). This is used to control leaf whitening disease and worm damage in paddy, kurakkan and crops cultivated in Chena cultivation (Irangani and Shiratake, 2013). According to Filho et al. (2013), the plant has also shown insecticidal and fungicidal activity. This plant extract is rich in alkaloids, flavonoids, tannins, terpenoids and essential oils that work as deterrents and insect oviposition reducers. *Croton* species are known for the production and accumulation of terpenoids, especially monoterpenes, sesquiterpenes and diterpenes, which are generally found in all parts of the plant and with considerable structural diversity, including many bioactive molecules with effects against arthropods (Filho et al., 2013; Kuo et al., 2013).

*Lighting oil lamps*

According to Irangani and Shiratake (2013), five *malpales* (මල්පැල්)(altars) are established at the four corners and the center of the paddy field using tender leaves of coconut and if a footpath divides into a paddy field, then both sides of the footpath should be considered as two different fields. Coconut oil is extracted from two fresh

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coconuts by a male farmer in a fresh pot and this coconut oil is poured into three lamps made from immature *Carica papaya* L. (Family Caricaceae) fruit halves and lit during the night, followed by spreading of charmed virgin sand at a rate of three *seruwa* (ඉස්රුව) (traditional measuring unit, approximately equal to 1.0 kg) per acre. After this ritual, no one is allowed to enter the field for three days with the intention of ash and burnt parts of the unripe papaya will control insects. Scientific studies have shown that immature papaya fruits exhibit insecticidal properties and make them potentially useful for controlling insect infestations due to compounds like carpain and other secondary metabolites (Malathi and Vasugi, 2015). Specifically, papaya latex and leaf extracts have shown larvicidal effects against various mosquito species, including Aedes aegypti and *Culex quinquefasciatus*. Idoko and Adebayo (2018) showed that the powders and ashes of unripe C. papaya seeds significantly reduced the oviposition potential of adult *C. maculatus* and caused a significant reduction of damaged seeds.

*Offer madu flowers*

In traditional agriculture, *madu* (මඩු) (*Cycas circinalis* L.-Family Cycadaceae) has been used as an insect repellent in pest management activities because the reproductive structure emits a strong odour when decaying which repels pests (Irangani and Shiratake, 2013). In this ritual, the farmer gets up early in the morning (before seeing the lines of a hand or stalks of jackfruit leaves) and collects a Madu inflorescence and goes to the field to establish the inflorescence against the wind after walking around the paddy field three times (Irangani and Shiratake 2013). Cycasin is one of the constituents of the Cycas and it has insecticidal and inhibitory properties (Raja Mamannan and Natarajan, 2010).

*Placing polpithi (Coconut mid-ribs)*

According to Jayatissa et al. (2019), *polpithi* (පොල්පිති) (coconut midribs) is erected randomly in such a way to keep its base (bottom) on top at several locations in the paddy field to control flies in the field. Once *polpithi* is placed in the field, birds such as crows and owls perch on them and catch flying insects.

*Crushing pus wines*

Pieces of pus wines (පුස් වැල්) (*Entada pursaetha* DC. Family: *Fabaceae)* in the wet zone or *Kalawel* (කළු වැල්) (*Derris scandens* (Aubl.) Pittier -Family Fabaceae) in the dry zone are crushed at the upper water inlet of the *Yaya* (paddy cultivation area) and mixed with water in silence to control insects (Irangani and Shiratake, 2013). The presence of the Entada plant in swidden fields is believed by the Naga farmers to be a sign of prosperity and a good harvest (Changkija, 1999). According to research by Hymavathi et al. (2011), the vapor-phase toxicity of *Derris scandens* Benth-derived constituents was evaluated against four stored-product pests (*Callosobruchus chinensis*, *Sitophilus oryzae*, *Rhyzoperthado minica,* and *Tribolium castaneum*) using bioassays and compared to those of commonly used insecticides and the results of fumigation tests indicated that compounds from *D. scandens* whole plant extract are potential candidates to control stored-product pests.

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*Mixing habarala pithi*

According to (Irangani and Shiratake 2013), *habarala pithi* (හබරල) (*Alocasia macrorrhiza* (L.) Schott. Family**-**Araceae) is sliced into small pieces and spread on several locations of the paddy field before throwing control mole cricket in the paddy field. When slices of *Habarala pithi* get decayed, the juice is mixed with mud when bunds are newly built and decaying *Habarala pit*hi juice inside the bunds is harmful to mole cricket. Oriyomi et al (2022) conducted a study aimed at investigating the insecticidal, repellent, genotoxic, and cytotoxic effects of *Colocasia* species leaf extract and concluded that the potent fraction leaf extract possessed bioactive phyto constituents suggesting its use as natural alternative control agents in the integrated pest management.

*Spring water mixed with gurunda hardwood*

Cut hardwood pieces of the *gurunda* (ගුරුන්ද) (*Celtis cinnamomea* Lindl. ex Planch. - *family* Cannabaceae) plants are added to a pot of water and the mixture is kept for several days. The water is then collected and sprayed onto the paddy field to control flies on the paddy field (Kumari, 2016). According to Hewage et al. (1997), *C. cinnamomea* reported the highest insecticidal activity against the *Aphis craccivora*.

*Using mee tree and its parts*

Ancient farmers planted 3-4 mee trees per acre of paddy field because they were also aware of the fact that by planting Mee trees at water exit points, nutrition-rich liquid fertilizer would be carried away to downstream paddy fields. These trees also have a deep as well as a superficial root system that prevents soil erosion at the water entry and exit points (Irangani and Shiratake 2013). Furthermore, the ancient farmers knew the chemical properties of the various parts of the Mee tree that can be applied for pest control and took advantage of having these trees at the water inlet points of paddy fields (Jayatissa et al., 2019). For instance, mee (මී) (*Madhuca longifolia* (J. Koenig ex L.) J.F. Macbr. - family Sapotaceae**)** is one of the popular trees grown in the vicinity of paddy fields for controlling pests (Kumari, 2016). Chopped roots of the Mee tree exposed to water helped to control insect larvae and pupae in the paddy field (Jayatissa et al., 2019). Seeds of the tree were chopped and sprayed to the field to get rid of paddy bugs (Jayatissa et al., 2019). The oil extracted from the seeds was used as a natural pesticide against leaf rolling caterpillars (leaf roller – *Cnaphalocrocis medinalis*) (Jayatissa et al., 2019). According to Kaushalya and Karunaratne (2019), mee seeds contain a rich source of bioactive chemicals which have been exploited in pest management strategies, mainly as repellents, toxicants and antifeedants. Furthermore, Mee seeds contain saponins which are known to possess bio-pesticidal properties against several species of pathogenic bacteria, fungi, and insects. Madhua also enhances soil fertility and nutrient uptake by plants, acting as an antagonist against soil-borne pathogens (Kaushalya and Karunaratne, 2019).

**Sheath blight (Kokkana Rogaya) diseases in paddy cultivation**

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*Stir alakola leaves*

According to Kumari (2016), sheath blight is a soilborne disease caused by the fungus *Rhizoctonia solani.* Traditionally, farmers mark the center of the paddy field with *gurulla* (ගුරුල්ල) (*Leea indica* (Burm. f.) Merr. -Family Vitaceae) sticks and threads are directed from the center stick to various directions (Kumari, 2016). According to the research studies carried out, the extracts of *Gurulla* are reported to have a wide range of pharmacological properties, including antifungal and phosphodiesterase inhibitory activities (Srinivasan et al., 2009; Dalu et al., 2014; Kekuda et al., 2018). In another method, according to Kumari (2016) mustard (*Brassica nigra* (L.) W.D.J. Koch - Family Brassicaceae), *perumkayam (Ferula assa-foetida* L. - Family Apiaceae*), alakola* leaves (*Alocasia species*), garlic (සුදු ළූණු) (*Allium sativum* L.-Family Amaryllidaceae) and red onion (*Allium cepa* L. -Family Amaryllidaceae*)* are put into a fresh pan and heated in a stove is made in the field and the mixture in the pan is heated by stirring at a pre-decided auspicious time in the evening. Once the mixture becomes watery, it is applied to the paddy field (Jayatissa et al., 2019). When performing this ritual, one must not speak to anybody. Further, on the same day, the farmer's family should include *Alakola* leaf curry in their dinner. The smell of the mixture helps to keep insects away from the field (Irangani and Shiratake 2013). Recent studies, including pharmacological and biological, have also shown that *F. assa-foetida* possesses several properties, such as antioxidant, antiviral, antifungal, cancer chemo preventive, antidiabetic, antispasmodic, hypotensive and molluscicide (Mahendra and Bisht, 2012). The numerous biological activities of Alocasia species were also presented, which include antifungal, antiparasitic and radioprotective activities as well as acute toxicity studies (Arbain et al., 2022).

*Hanging keppetiya branches and charming of ash*

In traditional methods, branches of *kappettiya* (කැප්පිටියා) (*C. laccifer*) are placed in several locations in a paddy field and ash is charmed using *gatha* and broadcast around the paddy field with scraped coconut after extracting the milk in the morning before the sun rises (Irangani and Shiratake, 2013). Application of ash destroys insects whereas the spread of scraped coconut attracts birds to the field and birds eat both scrapped coconut and insects (Hakbijl, 2002). It has also shown insecticidal and fungicidal activity (Filho et al., 2013).

*Spread green grams*

According to Kumari (2016), sticks are planted all around the paddy field and fixed with coconut husks on top of them with green gram mixed soil/sand collected from the field is placed on coconut husks. It is believed that when green grams germinate, the whitening of paddy leaves disappears because these coconut husks attract and serve as landing and observation perches for birds, such as owls, that prey on rodents and worms and help to control worms.

**Kem methods to control insect pests and worms in paddy and other field crops**

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*Filling fence with kaduru sticks*

According to Senanayake (2006), *kaduru* (කඳුරු) (*Cerbera manghas* L.- Family name: Apocynaceae) is another common plant found in traditional pest management activities in Sri Lanka. The establishment of a fence around the field using a single *Kaduru* stick started on Monday in the morning before hearing the crow's craw. The construction is then completed next Monday after placing another *Kaduru* stick. This method is used to protect the field from all kinds of pests. *Kaduru* is also used as an insecticide, pesticide, or antifungal agent (Saxena et al., 2023).

*Light neem oil pandam*

*Pandam* (torches of fire) are made using neem oil and lighted and the smoke of the *pandam* is passed through each plant in the field without burning the leaves because *neem* (*Azadirachta Indica-* Family *Meliaceae)* oil fumes is used to destroy the laid eggs of insects and pests in vegetable cultivation (Irangani and Shiratake 2013). The neem oil is believed to be poisonous to insects, providing a natural alternative to synthetic pesticides (Srivastava et al., 2013).

*Crush marigold flowers and leaves*

According to Irangani and Shiratake (2013), marigold (*Calendula officinalis* L.-Family Asteraceae) flowers and leaves are crushed and spread in the field without talking in chena cultivation and marigold plants are cultivated randomly in the field to protect vegetable crops from insects. According to Jankowska and Wi (2011), the study on the effects of pot marigold (*C. officinalis*) plant water extracts on the occurrence of pest insects on white cabbage proved that the marigold extract had a positive impact on reducing its number of diamond back moth (*Plutella xylostella*).

*Spraying soap, water, gasoline, and wood ash*

Early in the morning, soap, water, gasoline or wood ash is sprinkled all over the field. This is used to control insects in the field (Irangani and Shiratake, 2013). According to Hakbijl (2002), a study on the traditional, historical and prehistoric use of ashes as an insecticide, an experimental study on the insecticidal efficacy of washed ashes proved that ashes and other insert dusts can be used as insecticides. Desiccation, caused by damage to the protective epicuticular lipid layer by dust particles, is the major reason for insect mortality. There has been evidence of many societies using dust in the protection of stored products, according to Archaeological records from Egypt connected with historical records dating back to the second millennium BC (Hakbijl, 2002).

*Use dummala smoke*

*Dummala* (දුම්මල) (resin obtained from *Shorea oblongifolia* Thwaites- Family Dipterocarpaceae) dust is put on to a fire plate (a plate with burning pieces of coconut and other wood charcoal) to create a smoke to control files in vegetable fields (Kumari, 2016). According to Subasinghe, et al., (2019), using *Dummala* for mosquito and gnat repellence is also evident. *Dummala* latex contains substances like alkaloids,

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terpenoids, and phenolics that impart antibacterial and antifungal characteristics (Murthy, 2021).

*Spray of tobacco stalks extract*

In traditional farming systems, farmers collect a handful of tobacco stalks (*Nicotiana tabacum* L.-Family Solanaceae) mixed with four bottles of water and boiled to evaporate until the volume of the mixture is reduced to one bottle (Irangani and Shiratake 2013). About quarter of a bottle of extract is diluted with six bottles and sprayed to the field using a sprayer after cooling and filtering. This spraying needs to be repeated three times on three consecutive evenings to control worm problems in crops. Rice is the staple food in Sri Lanka and an essential agricultural commodity with the third-highest worldwide production and losses in rice storage due to insect pests may drastically affect the food availability of a growing population. One of its serious pests in the tropics is the "rice weevil", Sitophilus oryzae (Kanmani et al., 2021). Although few effective fumigants are available, there is a serious global concern about environmental pollution, toxicity to non-target organisms, and pesticide residues. According to Kanmani et al. (2021), the chloroform and acetone extracts of *N. tabacum* leaves exhibited the highest adulticidal activity against S. oryzae (Kanmani et al., 2021). Their $LD_{50}$ values were 1.62, 0.64, and 0.48; 1.54, 0.83, and 0.48 mg/L after 24, 48, and 72 h of exposure, respectively. In addition, the petroleum extracts also indicated high adult mortality with an $LD_{50}$ value of 0.53 mg/L only at 72 h (Kanmani et al., 2021).

*Spray neem leaf extracts*

Fresh neem (කොහොඹ) (*A. indica*) leaves are crushed, and the juice is collected and diluted with water and sprayed on the field without talking to anyone to control worms in vegetable fields (Irangani and Shiratake 2013; Jayatissa et al., 2019). According to Quelemes et al. (2015), neem leaf ethanolic extract presented inhibitory effects on Methicillin-resistant Staphylococcus aureus (MRSA) biofilm and planktonic aggregation formation, and anthelmintic activity against S. mansoni worms and snails in paddy and other field crops.

*Use perumkayam smoke*

Ancient farmers collected garlic (සුදු ළූණු) (*A. sativum*), cumin (සුදුරු) (*Cuminum cyminum* L. - Family Umbelliferae), kaluduru (කලුදුරු) (*Nigella sativa* L. - Family Ranunculaceae) and *perumkayam (පෙරුම්කායම්) (F. assa-foetida* Family Apiaceae) and mixed into a fresh pot with coconut milk and boiled using citrus wood fire in the direction of *maru* (death) at. 6.30 pm (Irangani and Shiratake 2013).

*Use gendagum smoke*

Four cones made from *Alakola* (*Alocasia* species) and hung them in the four corners of the field. If this *kem* is done in the paddy field, the mixture is added with straw to control flies and worms in paddy and vegetable cultivation (Irangani and Shiratake 2013). Black seed (Kaluduru) was more effective in the eradication of parasites, particularly adults of both worms, eggs and somewhat larvae of the nematode (EI-mansy et al., 2008). In traditional farming systems, *gendagum* (ගෙන්දගම්)(Sulphur) is

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burned under the vegetable beds of bitter and ridge gourds because the smoke of sulphur is used to control flies in gourds (Jayatissa et al., 2019). Sulfur is burned or vaporized to control fungus, mites, or insects (USDA, 2011).

*Spraying thunkiri pan*

*Thun kiri pan* means three latex treatments: the latex of breadfruit and jackfruit with coconut milk is added to clean and filtered water and mixed thoroughly and then the mixture is sprayed on vegetable plots whilst worshiping the goddess *Paththini* to control worm problems in vegetable cultivation (Jayatissa et al., 2019). Sri Lanka has a prestigious history of hydraulic-based civilization running back to the 5th century BC (Dharmasena, 2010). Rice cultivation began around 900 BC and has developed in an organized way since 300 BC (Chambers, 1994; Deraniyagala, 1992; Senanayake, 2006). With the introduction of the Green Revolution in the mid-1960s, modern farming techniques, such as inorganic fertilizers and other agro-chemicals, were introduced (Farmer, 1986; Wilson, 2000). The cultivation of paddy in Sri Lanka was entirely based on indigenous techniques until the introduction of the Green Revolution (Deraniyagala, 1992).

## CONCLUSION

Traditional farming systems since ancient times were successful and self-sustained according to ancient literature. Numerous *kem* methods were available and practiced by ancient farming communities and some are practiced even in the 21st century by some farmers. Therefore, in this paper, a certain number of *kem* methods were quoted from the literature and their scientific basis are justified with recent research findings. This is proved that even though the ancient community did not have technological advances as it in present time, they had some sort of evidence to continue these methods for sustainable agricultural production. Most of these methods are based on medicinal plants and their properties, which are proved scientifically to control pests and diseases. Since the large number of farming communities in Sri Lanka are in small-scale cultivation, they could follow these methods to control pests and diseases in paddy and other filed crops to increase the profit margin, as most of the methods are based on locally available plant material and low-cost methods. This will enhance the environmentally sound sustainable ecosystem with low cost of production. Furthermore, organically produced harvest fetch high price so that the economic value will be high. In addition, use of chemical pesticides and insecticide has cause severe health hazards such as chronic kidney disease, tumors and caners among the farming communities. Therefore, the finding of this study will help the farmers in rural areas of Sri Lanka to minimize the health hazards and increase the productivity.

## DECLARATIONS OF INTEREST

None.

## DECLARATION OF HONOUR

We declare in our honor that our results are not fake and made up.

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