SHORT COMMUNICATION

Chemical composition and larvicidal activity of *Zanthoxylum armatum* against diamondback moth, *Plutella xylostella*

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(Received 23 February 2015; final version received 28 March 2015)

The diamondback moth, *Plutella xylostella* (L.) (Lepidoptera: Yponomeutidae) is the most serious pest of cruciferous crops grown in the world causing economic yield loss. Several synthetic insecticides have been used against *P. xylostella* but satisfactory control was not achieved due to development of resistance to insecticides. Therefore, the present study was carried out to screen different fractions of *Zanthoxylum armatum* for their insecticidal activities against second instar larvae of *P. xylostella*. Results indicate, all the fractions showed activity to *P. xylostella*. However, *n*-hexane fraction of *Z. armatum* showed maximum larvicidal activity with minimum LC\(_{50}\) value of 2988.6 ppm followed by ethanol (LC\(_{50}\) = 12779.7 ppm) and methanol fraction (LC\(_{50}\) = 12908.8 ppm) whereas chloroform fraction was least toxic (LC\(_{50}\) = 16750.6 ppm). The GC–MS analysis of *n*-hexane fraction of leaf extract showed maximum larvicidal activity, which may be due to two major compounds i.e., 2-undecanone (19.75%) and 2-tridecanone (11.76%).

**Keywords:** *Zanthoxylum armatum*; fractions; insecticidal activity; *Plutella xylostella*

1. Introduction

The diamondback moth, *Plutella xylostella* (L.) (Lepidoptera: Yponomeutidae) is the most damaging insect pest of cruciferous crops throughout the world and greatest threat to crucifer production in many parts of the world causing more than 90% crop loss (Talekar & Shelton 1993; Verkerk & Wright 1996; Gu et al. 2010). Intensive use of chemical pesticides in its control has led to this pest developing resistance to a wide range of insecticides and caused serious damage to natural enemies (Liu et al. 1982; Talekar & Shelton 1993). Cabbage, *Brassica oleracea* var. *capitata* L., is cultivated throughout the year in many parts of India with

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approximately 2.4 lakh ha planted commercially and 52% yield loss was reported due to *P. xylostella* (Krishnamoorthy 2004).

Due to harmful effects of synthetic pesticides to health, environment and resistance development in pests, there is a need for alternate strategies to control the pests. The natural plant products can be an excellent alternative source of novel insecticides due to less toxic to non-target species and more environment friendly because of their biodegradable nature. Mid hills of western Himalayas are endowed with a wide range of promising flora known for their medicinal values and many have a history of usage, either to kill or to repel insects. Medicinal and other bioactive properties of *Zanthoxylum armatum* are known (Mehta et al. 1981; Ramidi et al. 1998; Kalia et al. 1999). However, studies on pesticide activities of this plant are scanty and no quantitative report is available on their activity against *P. xylostella*. Some of the researches have reported the essential oils and leaf extracts of other species of *Zanthoxylum* have insecticidal activity against cabbage butterfly, *Pieris brassicae*, *P. xylostella*, stored grain pests and mosquitoes (Kokate et al. 2001; Lee et al. 2004; Tewary et al. 2005; Kordali et al. 2006; Arannilewa 2007; Tiwary et al. 2007; Denloye et al. 2010; Prieto et al. 2011; Paul & Sohkhlet 2012).

The medicinal plant, *Z. armatum* growing abundantly in the region of mid hills of western Himalayas, was selected to study the chemical composition and insecticidal activity of different fractions against *P. xylostella*. The results of the present study would be useful in promoting research aiming at the development of new agents for insect pest control based on natural products.

## 2. Results and discussion

### 2.1. Chemical constituents of n-hexane fraction

The characterisation of volatile constituents of *n*-hexane fraction was carried out by GC–MS analysis and a total of 22 compounds were identified representing 90.48% of the constituents detected. The identified constituents, percentage composition and their KI values are shown in Table S1. The extract mainly consisted of oxygenated aliphatics (50.06%) followed by sesquiterpenes (14.33%), diterpenes (9.99%), monoterpenes (8.86%), oxygenated monoterpenes (5.15%), oxygenated sequiterpenes (1.58%) and aliphatic hydrocarbons (0.51%). The major components were 2-undecanone (19.75%), 2-tridecanone (11.76%) and *E*-carryophyllene (9.88%).

### 2.2. Screening bioassay

A leaf-dip method was used to evaluate the activity of the test samples. Preliminary screening of the test samples was carried out at higher dosage (20,000 ppm) as described in the Section 3.3. Initially, 80% aqueous methanol extract (ZALMW) of *Z. armatum* was evaluated against second instar larvae of *P. xylostella* for larvicidal activity and found to cause 66.67% mortality at 20,000 ppm. Further, successive fractionation of this crude extract with solvents of different polarity (*n*-hexane, chloroform, ethyl acetate and *n*-butanol) was carried out to get corresponding fractions ZALH, ZALC, ZALE and ZALB, respectively. All these fractions were tested for insecticidal activity against *P. xylostella* except ZALB. Among these, ZALH was found to be most active at 20,000 ppm causing 95.56% mortality followed by ZALE (78.89%) and ZALC (60.0%) (Figure S1).

### 2.3. Larvicidal activity

Based on the preliminary screening results, different fractions of extracts were prepared from *Z. armatum* leaves and dose–response experiments were carried out under laboratory. LC$_{50}$ (lethal concentration to kill 50% mortality) and other statistical parameters generated by linear
regression analysis are summarised in Table S2. It was observed that, the activity of the test samples was significantly correlated with contact time. The results showed that all the four fractions of *Z. armatum* have toxic effects on larvae of *P. xylostella* after 48 h of treatment. Among test samples, n-hexane fraction of the *Z. armatum* showed highest larvicidal activity with LC$_{50}$ of 2988.64 ppm followed by ethyl acetate (LC$_{50}$ = 12779.75 ppm), whereas chloroform fraction was least effective (LC$_{50}$ = 16750.6 ppm).

The results of present study showed that, the insecticidal activity was enhanced with increasing amount of doses and exposure times for all fractions. These results suggesting that leaf extracts of *Z. armatum* may have great potential to be used for effective management of *P. xylostella*. A further study is also necessary to determine the toxicity of these extracts on other economically important pests in field and greenhouse crops. Our data demonstrated that, the insecticidal activity was relatively enhanced with increasing amount of doses and exposure times for all solvent leaf extracts (Figure S1). Present results showed that n-hexane fraction of *Z. armatum* showed significant larvicidal activity against larvae of *P. xylostella*. The compounds, 2-undecanone and 2-tridecanone can be anticipated as the main active constituents responsible for insecticidal activity of *Z. armatum* (Table S1). Chemical composition studies by others showed that 2-undecanone and 2-tridecanone as major constituents of extract of *Lycopersicon hirsutum* (Walsingham) (Lepidoptera: Gelechiidae) and *Spodoptera exigua* (Hubner) (Lepidoptera: Noctuidae) (Lin et al. 1987).

There is no work/literature on larvicidal activity of different fractions/compounds of *Z. armatum* against *P. xylostella*. However, this is the first study demonstrating that n-hexane extract of *Z. armatum* had promising insecticidal activity against *P. xylostella*. Some of the previous studies reported that insecticidal effects of *n*-hexane + ethyl ether extract of *Zanthoxylum alatum* as a feeding deterrent and repellent to third instar larvae of *P. brassicae* which is also belongs to the Lepidoptera (Paul & Sohkhlet 2012). However, essential oils of *Z. armatum* and *Zanthoxylum monophyllum* also reported insecticidal activity against larvae of *Helicoverpa armigera*, *P. xylostella*, mosquito larvae (Tewary et al. 2005; Tiwary et al. 2007) and fumigant activity to rice weevil, *Sitophilus* spp. (Kokate et al. 2001; Lee et al. 2004; Kordali et al. 2006; Prieto et al. 2011). The fumigant activity of *Z. monophyllum* can be attributed to 1,8-cineole, terpinen-4-ol and α-terpinene present in the essential oil; these compounds have shown 100% mortality on insects. In the present study based on LC$_{50}$ values, larvicidal activity of different fractions after 48 hrs of treatment was found in the order of hexane > ethyl acetate > methanol > chloroform fraction.

3. Conclusion

The present study indicated that, *n*-hexane fraction of leaf extract of *Z. armatum* showed maximum larvicidal activity *P. xylostella*, which may be due to two major compounds i.e. 2-undecanone (19.75%) and 2-tridecanone (11.76%).

Supplementary material

Supplementary material relating to this article with respect to experimental section is available online alongside Tables S1–S2 and Figure S1.

Acknowledgements

The authors are grateful to Dr. P.S. Ahuja, Director, CSIR-IHBT, Palampur for encouragement and support. Mr. VK is grateful to UGC for Senior Research Fellowship. This work was supported by Council of Scientific and Industrial Research, New Delhi, India [BSC 0213, BSC 0110].
Disclosure statement
No potential conflict of interest was reported by the authors.

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