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Antibiosis and insecticidal properties of *Madhuca indica* and *Bixa orellana* against *Spodoptera litura*

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Abstract

Studies were conducted to test the efficacy of medicinal plants viz *Anthocephalus chinensis*, *Bixa orellana*, *Calotropis procera* and *Madhuca indica* against various instars (4, 7 and 8day old larvae) of *Spodoptera litura*. Strong antifeedant activity was shown by *M.indica* against 8day old larvae. *M.indica* when tested further caused death of 4day old larvae four days after feeding. *A.chinensis* and *C.procera* could support the growth and development of insects causing 10 and 63.33% larval mortality respectively. Larval period was prolonged in *A.chinensis* (20.21d) as compared to control (9.95d) indicating adverse effect on biology. Pupation and adult emergence was minimum in *C.procera* (36.66 and 33.33%).The four medicinal plants reduced the mean leaf area consumed by 7day old larvae in the order *M.indica* (4.88cm^2)> *B.orellana* (6.07cm^2)> *A.chinensis* (10.06cm^2)> *C.procera* (15.34cm^2). *B.orellana* was most toxic showing 96.66% terminal larval mortality. *M.indica* leaves showed a visible effect on the ecdysis and development of insects. The insects fed on *M.indica* leaves were not able to moult into the next instar and finally died. *M.indica* and *B.orellana* were most toxic as natural botanical control agents in limiting the insect population. *C.procera* and *A.chinensis* were also detrimental to *S.litura* 7 day old larvae showing 56.66 and 70% adult emergence. All the medicinal plants were effective in controlling the growth and development of *S.litura*.

Keywords: bioactive, mahua, medicinal plants, *Spodoptera litura*, tobacco caterpillar

Introduction

Spodoptera litura is a widely distributed polyphagous insect feeding on soybean, tobacco, castor, mulberry, cotton, groundnut, sugarbeet, cauliflower, jatropha, lucerne, sunflower, onion, chilli, cabbage, jute, tomato, coffee etc. (Carasi *et al*., 2014) [2]. Insecticides used to control this pest show persistence in the environment and the insect has also shown resistance to great number of insecticides (Rehan & Freed, 2014) [18]. There is a global need for searching alternatives to pesticides and in this context plants may provide potential alternative to currently used insect- control agents because they constitute a rich source of bioactive chemicals. Various efforts have been made to test the efficacy of botanicals for crop protection. Different types of plant preparation such as powder, solvent extract, essential oils and whole plant are being investigated for their insecticidal activity including their action as fumigants, repellents, anti-oviposition and insect growth regulators (Isman, 2000., Koul, 2004., Negahban and Moharramipour, 2007) [4, 12]. Plants are principal source of terpenes, alkaloids, steroids and other phytochemicals such as curcumin extracted from turmeric, caffeic acid, quercetin from *Albizia lebback*., annonine from *Annona squamosa*, azadirachtin, meliantrol, nimbidin, salanin from *Azadirachta indica.*, *lantadenes* from *Lantana camara*., saponins from *Madhuca indica* are some of the secondary metabolites which have been reported to be insecticidal, repellent, insect growth regulators, oviposition deterrent and antifeedant. The present investigation was carried out to study the antifeedant, insecticidal and insect growth inhibitory properties of *Anthocephalus chinensis Bixa orellana*, *Calotropis procera* and *Madhuca indica*. *Calotropis procera* latex contains alkaloids such as hevein (an alpha amylase inhibitor in the green parts of the plant) which gives the plant protection against fungi and insects (Dubey and Jagannadham, 2003) [3]. *Bixa orellana* seed extract contains caretenoids bixin and norbixin which has been reported to be antidiabetic, antimicrobial, cardioprotective, anticonvulsant and insecticidal specifically against dipteran insects (Nagamani *et al*., 2015) [11]. Very little information is available on the insecticidal properties of *Anthocephalus chinensis*, however reports have been published on the mosquitocidal activity of *A.cadamba*. This would be perhaps the first report on the toxicity of *A.chinensis*.

Material and methods

Antifeedant potential of *Bixa orellana*, *Madhuca indica*, *Calotropis procera* and *Anthocephalus chinensis* were evaluated under laboratory conditions against 8day old larvae of *S.litura* using choice feeding bioassay technique (Belles *et al*., 1985) [1]. Fresh and mature leaf disc of plants (area= 7×7cm^2) were fed to the insects. Control consisted of *Ricinus communis* leaves. The worms were allowed to feed until 75% of the leaf disc were eaten away in control. The calculations were made on the feeding per cent (Purwar and Srivastava, 2003) [17], feeding inhibition (Pande and Srivastava, 2003) [13], preference index (Kogan and Goeden 1970) [8]. Based on the outcomes of this initial experiment the insects were grouped in two ages of 4 and 7days old larvae. Prestarved (3hours) and freshly moulted (n=10) larvae were released in each of the two experiments (i.e 4 and 7day old). Fresh leaf disc of medicinal plants (area= 5×5cm^2) were cut and fed to 4day old larvae while 7day old larvae were fed with fresh and mature leaves of respective medicinal plants until pupation. Control consisted of castor leaves. All the treatments were replicated three times and the observations were made on the growth and development of the insects including larval mortality, pupation and adult emergence. The experiments were conducted in completely randomized design (CRD) (Gomez and Gomez, 1984) [5] and the data was analyzed by one way Analysis of Variance (ANOVA) following Snedecor and Cochran (1967) [21] and the means were separated using, Duncan Multiple Range Test (DMRT) (Duncan, 1955) [4] based SPSS16 computer programme

Results & Discussion

All medicinal plants gave efficient control of the pest, however the strong antifeedant activity was shown by *M. indica* leaves against 8d old larvae of *S.litura*. *M. indica* plant has been reported to show antifeedant property to various insect pests due to the presence of saponin (Longanathan *et al*., 2005., Peta and Pathipati 2008) [15]. *M. indica* showed high value of feeding inhibition (51.34%) with a C value of 0.48 being strongly antifeedant while *C.procera* (0.56), *B.orellana* (0.67) & *A.chinensis* (0.71) were moderately antifeedant (Table1). A reverse trend in antifeedant activity was observed against 4day old larvae, *B.orellana* and *M.indica* were above the category extremely antifeedant proposed by Kogan & Goeden (1970) [8] (range 0.1-0.25) with a c- value of 0.04 and 0.02 respectively. *A.chinensis* (0.22) was extremely antifeedant and *C. procera* (0.36) strongly antifeedant. It showed that smaller larvae were more susceptible to the medicinal plant toxins as compared to older 8d old larvae. *M.indica* besides saponins also consist of sapogenin, madhucic acid, triterpene glycosides and madhucosides indicating that these chemicals may be responsible for the repellent, antifeedant and insecticidal effects (Siddiqui *et al.*, 2010) [20]. It has been observed in field conditions, when the females oviposit on *M.indica* leaves the newly hatched larvae are not able to feed on the plant and die due to starvation. Maximum reduction in weight gain was recorded in *M.indica* (0.002g) & *B.orellana* (0.006g).Control recorded maximum weight gain of 0.24g, also *M.indica* and *B.orellana* proved lethal causing death of larvae by inhibiting their normal growth and development. Larvae fed with the leaves of *M. indica* showed loss in weight, contracted size, incomplete moulting and failure to pupate leading to death. Larvae fed on *B.orellana* leaves could not complete their life cycle and died during pupation (100 per cent terminal larval mortality). *C.procera* and *A.chinensis* could cause 63.33 and 10% mortality respectively 4DAF(days after feeding) respectively compared to control (16.66%). The larval period was lengthy in *A.chinensis* (20.21d) as compared to control (9.95d), there was no effect in duration of larval period in *C.procera* when compared to control. Pupation (36.66%) and adult emergence (33.33%) was minimum in *C.procera* (Table 2). *C.procera* has been reported to be most toxic against last instar larvae of *S.litura* by Sahayaraj & Pauraj (1998) [19], Veeravel & Manikantan (2008) [22] and Khoso *et al* (2011) [7]. Another related species *C.gigantea* showed ovipositional deterrent activity against *H.armigera* (Prabhu *et al*., 2012) [16]. There have been very few published records on the insecticidal property of *B.orellana*. The seed coat of this plant contains bixin which has insect repellent property, paralytic activity against mammmalian intestinal parasites (Perry, 1980) [14]. The effect of these plants on developmental parameters, when tested against 7d old larvae recorded a significant reduction in mean leaf area consumed over control (23.23cm^2) which is as follows *M.indica* (4.88cm^2)> *B.orellana* (6.07cm^2)> *A.chinensis* (10.06cm^2)> *C.procera* (15.34cm^2). All the medicinal plants were efficient in reducing weight gain of larvae 2DAF. Maximum reduction in weight gain over control was observed in *M.indica* (96.46%) followed by *C.procera* (78.30%),), *B.orellana* (70.33%) and *A.chinensis* (51.94%). Larval period increased slightly in all the medicinal plants. *B.orellana* again showed lethal toxicity causing 96.66% terminal larval mortality of 7d old larvae (Table 3). *M.indica* was reported to act as moulting hormone antagonist against 7day old larvae. The larvae fed on mahua plant failed to moult into the next instar and finally died in the ecdysis stage. Significant increase in pupal period was noticed in all the treatment as compared to control (17.54d). *B.orellana*, *M.indica* & *A.chinensis* lowered pupal weight by 0.03g, 0.10 and 0.16g respectively over control (0.23g). *B.orellana* & *M.indica* resulted in minimum pupation by the insect, the values being 10 and 30% respectively, with respect to pupal parameters, it was obvious that *C.procera* was at par to control where as *A.chinensis* showed some detrimental effect on pupal weight gain and adult emergence. It is concluded that *M. indica* and *B.orellana* are most potential insect growth regulators. More studies should be made on their biorational properties so that they can play a major role against insects in integrated pest management programmes.

Table 1: Effect of medicinal plants on feeding behaviour of 8 d old larvae of *S. litura*

Plant species	MLAC (cm^2)/larva	Mean Feeding (%)	Mean Feeding over Control (%)	Feeding Inhibition (%)	Preference index	Antifeedant category
A. chinensis	12.24±0.50^a	24.97	55.58	44.41	0.71	Moderately antifeedant
B.orellana	11.27±1.47^a	23.00	51.18	48.79	0.67	Moderately antifeedant
C. procera	8.68±0.54^a	17.71	39.41	43.45	0.56	Moderately antifeedant
M. indica	7.09±0.27^a	14.46	32.19	51.34	0.48	Strongly antifeedant
R. communis (Control)	22.02±3.52^b	44.93	-	-	1.00	-
SEM±	1.74	-	-	-	-	-
CD at 1%	7.80	-	-	-	-	-
CD at 5%	5.49	-	-	-	-	-
F value	**	-	-	-	-	-

Means followed by common letters do not differ significantly by DMRT (p=0.05%)., Mean±SD (Standard Deviation)

MLAC= Mean leaf area consumed., Antifeedant category following Kogan & Goeden, (1970).,

Fresh leaves were directly fed to the larvae., **= Highly significant

Table 2: Effect of medicinal plants on development of 4d old larvae of *S. litura*

Plant species	MLAC (cm^2)/larva	Larval mortality 4DAF (%)	Preference Index	Antifeedant Category	Larval period (d)	Terminal larval mortality (%)	Pupal period (d)	Pupation (%)	Adult emergence [On the basis of pupation] (%)
A. chinensis	3.29±0.76^{ab}	10±10.00^{a}	0.22	Extremely antifeedant	20.21±0.99^{a}	49.04±4.97^{b}	12.12±0.68^{a}	90.00±8.16^{b}	50.95±4.97^{ab}
B. orellana	0.61±0.12^{a}	100±0.00^{c}	0.04	Extremely antifeedant	-*	100±0.00^{c}	-*	-*	-*
C.procera	5.91±2.6^{c}	63.33±20.27^{b}	0.36	Strongly antifeedant	12.19±6.09^{a}	66.66±16.66^{b}	9.00±3.68^{a}	36.66±16.55^{a}	33.33±16.66^{a}
M. indica	0.29±0.13^{a}	100±0.00^{c}	0.02	Extremely antifeedant	-*	100±0.00^{c}	-*	-*	-*
R. communis (Control)	26.21±0.40^{d}	0.00±0.00^{a}	1.00	-	9.95±0.48^{a}	16.66±12.01^{a}	10.03±0.75^{a}	100±0.00^{b}	83.33±12.01^{c}
SEM(±)	1.23	10.11	-	-	2.27	9.45	2.09	10.11	9.45
CD at 1%	5.53	45.26	-	-	12.40	42.33	9.36	45.26	42.33
CD at 5%	3.89	31.84	-	-	8.72	29.78	6.59	31.84	29.78
F value	**	**	-	-	**	**	**	**	**

Means followed by common letters do not differ significantly by DMRT (p=0.05%)., Mean±SD (Standard Deviation)

*-Data could not be tabulated due to 100 per cent mortality., **= Highly significant

Table 3: Effect of medicinal plants on development of 7d old larvae of *S. litura*

Plant species	MLAC (cm^2)/larva	Larval mortality 2DAF (%)	Preference Index	Antifeedant Category	Larval period (d)	Terminal larval mortality (%)	Pupal period (d)	Pupation (%)	Adult emergence [On the basis of pupation] (%)
A. chinensis	10.06±1.76^{b}	10.00±0.00^{a}	0.60	Moderately antifeedant	12.28±0.07^{bc}	26.66±15.39^{a}	20.26±0.39^{b}	80±10.00^{b}	70.00±5.77^{b}
B. orellana	6.07±0.47^{ab}	90.00±10.00^{c}	0.41	Strongly antifeedant	12.00±0.00^{b}	96.66±55.81^{b}	20.00±0.00^{b}	10±10.00^{a}	3.33±3.33^{a}
C.procera	15.34±0.79^{c}	13.33±8.81^{a}	0.79	Slightly antifeedant	11.69±0.24^{ab}	36.66±21.16^{a}	19.43±0.29^{b}	86.66±8.81^{b}	56.66±14.52^{b}
M. indica	4.88±0.92^{a}	63.33±6.66^{b}	0.34	Strongly antifeedant	12.75±0.38^{c}	73.33±42.33^{b}	20.66±0.33^{a}	30±11.54^{b}	16.66±8.81^{a}
R. communis(Control)	23.23±2.35^{d}	0.00±0.00^{c}	1.00	-	11.03±0.03^{a}	13.33±7.69^{a}	17.45±0.85^{b}	96.66±3.33^{b}	83.33±12.01^{b}
SEM(±)	1.43	6.66	-	-	0.207	10.85	0.46	9.18	9.77
CD at 1%	6.43	29.84	-	-	0.92	48.59	2.07	41.14	43.76
CD at 5%	4.53	21.00	-	-	0.65	34.18	1.46	28.94	30.79
F value	**	**	-	-	**	**	**	**	**

Means followed by common letters do not differ significantly by DMRT (p=0.05%)., Mean±SD (Standard Deviation)., **= Highly significant

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