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ARECA PALM **MOSQUITOES**

ARECA PALM (*Areca catechu* L.) LEAF AS A POTENT BIO-PESTICIDE AGAINST MOSQUITOES

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ABSTRACT

Mosquitoes are predominantly vector insects responsible for transmitting several diseases to man. Presently, mosquito control programmes are being carried out by using chemical insecticides. But, continuous use of such insecticides posed several health problems and developed resistance on mosquitoes. Because of these factors, there is an increasing demand for some effective and environmentally safe alternatives to these insecticides to control such vector mosquitoes. Bio-pesticides of plant origin could be an effective alternate for this. Areca palm, *Areca catechu* L. is widely distributed in several tropical and subtropical Asian countries and is one of the major commercial crops of India. Areca palm contains lots of beneficial bioactive compounds which could be extracted and used effectively for the control of several pests and diseases. Most of the works carried out so far on the mosquitocidal and larvicidal activities of this plant are reviewed in this report. These observations revealed that the areca leaf is having very potent larvicidal action against the larvae of *Aedes aegypti* and *Anopheles stephensi*. Cent per cent mortality achieved by the methanolic extract of the leaves of areca palm against the larvae of *A. stephensi* suggest that this bio-product could be successfully used for the control of such mosquitoes in and around human habitations. Similar studies may also be carried out against all other species of mosquitoes and the data be exploited further for use in large scale in the mosquito eradication campaign as areca palms are available in plenty in India and several other countries.

KEY WORDS: **Arecanut, *Areca catechu* L., Phytochemicals, Mosquito, Toxicity, Management.**

Introduction

The areca palm, *Areca catechu* L (family Palmaceae) is mainly distributed in India and several other south and southeast Asian countries including China, Malaysia, Indonesia, the Philippines, Burma, Thailand, Sri Lanka, etc. (Arjungi, 1976; Balasimha and Rajagopal, 2004). It is one of the important plantation crops of India with extensive cultivation in the states of Karnataka, Kerala and Assam. Other states and Union Territories like Meghalaya, Tripura, West Bengal, Tamil Nadu, Maharastra, the Andaman and Nicobar Islands, etc. are also known for the cultivation of this crop (Selvan *et al.*, 2004; Thomas and Balasimha, 2011). Total area under arecanut in India during 2013-14 was assessed to be around 4.5 lakh hectares (Directorate of Arecanut and Spices Development, Ministry of Agriculture, GOI, Calicut, India - Figures for 2013-14: Arecanut- Area, production and productivity). One hectare of areca plantation at the recommended spacing of 2.7 x 2.7 m shall accommodate around 1,300 palms (Bhat *et al.*, 1999).

Areca palm has a solitary, slender (about 50 cm circumference), straight trunk grows up to 25-30 m height, with a compact crown surrounded by 7-12 leaves at various stages of development (Ananda, 2004). The leaves are quite big (1.2 -1.8 m in length), with numerous leaflets (30-60 cm length and 5.8-7 cm breadth). On an average 6.3 leaves are shed from each palm every year amounting to about 4 kg dry weight of leaves (Bhat and Sujatha, 2011). Not much work has been done so far on the chemical constituents and pharmacological properties of areca leaves.

The fruit or seed of areca palm is commonly called as arecanut (misnamed as betel nut in some parts of the world as it is usually chewed along with the leaves of *Piper betle* L.) is well known for its folklore medicinal properties (Aman,1969). It is being used in traditional herbal medicines in several countries including India and China from time immemorial (Tavera, 1901; Arjungi, 1976; Rao, 1982; Farnsworth *et al.*, 1985; Fabricant and Farnsworth, 2001; Li Shizhen, 2003; Badanaje, 2008; Krishnamurthy, 2008; Rahmatullah *et al.*, 2009; Jaiswal *et al.*, 2011; Peng *et al.*, 2015a). The World Health Organization (2009) has listed out as many as 25 beneficial effects of *A. catechu*. The biopotential including the phytochemical and pharmacological properties of arecanut has been studied and reviewed (Patil *et al.*, 2009; Amudhan, 2011; Amudhan *et al.*, 2012; Rashid *et al.*, 2015; Bhat *et al.*, 2016a; 2016b).

Mosquitoes are predominantly vector insects responsible for the spread of several dreaded diseases such as malaria, filaria, dengue, yellow fewer, etc. to man. The mosquito species such as *Anopheles gambiae* and *A. stephensi* are the vectors of malaria (Obomanu *et al.*, 2006; Vinayagam *et al.*, 2008); *Aedes aegypti* is the vector of dengue, chikungunya, etc. (Jawale, 2014); *Culex quinquefasciatus* is the vector of filaria (Kovendan *et al.*, 2012) and *C. tritaeniorhynchus* is the vector responsible for transmitting Japanese encephalitis (Elumalai *et al.*, 2012). For the successful management of these diseases, control of vector mosquitoes is very important.

As the mosquitoes breed in stagnant waters, it is appropriate to control their larval stages in such confined habitats. But the control of mosquitoes by using chemical insecticides is becoming increasingly difficult because of the development of resistance by the larval stages of these mosquitoes and the hazards the insecticides do to the environment. With the growing awareness of environmental pollution and toxicity to non target animals caused by the use of such chemicals there is an increasing demand to find out some environmentally safe and effective molecules for the control of these vectors. Use of suitable and effective bio-pesticide is a safe alternate for this.

Plants contain many important biologically active compounds such as tannins, saponins, terpenoids, steroids, alkaloids, flavonoids, etc., which naturally give them certain amount of protection against several pests and diseases. Such compounds have already been reported to exhibit potential larvicidal properties (Deore and Khadabadi, 2009; Ghosh *et al.*, 2012; Jawale, 2014).

The chemical constituents of the leaves of arecanut have not been studied much. However, the nuts or fruits of arecanut mostly contain 11.1–29.8% polyphenols (including flavonoids and tannins); 17.3–25.7% polysaccharides; 6.2-9.4% proteins; 8.1–15.1% fats; 8.2–15.4% fibres; 0.11–0.24% alkaloids and 1.1–2.5% minerals (Shivashankar *et al.*, 1976). The alkaloid fraction of arecanut contains: arecoline, arecaidine, guvacine, guvacoline, isoguvacine, arecolidine and homoarecoline and all possess good drug-like properties (Peng *et al.*, 2015b). The chemical constituents vary slightly from one processed type of arecanut to another (Shivashankar *et al.*, 1969; Shvashankar and Nambudiri, 1985). The tannin contents in the nut decrease with maturity, whereas the alkaloid contents increase with maturity of the nut (Mathew *et al.*, 1964). According to them, the tannin content in very tender arecanut was 43.85%, which decreased to 17.8% when the nuts ripened. On the other hand, the arecoline content was nil in very tender arecanuts, increased to 0.22% in ripe nuts. Further, all the major chemical constituents of arecanut decreased significantly when the nuts were dried and stored with husk compared to fresh mature nuts (Chempakam and Saraswathy, 1985). Awang (1988) also reported that the active chemical constituents in arecanut, namely arecoline and polyphenols could be reduced by treatments such as sun drying, roasting, soaking or boiling.

Mosquitocidal activities of plants with special reference to arecanut:

Studies have been conducted on the effectiveness of the extracts of several plants including arecanut against mosquitoes (Ahmed *et* *al.*, 2001; Obomanu *et al.*, 2006; Vinayagam *et al.*, 2008; Deore and Khadabadi, 2009; Rawani *et al.*, 2010; 2014; Kovendan *et al.*, 2012; Tennyson *et al.*, 2012a; 2012b; Elango *et al.*, 2012; Jawale, 2014; Poolprasert *et al.*, 2015). The toxicity varied from plant to plant. Obomanu *et al.* (2006) compared the larvicidal properties of two plants, *Lepidagathis alopecuroides* and *Azadirachta indica* against the mosquitoes *Anopheles gambinae* and *Culex quinquefasciatus* and found that the aqueous leaf extract of the former was more toxic than that of the latter against the larvae of both these species of mosquitoes. Maurya *et al.* (2008) studied the larvicidal property of *Aloe barbadensis* and *Cannabis sativa* leaf extracts against the larvae of *C. quinquefasciatus* and found that the former was more toxic than the latter with the LC 50 of 15.31ppm after 24 hours. For the same period, the LC50 value for *C. sativa* was as high as 88.51ppm. Tandon and Sirohi (2010) compared the larvicidal properties of aqueous extracts of four plants, *Azadirachta indica, Gymnema sylvestre, Nerium indicum* and *Datura metel* against the larvae of the mosquito *C. quinquefasciatus* in the laboratory and found that the extract of *A. indica* was more toxic with 70-99% mortality, followed by *G. sylvestre* 44-89%, *N. indicum* 41-74% and *D. metel* with 19-54% mortality to the larvae of this vector. The LC50 of the aqueous extract of the seeds of *A. indica* to the larvae of this mosquito was 0.53 mg/L.

Vinayagam *et al.* (2008) compared the larvicidal activities of the leaf extracts of ten medicinal plants including *A. catechu* against the larvae of the mosquito *Anopheles stephensi* and found that among these plants, only four plants, *A. catechu, Albizzia amara, Leucas aspera* and *Ocimum sanctum* were very effective and showed 100% mortality of the vector larvae after 24 hours of treatment with 10% of the extract. The rest of the plants, *Adathoda vasica, Eucalyptus globules, Musa paradisiaca, Phyllanthus amarus, Piper nigrum* and *Tamarindus indica* showed 50, 80, 90, 85 and 90% mortality, respectively after 24 hours. They further observed that continuous exposure of the larvae to 5% extract effectively inhibited the development of pupae and emergence of adults. Tennyson *et al.* (2012a) made a comparative study on the larvicidal activities of the mature fresh leaf extracts of three plants such as *A. catechu, Nicotiana tabacum* and *Piper betle* against the mosquito *Aedes aegypti* and found that the extract from *A. catechu* exhibited highest larvicidal activity, followed by *N. tabacum* and *P. betle* with LC50 values of 124.28, 236.73 and 313.58 ppm, respectively at 24 hours and 95.75, 98.45 and 122.99 ppm, respectively at 48 hours. The corresponding figures for LC90 were 271.73, 892.49 and 647.03 ppm for 24 hours and 221.19, 347.46 and 309.18 ppm for 48 hours, respectively.

The mosquitocidal activity of plant extract varied depending on the solvents used for extraction. Rawani *et al.* (2010) evaluated seven different solvent extractions such as petroleum ether, benzene, ethyl acetate, chloroform: methanol (1:1 v/v), acetone and absolute alcohol of the leaves of *Solanum nigrum* and recorded their toxicity against the larvae of *C. quinquefasciatus.* They found that the mortality rate with ethyl acetate extract was significantly higher than that of other extracts against the larvae of this mosquito. They got 100% mortality of the larvae with 50ppm concentration of ethyl acetate extract. In the same concentration with benzene, chloroform: methanol, petroleum ether, absolute alcohol and acetone extracts they achieved only 86.7, 76.7, 43.3, 33.3 and 23.3% mortality, respectively.

In *A. catechu* the methanolic extract of leaves exhibited very high toxicity against the larvae, pupae and adults of *Anopheles stephensi* (Vinayagam *et al.* 2008). Tennyson *et al.* (2012a) also reported that the methanolic extract of the leaves of *A. catechu* exhibited very high larvicidal property against the larva of *Aedes aegypti.* Tennyson *et al.* (2012b) further evaluated the larvicidal activities of four solvent extracts (hexane, diethyl ether, dichloromethane and ethyl acetate) of different morphological parts of 25 plant species and found that the hexane extract was more potent than that of the others. But, they did not include methanol extract in their study. However, Kovendan *et al.* (2012) compared the larvicidal activities of methanol, ethyl acetate, chloroform and hexane extracts of four different medicinal plants against the larvae of *Culex quinquefasciatus* and found that the methanolic extract showed maximum larvicidal activity followed by ethyl acetate, chloroform and hexane extracts.

Elango *et al.* (2012) compared five solvent extracts (methanol, hexane, chloroform, ethyl acetate and acetone extracts) of the leaves of six plant species and found that the methanolic extract was more potent than that of other extracts in inhibiting adult emergence and adulticidal activity against the mosquito *Culex tritaeniorhynchus*. Maurya *et al.* (2008) while studying the larvicidal properties of *Aloe barbadensis* and *Cannabis sativa* leaf extracts against the larvae of *C. quinquefasciatus* found that the carbontetrachloride extract was more potent than that of the petroleum ether and methanol extracts of these plant species.

The mosquitocidal activity of plants also varied depending on the morphological parts used for extraction of phytochemicals. In some plants the extracts of leaves were more toxic, whereas in others it was either the seeds or roots which were more toxic. In *A. catechu,* the leaf extract was found to be more effective than that of the seed extract. Vinayagam *et al.* (2008) achieved 100% mortality against the larvae of the mosquito *Anopheles stephensi* by using the leaf extract of *A. catechu.* Similarly, Tennyson *et al.* (2012a) reported that arecanut leaf extract was having potent larvicidal activity. By using the arecanut seed extract, Poolprasert *et al.* (2015) got only 23.33% mortality of the larvae of *Culex quinquefasciatus* at 1000 ppm. However, they did not use the leaf extract of arecanut in their study. They got 100% mortality of the larvae of *C. quinquefasciatus* by using the root extracts of turmeric, stem of citronella grass, leaf of sweet basil and peels of the fruit of kaffir lime. This clearly shows that within the same plant, the toxicity differs from one morphological part to another and it is very essential to evaluate and compare the mosquitocidal property of each part separately to ascertain its effectiveness and find out the most potent one for further use in the management programmes against these vector insects.

Studies were also made to identify the actual chemical compound responsible for the larvicidal activity of plants. Tandon and Sirohi (2010) reported that the major bioactive constituents of the plant *Gymnema sylvestre* against the larvae of the mosquito *C. quinquefasciatus* were saponins and tannins. Jawale (2014) found that the plants having more of phytochemicals such as alkaloids, saponins, flavonoids, steroids and tannins produced more larvicidal effects against the mosquito *A. aegypti*. Hence, arecanut, which is having good amount of tannins and alkaloids would be an ideal bio-pesticide for the control of these vectors.

Conclusion

Plants have rich stock of phytochemicals which could also be used as effective bio-pesticides for the benefit of human being. These bio-pesticides have several advantages over synthetic chemical pesticides as the former are less toxic, easily available and completely biodegradable. The present review highlights the results of the studies on the toxicity of the extracts of several plant species, especially arecanut, *Areca catechu* L., which is widely grown in several Asian and southeast Asian countries including India, against some of the major species of mosquitoes. It was observed that the toxicity of phytochemicals of plants varied considerably depending on several factors such as the parts of plants used for extraction, the solvents used for such extraction and above all the chemical constituents of the plant species. In arecanut, the leaf extract exhibited more larvicidal property than that of the nut. This is in fact an added advantage to areca farmers as there is no effective value added product evolved so far out of the leaves of arecanut which are available in plenty. Among the solvents tested, it was noticed that the methanolic extract was more potent in most of the plants. However, more studies are needed to identify the actual phytochemical compound(s) responsible for the mosquitocidal activity, the effective plant part to be used, the efficient method of extraction, and the toxicity values against all target species of mosquitoes, so that the mosquito control programme by using such bio-pesticide from areca palm, which is available in abundant, could be of more effective, beneficial and acceptable to mankind.

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