

Individual and Synergistic Effects of Leaf Powder of Few Medicinal Plants against American Bollworm, *Helicoverpa armigera* (Hubner) (Noctuidae: Lepidoptera)



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Abstract : *Argemone mexicana*, *Cipadessa baccifera*, *Clausena dentata*, *Dodonaea angustifolia* and *Melia dubia* are medicinal plants predominantly present in India. The individual and synergistic effects of *A. mexicana* leaf powder with the other plants were investigated for their insecticidal property against *Helicoverpa armigera*. The different treatments differed significantly in their efficacy with 5 gm of *A. mexicana* + *D. angustifolia* and *A. mexicana* + *M. dubia* being the most effective in curtailing the pupation followed by 10 gm of *A. mexicana* alone. The pupal weight and length were low in the synergistic combination. Malformed moth emergence was 89% in 5 gm of *A. mexicana* + *C. dentata*. The adult life span was least in *A. mexicana* + *C. baccifera*. The fecundity and egg hatchability were also subsequently affected due to the impact on the first generation larvae.

Key words : *Argemone mexicana*, *Dodonaea angustifolia*, pupation, fecundity

Introduction

American bollworm, *Helicoverpa armigera*, a polyphagous noctuid, draws attention worldwide because of its migration, higher reproduction rate and wide distribution. It feeds on 181 plant species of 39 families, most affected being maize, sorghum, chick pea, pigeon pea, cotton, tobacco, okra, sunflower and groundnut (Reed and Pawar, 1982; Manjunath *et al.*, 1989). In India, it causes an annual loss of \$300 million in pigeon pea and chickpea alone (Jayaraj *et al.*, 1990). The repetitive use of synthetic chemicals for several decades to manage this pest resulted in resurgence and outbreak, resistance to insecticides, elimination of existing natural enemies in addition to polluting soil, water, air and food (Gunning *et al.*,

1992; Mehta *et al.*, 1992; Patel *et al.*, 1992). Hence, search for viable and sustainable alternatives to synthetic pesticides is given priority (George and Seenivasagan, 1998; Talekar *et al.*, 1999). Among them, novel natural substances derived from higher plants are preferred over others due to its environmental safety (Arnason *et al.*, 1989). Insecticidal activity of many plants against several insect pests has been demonstrated (Jilani and Su, 1983; Isman, 2000; Carlini and Grossi-de-Sá, 2002).

Argemone mexicana (Family: *Papaveraceae*) is an erect prickly annual plant with yellow flower and latex. It is a native of tropical America and now widely naturalized in tropics. The plant is available along riverbanks and in Tamil Nadu, it is

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predominantly present at Yercaud (1400 m) (Matthew, 1983). The plant is used mostly for the treatment of HIV (YuhChwen *et al.*, 2003). The plant contains many alkaloids (Sangwan and Malik, 1998; YuhChwen, *et al.*, 2003) and was found to possess larvicidal and growth inhibiting activity against the second instar larvae of *Aedes aegypti* (Sakthivadivel and Thilagavathy, 2003).

Cipadessa baccifera Miq. (Family: *Meliaceae*) is a bushy shrub distributed in North Circas, Deccan and Western Ghats. It has multiple uses such as fuel, fodder and fish poison. In addition, it is used against piles, diabetes, diarrhoea and headache. The active constituents isolated from the seeds of *C. baccifera* include cipadesin, 17a, 20R-dihydroxypregnan-3, 16-dione, 1,4-epoxy-16-hydroxyheneicos- 1,3,12,14,18-pentaene, etc (Luo *et al.*, 2000).

Clausena dentata (Family: *Rutaceae*) is a small tree distributed in Western Ghats in Wayanad, Malabar, Anamalais, Pulneys and Travancore at 3,000 to 5,000 ft and North Circas, Hills of Ganjam and Vizagapatanam to 5,000 ft. It is used against kidney pains (Armando, 2003). *Clausena* was toxic to the grasshopper *Zonocerus variegata* (Okunade and Olaifa, 1987) and the main compounds isolated are β -sitosterol (Prakash *et al.*, 1980), amides (Mingh *et al.*, 1988) and terpenoids (Ito *et al.*, 2000).

Dodonaea angustifolia (Family: *Sapindaceae*) is a perennial shrub distributed in Pacchaimalai, Kolli hills, Servarayans, Yercaud, Ulundurpettai, Chitteris, Oomathi and in Western Ghats (Gamble, 1987; Matthew, 1983). It is used for fencing, thatching apart from curing open wounds, snake bite, rheumatism, etc. (Subashini *et al.*, 2004). It contains essential oil, flavonoids,

terpenoids, phenols, coumarins, sterols and unidentified alcohols (Sachdev and Kulshreshtha, 1986; Van *et al.*, 2000; Abdelmogib *et al.*, 2001). *D. viscosa* caused growth inhibition in *Spodoptera littoralis* (Abdelaziz and Omer, 1995), *H. armigera* (Subashini *et al.*, 2004) and human pathogens namely *Bacillus* sp. *Salmonella* sp. *Corynebacterium diphtheriae*, etc. (Sukkawala and Desai, 1962).

Melia dubia (Cav.) (Family: *Meliaceae*) is a large deciduous tree/shrub distributed in North Circas, Ganjam, Nallamalai Hills and Western Ghats. Its timber is mainly used for furniture and agricultural implements (Amarasekara, 1995). Tetraterpenoids (Porushothaman *et al.*, 1984) and monoterpenes (Nagalakshmi *et al.*, 2001) are its major constituents and reported to be toxic to *S. litura* and *H. armigera* (Opende *et al.*, 2000).

Though the effect of *A. mexicana* has been studied earlier on few insects, an in-depth study using *A. mexicana* individually as well as in combination with less explored traditional plants such as *C. baccifera*, *C. dentata*, *D. angustifolia* and *M. dubia* against *H. armigera* has not been done elsewhere.

Synergistic effect of plants on *H. armigera*

Methanolic leaf extracts of *Persea indica* and *Aglaia* (Gonzalez Coloma *et al.*, 1996), *Annona squamosa* and *Azadirachta indica* (Das *et al.*, 2000) and seed kernel extract (Boreddy Yerasi and Chitra, 2001) tested on *H. armigera* showed high larval mortality. Synergistic effect of *Lantana camera*, *L. veerbenaceae* and *Schinus molle* sp. resulted in reduced egg hatchability in *H. armigera* (Lannacone and Lamas, 2003).

Petroleum ether extracts of *A. mexicana*, *Jatropha curcus*, *Pergularia extensa* and *Withania somnifera* showed larval and pupal mortality, larval-pupal intermediates, half ecdysed organisms, and prolonged larval and pupal duration (Karmegam *et al.*, 1997). Similarly, water extracts from 10 weed species inhibited feeding of *Spodoptera frugiperda* (Smith, 1995).

Materials and Methods

Insect source

H. armigera larvae were collected from the lady's finger, red gram and cotton fields of Dindigul District, Tamil Nadu, India. The larvae collected from the fields were maintained in the laboratory at $22 \pm 2^\circ\text{C}$ and 70 - 75 % RH. The larvae were reared on semi-synthetic diet in individual containers to prevent cannibalism and contamination.

Plant material source

Leaves of *A. mexicana* was collected from different parts of Thirukazhukundram and Kumbakonam, while that of *C. dentata*, *C. baccifera*, *D. angustifolia* and *M. dubia* were collected from Kolli Hills, Tamil Nadu.

Bioassay of host plants

Ground leaf powder (individual)

Larvae

The leaves of *A. mexicana* were shade dried and powdered. The third instar larvae of *H. armigera* were bioassayed using normal diet with different concentrations (1.5, 3, 5, 10, and 15gm) of ground leaf powder for 100 gm of diet. Untreated normal diet served as control. Percent pupation, pupal weight, pupal size and percent moth emergence were recorded.

Synergistic effect

Larvae

The ground leaf powder of *A. mexicana*

was mixed with the leaf powders of the other test plants viz., *C. baccifera*, *C. dentata*, *D. angustifolia* and *M. dubia* at 5, 10 and 15 gm (1:1 ratio) respectively for 100 gm of diet against third instar larvae of *H. armigera*. Percent pupation, pupal weight, pupal size and percent moth emergence were recorded.

Adult longevity, fecundity and egg hatchability of *H. armigera*

The resultant moths of the previous study, if any, were tested for longevity, fecundity and hatchability. For those moths emerged from the larvae treated with the ground leaf powder of *A. mexicana*, honey solution mixed with the petroleum ether extract in 9:1 ratio was fed and for those emerged from the synergistic treatments, honey solution mixed with the petroleum ether extracts of *A. mexicana* and the other test plants in 1:1 ratio were fed.

Results and Discussions

Efficacy of *A. mexicana* ground leaf powder (individual and synergistic)

The pesticidal activity of the leaf extract of *A. mexicana* (individually) and its synergistic effect with *C. baccifera*, *C. dentata*, *D. angustifolia* and *M. dubia* were tested against third instar larvae of *H. armigera*. The parameters checked for the pesticidal activity were percent pupation, pupal weight, pupal size and moth emergence (healthy and malformed).

Among the different doses of *A. mexicana* tested (individual effect), reduced pupation (56 %) was observed in 10 gm followed by 73.3 % in 15 gm. However, the synergistic effect of *A. mexicana* + *D. angustifolia* and *A. mexicana* + *M. dubia* at 5.0 gm dose resulted in 50 % pupation, followed by 63.3 % in the same dose of *A. mexicana* + *C. dentata* which was better

than others (Table 1). The overall effect of *A. mexicana* alone as well as its synergy with other plants revealed less pupation at moderate doses, when applied alone, whereas its efficacy was more at lower dose when applied in combination with *D. angustifolia*, *M. dubia* and *C. dentata*. Similar results were recorded in *H. armigera* with the *Eucalyptus* ground leaf powder (2 %) with significant reduction in

pupation (12 %) and mean larval weight (Kaushik, 2001). The root extract of *Tagetes erecta* proved more toxic to the lesser grain borer and red flour beetle than malathion (Morallo Rejesus and Decena, 1982). Similarly, the root extract when incorporated into the semi-synthetic diet caused sterility and growth inhibition in corn borer (Morallo Rejesus, 1982).

Table 1 : Individual and synergistic effect of *A. mexicana* leaf powder on *H. armigera* (larvae 1st generation)

Treatment	Wt. gm.	Characters*				
		Larval Development			Moth emergence %	
		Pupation %	Pupal Wt. (mg)	Pupal Size (cm)	Healthy	Malformed/Dead
<i>A. mexicana</i> Individual	5	93.3	229	1.73	21.4	78.5
	10	56.6	222	1.70	52.9	47.0
	15	73.3	220	1.80	40.9	59.1
<i>A. mexicana</i> + <i>C. baccifera</i>	5	90.0	220	1.46	40.0	60.0
	10	83.0	250	1.54	36.0	64.0
	15	80.0	250	1.60	29.0	1.0
<i>A. mexicana</i> + <i>C. dentata</i>	5	63.3	120	1.40	10.5	89.5
	10	83.3	140	1.51	28.0	72.0
	15	86.6	140	1.53	26.9	73.1
<i>A. mexicana</i> + <i>D. angustifolia</i>	5	50.0	220	1.60	53.3	46.6
	10	63.0	230	1.55	47.3	52.6
	15	56.0	250	1.55	54.9	47.6
<i>A. mexicana</i> + <i>M. dubia</i>	5	50.0	233	1.58	48.6	63.3
	10	73.3	180	1.59	66.6	33.3
	15	66.6	213	1.62	40.0	60.0
Untreated		100.0	240	2.00	100.0	0.0
CD (P=0.05)		23.58	58.24	0.16	18.71	10.70

*Mean of triplicate

In addition to the larval mortality, reduced feeding, sluggishness and moulting disruption was observed in both individual (*A. mexicana* alone) and its combined effect

(*A. mexicana* + *D. angustifolia* and *A. mexicana* + *M. dubia* at 5.0 gm). This led to increased larval-pupal intermediates as against normal development in untreated larvae (Plate 1). This coincided with synergistic effect of seed extracts of neem, *Pongamia* and *Vitex negundo* in which delayed metamorphosis coupled with larval-

pupal intermediates was observed (Babu *et al.*, 2000).

Reduced pupal weight (120 and 140 mg) was observed in *A. mexicana* + *C. dentata* at 5.0 and 10.0 gm doses. The development of larvae to the pupal stage, with a markedly low pupal weight has been studied earlier (Gurusubramanian and Krishna, 1996). The pupal size was reduced (1.4 cm) in 5.0 gm of *A. mexicana* + *C. dentata* as against the highest in 2.0 cm in the untreated control (Plate 2).

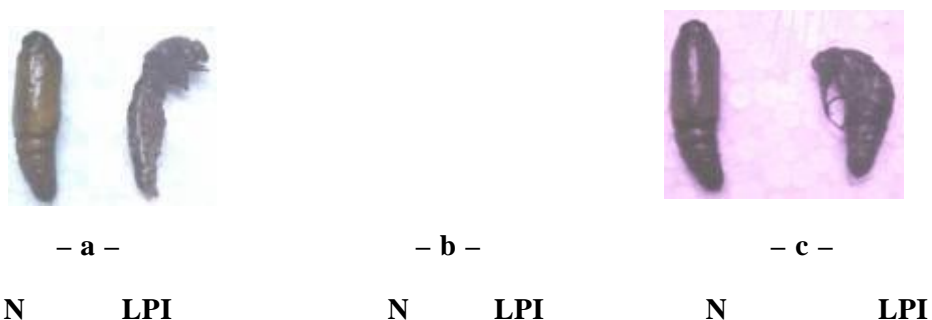


Plate 1 : Incomplete metamorphosis due to individual and synergistic effects of *A. mexicana*

a: *A. mexicana*; b: *A. mexicana* + *D. angustifolia*; c: *A. mexicana* + *M. dubia*

N: normal pupa; LPI: larval pupal intermediate

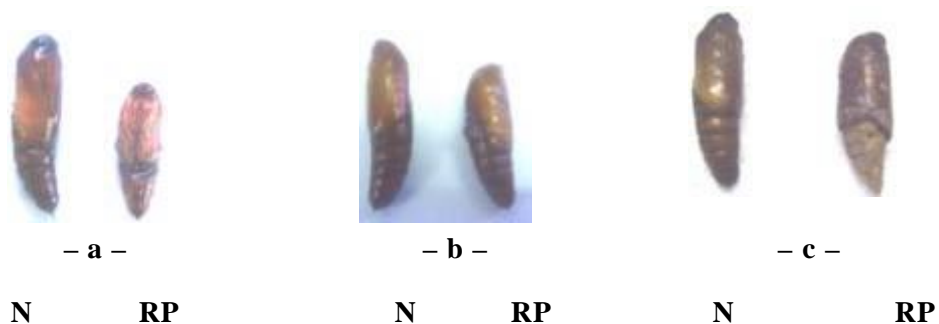


Plate 2 : Impact of disrupted moulting

a: *A. mexicana* + *C. dentata*; b: *A. mexicana* + *D. angustifolia*; c: *A. mexicana* + *M. dubia*

N: normal pupa; RP: reduced pupa

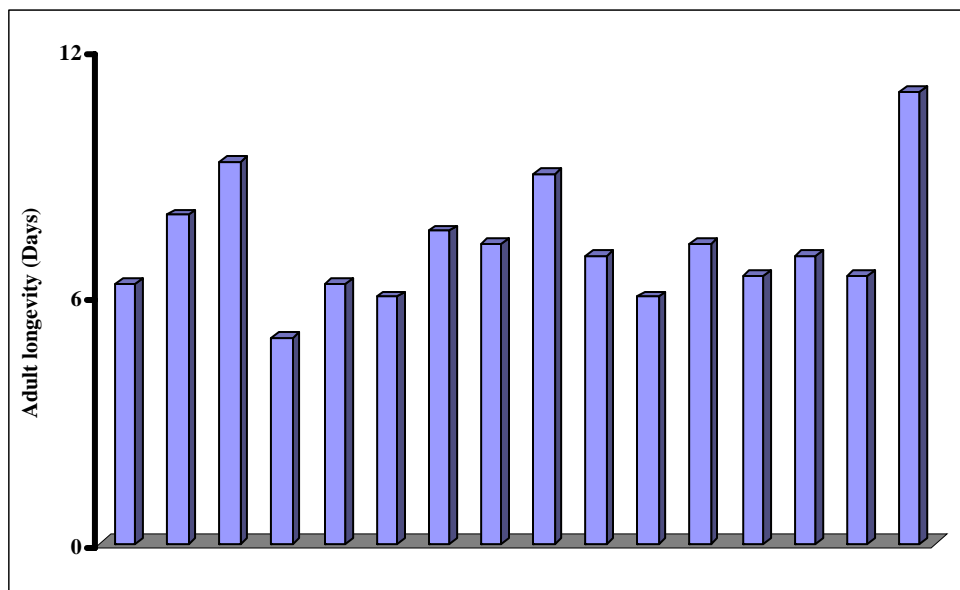
Least moth emergence was observed (10.5 %) in 5.0 gm of *A. mexicana* + *C. dentata* followed by 21.4 % in 5.0 gm of *A. mexicana* alone. Overall effect showed a considerable reduction in the healthy moth emergence both individually and in combination. Untreated larvae recorded 100 % healthy moth emergence. Though the pupation was not much affected due to *A. mexicana* + *C. baccifera*, the resultant moth emergence was drastically affected indicating the slow effect of botanicals. Reduced healthy moth emergence was noticed in extracts of *Catharanthus roseus* against *H. armigera* (Deshpande et al., 1988).

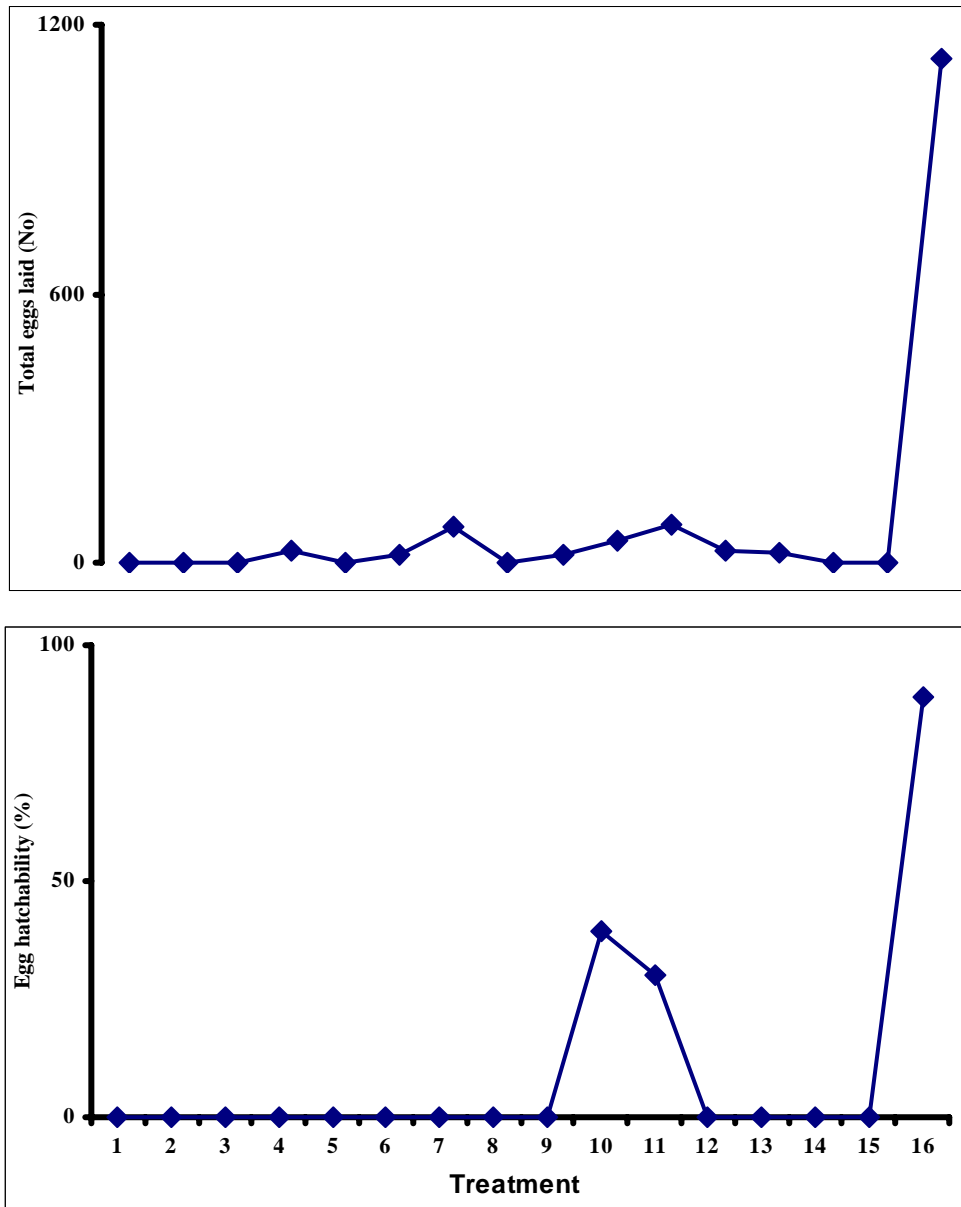
Efficacy of crude extracts against first-generation adults

Reduced adult longevity (5 days) was seen in 5.0 gm of *A. mexicana* + *C. baccifera* followed by 6.0 days in 15.0 gm

of *A. mexicana* + *C. baccifera*, 6.3 days in 5.0 gm of *A. mexicana* alone and 10.0 gm of *A. mexicana* + *C. baccifera*. Fecundity response was more or less similar between the treatments except *A. mexicana* + *D. angustifolia* (51 and 83 eggs in 7 and 6.8 days of life span at 5 and 10 gm), whereas eggs were not laid in 5.0, 10.0 and 15.0 gm of *Argemone* alone and *A. mexicana* + *C. baccifera*, *A. mexicana* + *C. dentata* and *A. mexicana* + *M. dubia*. Hatchability was zero in many treatments except for 5.0, 10.0 gm of *A. mexicana* + *D. angustifolia* (39.2 and 30.1 %) as against 89.0 % in untreated control (Fig 1). The impairment of gonotrophic cycle of adults might have prevented the eggs from hatching, as reported in cabbage diamond back moth (Dilawari et al., 1994), *Earias vitella* (Shukla et al., 1997) and *H. armigera* (Jeyakumar and Gupta, 1999).

Fig. 1 : Efficacy of *A. mexicana* (individual and synergistic) against first-generation adults of *H. armigera*





1-3: *A. mexicana* 5 gm, 10 gm and 15 gm; 4-6: *A. mexicana* + *C. baccifera* -5 gm, 10 gm and 15 gm; 7-9: *A. mexicana* + *C. dentata* - 5 gm, 10 gm and 15 gm; 10-12: *A. mexicana* + *D. angustifolia* -5 gm, 10 gm and 15 gm; 13-15: *A. mexicana* + *M. dubia* - 5 gm, 10 gm and 15 gm; 16: untreated control

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