Bioefficacy Of Herbals For The Management Of Brinjal Hadda Beetle, *Henosepilachna Vigintioctopunctata* Fabr. (Coleoptera: Coccinellidae)

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Abstract
Henosepilachna vigintioctopunctata is a polyphagous pest feeding on many solanaceous and cucurbitaceous crops especially egg plant (*Solanum melongena*). A significant damage caused by this pest due to varacious feeding nature on the foliage of eggplants has been reported with reduction in crop yield. Thus, it is essential to control this devastating pest of economic importance. The present study has been conducted using petroleum ether extracts of *Eucalyptus globulus* (Safeda), *Ipomoea fistulosa* (Besharam) and *Prunus persica* (Aru) prepared by Soxhlet extraction process and were tested against first instar larvae. It was found that 1.0 percent concentration of all the three extracts killed 73.33-93.3% larvae. All the extracts at 0.5% exhibited significant larval mortality of 60.0, 53.33 and 40.0%, respectively. The highest concentration i.e. 1% of all the extracts showed the reduction in total developmental period (16.17-19.34 days) in comparison to control (20.I7days). The adult emergence with 1% extracts of *E. globulus and I. fistulosa* was recorded 6.67% whereas *P. persica* extract showed 26.67% adult emergence. The extracts used at 0.5% were exhibited the adult emergence from 40 to 60%. The present study revealed *I. fistulosa* as the most effective extract against the first instar larvae of *H. vigintioctopunctata*. The LC_{50} values of the plant extracts had also been determined.

Keywords: Henosepilachna vigintioctopunctata, Mortality, Extracts, Larvae, Emergence

1. Introduction
Brinjal *(Solarium melongena)* is one of the most popular vegetables grown extensively throughout India. It is a heavy yielder and high remunerative crop but often growers suffer with recurring economic loss due to the attack of many insects /pests including brinjal hadda beetle, *Henosepilachna* 28-punctata (Fabr.) It is a polyphagous coccinellid pest, causing great damage to this crop, throughout its development. Both, its grubs and adults are furiously destructive to other solanaceous and cucurbitaceous crops (Jayanti and Jesudasan, 2000; Saxena and Sharma, 2005; Sharma and Saxena, 2012). Usually the management of this beetle has been insecticides oriented and their application in pest control programme, is time to time restricted due to pest resistance, toxic residues and other health hazards (Kannaiyan, 2002; Kumar et al., 2013; Hanif et al., 2021). Evidently, the safer plant products such as extracts, powders and oils of some medicinal plants, and less toxic compounds are proved to be useful in developing sound pest management strategies. Thus, in the present investigation, an extensive study has been done using different herbals to investigate mortality rate, growth period, etc.

2. Materials and methods
2.1. Processing of plant materials and their extraction
The plant species were selected by screening literature and potential knowledge reported by the local people. To develop environmental friendly pest control measures, the fresh leaves of *Eucalyptus globulus* (Safeda), *Ipomoea fistulosa* (Besharam) and *Prunus persica* (Peach) were collected from their natural habitats, washed thoroughly, shade dried for 8-10 days and finely ground to powder. The dried plant materials were subjected to Soxhlet extraction process to prepare petroleum ether extracts as per the method (Mehta et al., 1999; Sharma and Saxena, 2012). The extracted material in semi-liquid form was then dried in rotary evaporator to remove solvent from the crude extract. The solvent free crude extract thus obtained was transferred in glass vials and stored in refrigerator and used for the present study. To evaluate the bioactivity, different concentrations *viz.* 1, 0.5, 0.2 and 0.1% were prepared in distilled water from crude extract (Mehta *et al.,* 1999).

2.2. Test insect

The experimental insect, *H. vigintioctopunctata*, was originally collected from the brinjal fields of Nariawal village located at Bareilly district and was continuously reared in Pests and Parasites Research Laboratory in the Department of Zoology, Bareilly College, Bareilly. The nucleus culture of the beetle was maintained in laboratory as per the method of Saxena and Sharma (2007). The stock culture was maintained in the laboratory at 28ºC and 65±5% relative humidity (RH) to supply different life stages of the beetle for experimentation.

2.3. *In vitro* bioassay

For evaluation different herbal extracts, first instar larvae of *H. vigintioctopunctata* were procured from the nucleus culture reared and maintained in the laboratory. Various concentrations of the extracts viz., 0.1, 0.2, 0.5 and 1% were prepared in distilled water for evaluation. To work out antilarval activity of the extracts, the first instar grubs of hadda beetle were fed on brinjal leaves treated with different concentrations of these extracts for 24 h and kept in plastic jars covered with muslin cloth as per the method of Saxena and Sharma (2007). Thereafter, normal fresh leaves were provided to them upto the pupation. The control experiments were conducted with the same manner with water. The experiment was replicated thrice having five larvae in each to evaluate the bioactivity of extracts in terms of larval mortality, developmental period, adult emergence, diapause condition and any other morphological deformity.

2.4. Statistical Analysis

The dose response data of different plant extracts was subjected to probit analysis after transforming the percentage concentration into log and percentage mortality into probit mortality. The LC_{50} values of the extracts were determined by probit analysis (Finney, 1962) while differences in mean values of entomological data among the groups were analyzed by one way ANOVA with the help of GraphPad Prism 5.0 computer software (GraphPad Software, San Diego, California USA).

3. Results and discussion

The herbals occupy an important place in the management of integrated pest control system due to possessing ecofriendly nature and many bioactive principles which reduce the probability of developing resistance in targeted pests. In the present study, it was observed that petroleum ether guided herbal extracts from identified three plant species exhibited bioactivity against first instar larvae of hadda beetle. Results of the present study documented in table 1 showed that 1.0 % concentration of *I. fistulosa* and *E. globulus* exhibited 93.3±6.7% larval mortality while *P. persica* leaf extract caused only 73.3±6.7% larval mortality. Satpathi and Ghatak (1990) have reported 90% larval mortality in *H. vigintioctopunctata* with 1% leaf extracts of *Nerium oleander, Lanatana camera* and *Ocimum sanctum* which are in the agreement with the results obtained in the present study with same concentration of *E. globulus* and *I. fistulosa* leaf extracts. Kalaiyarasi and Ananthi (2015) reported 100% mortality of treated first instar larvae of hadda beetle with methanolic extract of *E. globulus* which is very close to the present findings showing 93.3±6.7% larval mortality of the same beetle. Similar observations in this beetle with same plant leaf extract were also recorded by Venkataramireddy et al. (1993). Similarly, here 0.5% extracts of *I. fistulosa* and *E. globulus* were proved to be superior to *P. persica* extract showing 60.0±0.0, 53.3±6.7 and 40.0±11.5% larval mortality respectively. Other concentrations (0.2 and 0.1%) of *P. persica* were found to be the least effective causing only 13.3±6.7% mortality whereas same concentrations of *I. fistulosa* showed 26.7±6.7% and 20±o.0% mortality and *E. globulus* exhibited 30.0 and 20.0% larval mortality with 0.2 and 0.1 % concentrations. It was noticed that after 24 h feeding on treated leaves, most of the larvae were more inactive in higher concentrations of all the three plant extracts as compared to lower concentrations. Larval mortality caused by *E. globulus* and *I. fistulosa* occurred mainly at earlier larval stages. The LC_{50} values with 95% confidence interval of *E. globules, I. fistulosa* and *P. persica* were determined as 0.29 (0.23-0.36), 0.29 (0.22-0.37) and 0.58 (0.47-0.71) %, respectively, showing that Eucalyptus and Ipomoea plants were found to have similar toxicity to the first instar larvae (Fig. 1).

Table 1. Effect of leaf extracts of different plants on the first instar larvae of *H. vigintioctopunctata.*

Plants Extract	Conc. %	Developmental Period (days)			Adult Emergence (Mean % ±SE)	Larval Mortality (Mean %±SE)	LC_{50} % (95% CI)
		Larva	Pupa	Total			
E. globulus	1.0	14.50	1.67	16.17	6.67±6.7	93.3±6.7^{c}	0.29 (0.23-0.36)
	0.5	16.83	2.83	18.83	46.7±6.7	53.3±6.7^{b}	
	0.2	17.83	4.17	22.00	70.0±6.7	33.3±6.7^{a}	
	0.1	16.50	3.83	20.33	80.0±0	20.0±0	
I. fistulosa	1.0	17.00	1.67	18.67	6.7±6.7	93.3±6.7^{c}	0.29 (0.22-0.37)
	0.5	16.83	4.33	21.16	40.0±0	60.0±0^{c}	
	0.2	17.00	5.33	22.33	73.3±6.7	26.7±6.7	
	0.1	18.16	4.00	22.16	80.0±11.5	20.0±11.5	
P. persica	1.0	16.67	2.67	19.34	26.7±6.7	73.3±6.7^{c}	0.58

	0.5	17.34	4.17	21.51	60.0±11.5	40.0±11.5[a]	(0.47-0.71)
	0.2	16.83	4.33	21.16	86.7±6.7	13.3±6.7	
	0.1	16.16	4.83	20.99	86.7±6.7	13.3±6.7	
	Control	15.50	4.67	20.17	93.3±6.7	6.67±6.7	

Superscripts showing significantly different mean values from control at [a] $p<0.05$, [b] $p<0.01$, [c] $p<0.001$

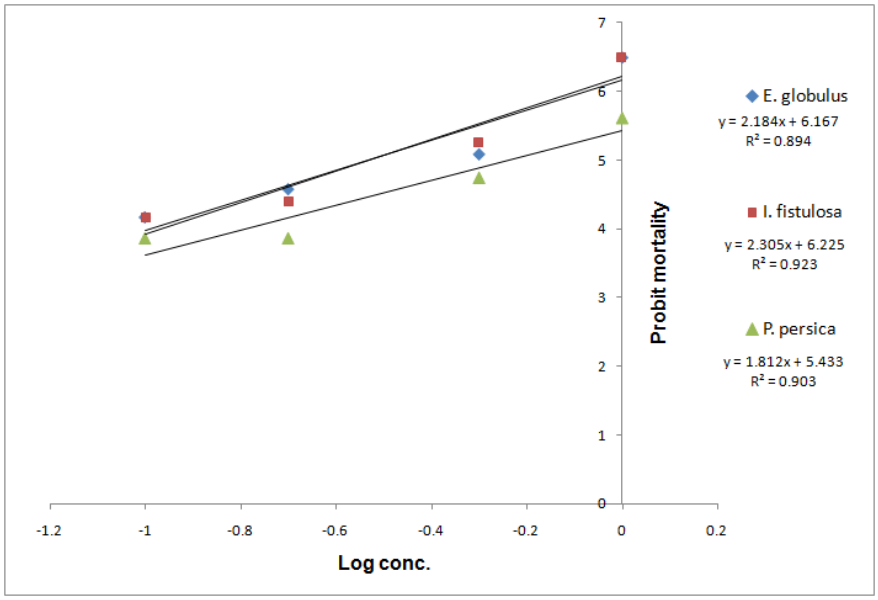

Fig. 1. Log-probit mortality graph of petroleum ether guided leaf extracts of different plants against first instar larvae of *H. vigintioctopunctata* Fabr.

Dwivedi et al., (2000) found that some herbal extracts including Eucalyptus were proved to be potent larvicide causing complete developmental arrest of mosquito. The adult emergence caused by both, *E. globulus* and *I. ftstulosa* leaves extracts, ranged from 6.67 to 80±6.7% while in case of *P. persica* it ranged from 26.7±6.7 to 86.7±6.7%. Maximum inhibition of adult emergence was recorded 6.67±6.7% with 1% extracts of *I. fistulosa* and *E. globulus*. Singh and Rao (2000) showed that leaf extract of *Ageratum conyzoides* significantly reduced the adult emergence to 59.86% in *Spodoptera litura* which matches the result (60.0%±6.7) caused by 0.5% extract of *P. persica* in *H. vigintioctopunctata*. Sharma and Saxena (2012) also reported that *E. globulus* seed extract inhibited adult emergence of this beetle which is in conformity with the present findings. It had been observed here that few hadda beetles could not detach their pupal case easily and remained attach to adult abdomen for sometime then left the puparium in *E. globulus* and *I. fistulosa* (0.2% and 0.5%) extracts. This indicates chitin synthesis inhibitor like activity of these extracts and such changes on this beetle are still under observation. 1.0% of all the three plant extracts reduced the total developmental period ranging from 16.17 to 19.33 days. Significant reduction in this period was recorded 16.17 days with 1.0% extract of *E. globulus* as compared to control, which showed 20.17 days. Mehta et al. (1999) reported that 1% extract of *Ageratum conyzoides* increased the total developmental period of hadda beetle up to 21 d as compared to control (19.33 d) which is not similar to the present observation made on this beetle with same concentrations of Besharam (18.67 days) and Safeda (16.17 d) extracts.

It is concluded that the *E. globules* and *I. fistulosa* were equally found effective against first instar larvae showing similar toxicity and can be used in the development of effective herbal insecticides.

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Conflict of interest

Authors declare that they have no conflict of interest in the data provided in the manuscript.

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