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Evaluation of aqueous and methanol extract of *Pongamia pinnata* (L.) Pierre against Yellow Tea Thrips, *Scirtothrips dorsalis* hood (Thysanoptera: Thripidae) on tea

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Abstract
In this study, aqueous and methanol extract of *Pongamia pinnata* seeds were evaluated against adults of *Scirtothrips dorsalis* on tea. The mortality rate was tested in the concentration range of 1%, 2%, 4%, 6%, 8% and 10% at the time interval of 24 hour (h), 48 h, 72 h and 96 h. The lethal concentration 50 (LC_{50}) was calculated after 24 h of treatment by probit analysis. In both aqueous and methanol extract percentage mortality increased with increased concentration and time. At 96 h of treatment, aqueous extract exhibited 95.65% mortality and methanol extract exhibited 100% mortality at 10% concentration. LC_{50} values were 6.70% and 3.11% in aqueous and methanol extract, respectively. From this study, it is concluded that *Pongamia pinnata* seed is having active principle which is responsible for controlling *Scirtothrips dorsalis.*

Keywords: Yellow tea thrips, *Pongamia pinnata*, aqueous and methanol extract, percentage mortality, LC_{50}

Introduction
Tea is the worldwide popular beverage which helps in revenue earning of a country including India. Relatively steady microclimate and food supply provided by monoculture of tea plant, *Camellia sinensis* (L.) O. Kuntze attracts several divergent arthropod pests resulting in 12-15% crop loss in India (Hazarika *et al*., 2009 [9]; Muraleedharan and Roy, 2016 [11]; Varatharajan *et al*., 2019) [19]. A minute sucking pest, yellow tea thrips, *Scirtothrips dorsalis* Hood (Thysanoptera: Thripidae) has been lately established as one of the major pests of tea plantations of Nort-East India including Assam which sucks the sap of tender leaves and buds forming thin lines on the leaf surface parallel to the mid vein, due to climate change, deforestation and over-reliance on chemical pesticides (Varatharajan *et al*., 2019) [19].

One of the alternatives that can be used to control pests instead of the chemical pesticides are the botanicals which are more environment friendly as these degrade more rapidly and are less likely to kill the beneficial arthropods. *Pongamia pinnata* (L.) Pierre belonging to the family Fabaceae is a multipurpose leguminous tree which is indigenous to the Indian subcontinent and South-East Asia (Belide *et al*., 2010) [3]. This is a widely used medicinal plant to treat a broad spectrum of wounds and diseases (Al Muqarrabun *et al*., 2013) [2]. Large number of compounds were discovered from various classes including flavonoids and terpenoids in phytochemical studies. In this study, the toxicity of the aqueous and methanol extracts of *P. pinnata* seeds were tested against *Scirtothrips dorsalis* on tea in laboratory condition.

Materials and methods
Seeds of *Pongamia pinnata* were collected from their natural habitats of Golaghat (N 26° 24' 33.12", E 93° 54' 42.948"), Assam, India. Seeds were removed from their pods, washed with tap water and then allowed to shade dry for 25 days. Dried seeds were pulverized to a powder by using an electric blender and was passed through a 20-mesh size sieve.

Powdered product was weighed to twenty grams and mixed with 100 mL of the solvents (distilled water and methanol) individually and were agitated in a mechanical shaker for 8 hours and then kept for 24 hours (Roy *et al*., 2014 [15] and Handique *et al*., 2017) [8]. Extracts were filtered and were concentrated by using a rotary vacuum evaporator. Collected residues were kept for the experiment.

Stock solution of the extracts was made by mixing 1 g of plant residue with 5 mL of acetone and then the volume was made up to 100 mL by the addition of distilled water. The required concentrations i.e., 1%, 2%, 4%, 6%, 8%, 10% were prepared from the stock solutions and a few drops of sticking agents were added and mixed with the spray fluids (untreated control and treatment) before application.

Laboratory bioassays of aqueous and ethanol extracts *P. pinnata* seeds on *S. dorsalis* were assessed by using leaf disc method (Mahendran, 2011) [10] at an optimum laboratory condition in a completely randomized design (CRD) with five replications. Plant extracts were sprayed on 20 healthy adult thrips (24-h old) on tea leaves within leaf cups with a glass atomizer (Roy and Mukhopadhyay, 2009) [17].

The mortality was observed at 24 h, 48 h, 72 h and 96 h of time intervals with the help of a stereomicroscope. Then percentage mortality was calculated by using the following formula (Mahendran, 2011) [10]:

$$\% \text{ mortality} = \frac{No,of\ dead\ thrips\ post\ treatment}{Total\ no.of\ thrips} \times 100$$

If natural mortality occurs in the control, then the mortalities were corrected by Abbott's formula (Abbott, 1925) [1] as follows:

$$\text{Corrected \% mortality} = \frac{(\%\ mortality\ \ in\ test - \%\ mortality\ \ in\ control}{(100 - \%\ mortality\ \ in\ control\ )} \times 100$$

Based on the Finney's probit analysis method (Finney, 1973) [6], LC_{50} for both the aqueous and methanol extracts were calculated after 24 hour of treatment using SPSS 16 software.

Results and discussion

The adults of *Scirtothrips dorsalis* were exposed to different concentration ranges of aqueous and methanol extract of *Pongamia pinnata* seeds to determine the percent mortality at different time intervals (Table). The extracts showed varied levels of mortality against *S. dorsalis* at different concentrations. The toxicity was observed to be concentration and time dependent.

Table 1: Average percentage mortality of adult *S. dorsalis* Hood exposed to a concentration range of aqueous and methanol extracts P. pinnata seeds after different time interval and their lethal concentration 50 (LC50) after 24 h of treatment under laboratory condition.

Concentrations Tested in %	Aqueous extract				Ethanol extract			
	24 h	48 h	72 h	96 h	24 h	48 h	72 h	96 h
1	4±5.47	9±6.51	21.05±3.53	40.22±6.12	20±5.00	34.02±7.41	50±5.70	68.88±4.47
2	24±4.18	36±4.18	38.95±5.70	47.83±5.70	33±5.70	56.7±4.47	68.75±5.00	85.55±2.73
4	35±3.53	44±2.23	50.53±2.73	58.7±5.70	58±9.08	68.04±8.94	82.29±4.47	94.44±3.53
6	48±4.47	59±6.51	63.16±6.12	70.65±6.70	71±8.21	80.41±7.41	89.58±3.53	97.77±2.73
8	54±6.51	63±5.70	67.37±4.18	81.52±2.73	77±6.70	87.62±5.70	95.83±4.18	100±0.00
10	60±6.12	69±4.18	84.21±3.53	95.65±4.18	83±5.70	90.72±4.18	98.95±2.23	100±0.00
Control	0.0±0.00	0.0±0.00	5±3.53	8±4.47	0.0±0.00	0.0±0.00	4±2.00	10±6.32
LC_{50} (%)	6.70				3.11			

The results revealed that the *Pongamia pinnata* aqueous extract showed 60%, 69%, 84.29%, 95.65% average mortality of *S. dorsalis* at 10% concentration after 24 h, 48 h, 72 h, 96 h of intervals, respectively. Methanol extract showed 83%, 90.72%, 98.95%, 100% average mortality of *S. dorsalis* at 10% concentration after 24 h, 48 h, 72 h, 96 h of intervals, respectively. Similar tendency of insecticidal activity was also observed at other concentrations also. A least toxicity was observed at lower concentrations (1% and 2%) of the extracts.

The adult percentage mortality in both aqueous and methanol extracts was in linear trend which is increasing with increasing concentration and time. The mortality was significantly higher in methanol extract than in the aqueous extracts ($P<0.05$). The LC_{50} values were 6.70% and 3.11% in aqueous and methanol extract, respectively.

Complex bioactive compound mixtures present in crude plant extracts may act synergistically than individual compounds (Berenbaum, 1985 [4]; Chen *et al*., 1995) [5] and resistance to insects is much less likely to develop with these mixtures (Roy *et al*., 2011) [16]. Both the aqueous and methanol extracts of *P. pinnata* seeds, in the current study, showed promising bioactive potential against the pest. *P. pinnata* extract's bioactivity was significantly diverse based on the solvents used for extraction, concentration and time. From the results, methanolic extracts caused higher percentage mortality in a shorter period of time than aqueous extract. The LC_{50} value is lesser in methanol extract which indicates higher toxicity of methanol extract than in aqueous extract. The reason behind this difference is the dissolving nature (polarity) of the active principles in particular solvent. However, aqueous extract is far better than methanol extract as it can be prepared at farmer's level easily which is cheap and demands less expertise. In many previous investigations on the insecticidal activity of plant extracts showed different levels of effects depending on the solvent used (Govindarajan, 2009 [7]; Nagappan, 2012) [12]. Reena Singh (2007a, 2007b) [13, 14] evaluated the effects of different fractional extracts of *P. pinnata* seeds on *Earias vitelli* and found that methanolic extract changes the biology of the pest significantly in a dose dependent manner. Verma *et al*., 2011 [18], showed that karanjin, a compound isolated from *P. pinnata* extract instigated 100% percentage mortality against *Odontotermes obesus* after 6 hours of treatment. This infers that karanjin may be the active principal compound responsible for insecticidal effects. Further, isolating this bioactive compound and developing it into simple formulations is necessary for implementation in large scales.

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