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Feeding and Oviposition Deterrence of *Murraya paniculata*, *Piper nigrum* and *Moringa oleifera* Extracts against *Spodoptera litura* (F).

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ABSTRACT

Spodoptera litura is one of the most destructive pests of various crops cultivating in Pakistan. Larvae of *S. litura* at early stages attacks on the leaves and later stage larva fed almost every part of plant. Due to environmental pollution and the incapability of toxic agents in controlling the target pests at the recommended doses of synthetic pesticides, alternative methods like botanical extract in the control of this pest consider greater importance nowadays. The antifeedant and oviposition deterrent index of *Moringa oleifera*, *Murraya paniculata* and *Piper nigrum* leaf extracts were evaluated against *S. litura* by choice and no choice method under laboratory controlled conditions. In *M. oleifera* extract, the maximum antifeedant index was recorded in 125.00 mg/ml (64.93±2.61), while minimum antifeedant index was observed in 7.81 mg/ml *i.e.* 8.39 ± 1.85 by no choice method. In case of *M. paniculata* extract, the maximum antifeedant index was 98.90±0.67 in 125.00 mg/ml, while minimum antifeedant index was 30.90±1.85 in 7.81 mg/ml by no choice method. In *P. nigrum* extract, the maximum antifeedant index was 85.57±2.30 in 125.00 mg/ml, while minimum antifeedant index was 23.92 ± 0.76 in 7.81 mg/ml by no choice method. In free choice method, the antifeedant index of *M. paniculata* at 125 mg/ml concentration was maximum (83.64±12.51), followed by *P. nigrum* and *M. oleifera* at 125 mg/ml concentration were 79.76±14.60 and 30.57±4.80, respectively. The higher oviposition deterrent index was recorded in *M. paniculata* extract (87.32±0.77) as compared to *P. nigrum* and *M. oleifera* extract *i.e.* 82.58±2.14 and 77.25±1.92, respectively, by no choice method. Similarly, higher oviposition deterrent index was recorded in *M. paniculata* extract (91.57±1.92) with respect to *P. nigrum* and *M. oleifera* extract *i.e.* 83.71±1.13 and 69.53±1.80, respectively, by free choice method. The significant antifeedant and as well as oviposition deterrent activity against the *S. litura* was found when the above mentioned botanicals were tested.

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AM performed the experimnents. SMZ supervised the work. MS coordinated the experiments. MB did the statistical analysis.

Key words
***Spodoptera litura*, Extracts, Antifeedant, Oviposition deterrence.**

INTRODUCTION

Spodoptera litura (Lepidoptera: Noctuidae), is the most damaging pest of agricultural crops such as cotton, groundnut, soyabean, tomato and sweet potato *etc*. that causes an estimated loss of 25.8 to 100% in crop production (Tong *et al*., 2013; Dhir *et al*., 1992). Damages of *S. litura* have largely been controlled by the use of synthetic insecticides. Resistance is developing in *S. litura* against almost all synthetic insecticides (Kranthi *et al*., 2001; Shad *et al*., 2012; Tong *et al*., 2013). Therefore it is essential to find some alternate sustainable methods for the management of this pest. Plants have evoked rich sources of natural substances for their protection against herbivores. These botanicals are not only biodegradable and environment friendly but also there is less likelihood for insects to develop resistance against these natural substances (Erdogan *et al*., 2012). Therefore, different botanicals extracts *i.e. Moringa oleifera, Murraya paniculata* and *Piper nigrum* were to be used against *S. litura* to check feeding and oviposition deterrent index. *Moringa oleifera* is cultivated largely all over the moderate areas of the countryside. Different parts of this plant *i.e.* fruits, leaves, flowers and roots have been used as feeding and oviposition deterrent activity against insect pest (Gautam *et al*., 2012; Ramachandran *et al*., 1989). Extract of *M. oleifera* was resulted in 62% reduction of *Phyllotreta cruciferae* (Alao and Adebayo, 2015). While, *M. paniculata* is cultivated as an ornamental tree or hedge. Different parts of this plant traditionally used as medicine (Sharker *et al*., 2009). Many bioactive compounds were extracted and evaluated in *M. paniculata* by many research groups. A number of these compounds present in *M. paniculata* exerted significant biological activities, which prove as the scientific evidence for the traditional usage of *M. paniculata.* Many pharmacological effects have been investigated from different parts of the plant and have been examined for various biological activities (Gautam *et al*., 2012). The presence of some antifeedant and oviposition deterrent chemicals in *Murraya koenigii* (another species

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of *Murraya*) leaves can be exploited for the control of *S. litura* (Senrung *et al*., 2014). While, *P. nigrum* (Piperaceae) is famous as the spices king due to its pungent quality (Srinivasan, 2007). The phytochemical present in black pepper fruit shows that it contains 4% alkaloids in the berry (Awoyinka *et al*., 2006). *Piper nigrum* (both black pepper and white pepper) reported to evoke the strongest and equivalent feeding deterrence against *Helicoverpa armigera* (Li *et al*., 2014). Previous study shown that the use of non chemical control like NPV in IPM under field conditions to control *S. litura* on cauliflower (Maqsood *et al*., 2017). In the present study, antifeedant and oviposition effect of leaf extracts of three different plant species (*M. oleifera*, *M. paniculata* and *P. nigrum*) was studied against the fourth instar larvae of *S. litura* reared on the leaves of *Ricinus communis* (castor bean).

MATERIALS AND METHODS

Study area and rearing of S. litura

Spodoptera litura larvae were collected from the cabbage (*Brassica oleracea*) field in Agriculture Department of Bahauddin Zakariya University, Multan, Pakistan during March, 2016. After the collection, All stages of *S. litura* were reared in the laboratory of Entomology Department, Faculty of Agricultural Science and Technology, Bahauddin Zakariya University, Multan under controlled conditions *i.e.* 25±2°C and 75±5% RH with dark and light duration of 12:12.

Larvae of *S. litura* were released in transparent plastic boxes (having dimensions of 15×8×5 cm) and fed with the fresh new leaves of *R. communis*, a natural host for the insect (Anuradha *et al*., 2010; Brown and Dewhurst, 1975) on daily basis. Newly emerged moths of *S. litura* were released in the transparent plastic jars (having dimensions 14×14×25 cm) and covered with cloth. These moths fed with twenty percent honey solution. For the substrate of egg laid, two transparent baby liners were hanged underside the jars and moist cotton wool were put to maintain the humidity.

Extraction method

Ethanol and water solvent were used for preparing extracts of leaves of *Moringa oleifera*, *Muraya paniculata* and *Piper nigrum*. The ground powder of dried leaves (12.5g) was dissolved in 80% of ethanol (40ml ethanol + 10ml distilled water) in air tight glass container for about 5 days, filtered and the final volume was measured and considered as 100 % concentration. From the condensed extract, different concentrations of each plant extract *i.e.* 3.12 % (7.81 mg/ml), 6.25 % (15.63 mg/ml), 12.50 % (31.25 mg/ml), 25.00 % (62.50 mg/ml) and 50.00 % (125 mg/ml) were prepared by adding required quantities of distilled water. The control solution was only water (Anuradha *et al*., 2010).

Effect of the plant leaves extracts on larval growth of Spodoptera liture

Two groups of fifteen newly hatched larvae were kept in plastic boxes (having dimensions 15×8×5 cm) separately. Fifteen newly hatched larvae were put into petridishes separately and fed with fresh leaves of the *M. oleifera*, while the other group of fifteen larvae was fed with *R. communis*, a natural host for the insect (Brown and Dewhurst, 1975). Fresh leaves were supplied as per need daily and the larvae were daily weighed under the first ten days of experiment. Same experiment was done with the leaves of *M. paniculata* and *P. nigrum.* The relative growth rate (RGR) over the first ten days of feeding was calculated for the two groups of each plant leaves.

$$\text{Relative Growth Rate (RGR)} = \Delta B / B_a T$$

Where, B_a is the arithmetic mean of insect weight during the experiment, T is the feeding period in days, ΔB is the change in body weight (Farrar *et al*., 1989; Waldbauer, 1968).

Antifeedant bioassay

No choice method

No choice leaf disc bioassay was investigated to observe the antifeedant activity of ethanol extracts of *M. oleifera, M. paniculata* and *P. nigrum*. Newly emerged fourth instar larvae of *S. litura*, which have been reported to consume food with minimum fluctuation, were to be carried out for experiment. For the initiation of experiment, thirty larvae of third instar were fed separately in petridish until the larvae molted into fourth instar and then these larvae were used for the bioassay. Under no choice bioassay leaf disc of *R. communis* (having dimensions 5 cm diameter) was cut and dipped two times for 0.5 sec each in five concentrations *i.e.* 7.81, 15.63, 31.25, 62.50 and 125.00 mg/ml of each extract of *M. oleifera, M. paniculata* and *P. nigrum*. The control leaf disc was dipped in the control solution (water solution). The leaf disc was put for 5 min in the open to dry off the solvent. The leaf was put into petridishes lined with filter paper. Single larvae was allowed to fed in each petri dish for 24 h of five concentrations *i.e.* 7.81, 15.63, 31.25, 62.50 and 125.00 mg/ml from each extract of plant leaves. Thereafter 24 h, the larvae were separated and the feeding leaves were kept out for observation. Under no choice method each experiment with five concentrations of each extract *i.e. M. oleifera, M. paniculata* and *P. nigrum* were replicated 3 times. The antifeedant index was calculated manually by the formula given below (Isman *et al*., 1990).

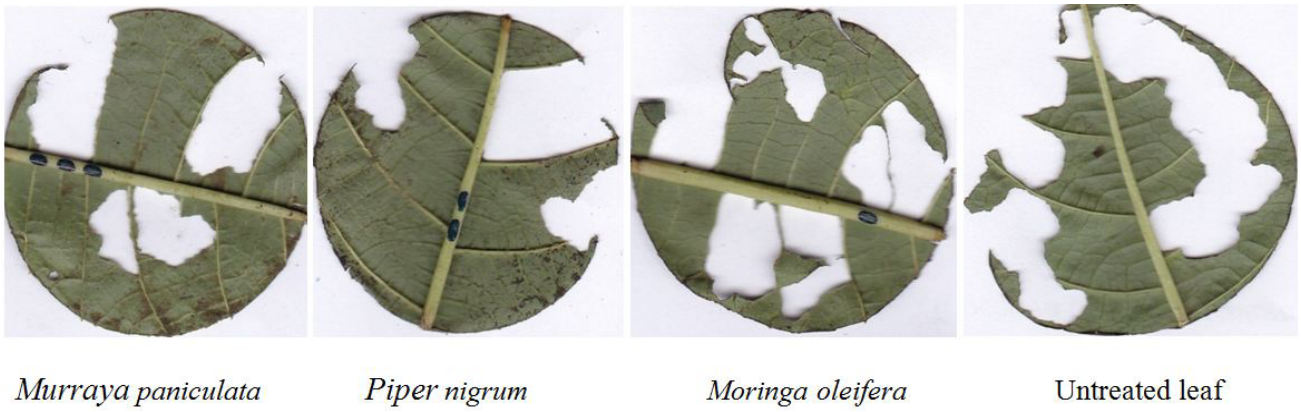

Fig. 1. *Spodoptera liture* larvae feeding on leaves treated with botanical extracts of *M. oleifera, M. paniculata, P. nigrum* and distilled water (control).

Antifeedant index (AI) = 100 {(C – T) / (C + T)}

Where, C is control leaf area consumed and T is the treated leaf area consumed by larvae.

Free choice method

Under free choice method leaf disc bioassay was carried out to determine the antifeedant activity of ethanol extract of *M. oleifera, M. paniculata* and *P. nigrum*. The free choice method was to be determined in transparent plastic box. In transparent plastic box three circle of petridish size (having dimensions 5 cm diameter) were pointed out outside at the bottom of the box with marker and numbered first, second and third circle as one, two and three, respectively. Three leaves of *R. communis* (having dimensions 5 cm diameter) were cut and pointed out first, second and third leaves as one, two and three dots, respectively, with marker at the midrib of the leaf (Fig. 1). For control one box is placed separately and fed with control solution (distilled water solution) with the same number of replications as in the treatments. One dot leaf was dipped two times for 0.5 sec in the extract of *M. oleifera* of 125 mg/ml concentration, while two three dots leaves were dipped two times for 0.5 sec in the extracts of *M. paniculata* and *P. nigrum*, respectively, of 125 mg/ml concentration each. All the solutions were made in distilled water. Control leaf was dipped in control solution. Dipped leaves were put into open for 5 minutes to dry off the solvent and placed as one dot leaf into first numbered circle, two dots leaf into second numbered circle and three dots leaf into third numbered circle underside the box. Single larva was released into this box allowed to feed for 24 h and covered with lid. Other larva was released into control solution of control box for 24 h. Each experiment with 125 mg/ml concentration of extracts was replicated 3 times. The feeding percentage and antifeedant index was calculated manually, by the given formula (Isman *et al*., 1990).

Antifeedant index (AI) = 100 {(C – T) / (C + T)}

Where, C is control leaf area consumed and T is the treated leaf area consumed by larvae.

Oviposition bioassay

No choice method

Oviposition bioassay under no choice method was carried out in transparent plastic jars (14×14×25 cm) in laboratory. Each five newly excised leaves of *R. communis* of petridish size (5 cm diameter) with petiole were cut and smeared two times for 0.5 sec on both sides with 125 mg/ml concentration of each extract of *M. oleifera, M. paniculata* and *P. nigrum* plant leaves. Five leaves of *R. communis* were also dipped in control solution. These wet leaves were left for about 5 min in the open to dry off the solvent. To kept the leaves fresh (to avoid wilting) throughout the experiment about 24 h, wet cotton were plugged with petiole of the leaves and hanged with strips into transparent plastic cage separately of each extract of *M. oleifera, M. paniculata* and *P. nigrum* plant leaves for oviposition substrate of the *S. litura* moths. Control leaves were hanged in control cage. One petridish with cotton swabs soaked in 20 % honey solution as food for the adults and one petridish with cotton soaked in water to avoid humidity was placed in the cage. Five pairs of two days old mated adults were released separately in each cage and removed after 24 h. The eggs deposited by females on the leaf area and in the cage were collected and counted separately with microscope. The experiment was replicated 3 times for 125 mg/ml concentration of each extracts separately. After counting of eggs laid in the cage, oviposition deterrent index (ODI) was calculated (Huang and Renwick, 1994) by the formula:

Oviposition deterrent index (ODI) =
$100\ \{(C_N - T_N) / (C_N + T_N)\}$
Where, C_N is the number of eggs laid on control leaf, and T_N is the number of eggs laid on treated leaf.

Free choice method

Transparent plastic jars (14×14×25 cm) were used in free choice method. Six leaves of *R. communis* (5 cm diameter) with petiole were cut. Two leaves were marked with one dot each at the midrib of the leaf with marker to avoid mixing extract leaves and dipped in 125 mg/ml concentration of *M. oleifera* extract, two leaves were marked with two dots each at the midrib of the leaf with marker and dipped in 125 mg/ml concentration of *M. paniculata* extract, while remaining two leaves were marked with three dots each at the midrib of the leaf with marker and dipped in 125 mg/ml concentration of *P. nigrum* extract. As a control, six leaves of *R. communis* were dipped in control solution and placed in separate cage. These wet leaves were left for about 5 min in the open to dry off the solvent. To kept the leaves fresh (to avoid wilting) throughout the experiment about 24 h, wet cotton were plugged with petiole of the leaves and hanged with strips into transparent plastic cage for oviposition substrate of the *S. litura* moths. Control leaves were hanged in control cage. One petridish with cotton swabs soaked in 20 % honey solution as food for the adults and one petridish with cotton soaked in water to avoid humidity was placed in the cage. Five pairs of two days old mated adults were released in the cage and removed after 24 h. Five pairs of adults were also released in control cage. The eggs deposited by females on the leaf area were collected and counted with microscope. The experiment was replicated 3 times for 125 mg/ml concentration of each extracts. After counting of eggs laid in the cage, oviposition deterrent index (ODI) was calculated (Huang and Renwick, 1994) by the formula given:

Oviposition deterrent index (ODI) =
$100\ \{(C_N - T_N) / (C_N + T_N)\}$
Where, C_N is the number of eggs laid on control leaf, and T_N is the number of eggs laid on treated leaf.

Statistical analysis

The data for antifeedant index and oviposition index were analyzed through statistical software 'Statistix 9.0 version' (Jandel, 1995) using one way analysis of variance (ANOVA), followed by all pair comparison tests of treatment with LSD test, at the alpha level of 0.05 for significance.

RESULTS

Effect of plant leaves

The difference in relative growth rate (RGR) calculated over a period of 10 days between larvae supplied with *R. cummunis, M. oleifera, M. paniculata* and *P. nigrum* leaves were highly significant (P= 0.0433, F= 7.07, DF= 3, 11). Significantly (P= 0.0433, F= 7.07, DF= 3, 11) maximum RGR was studied on *R. cummunis* leaves (0.63±0.02), followed by *M. oleifera* and *P. nigrum i.e.* 0.43±0.10 and 0.41±0.04, respectively. On the other hand minimum RGR was observed on *M. paniculata* leaves *i.e.* 0.38±0.07.

Table I.- Antifeedant index of ethanol extracts of *M. oleifera, M. paniculata* and *P. nigram* foliage against fourth instar larvae of *S. litura.*

Extract conc. (mg / ml)	Leaf area consumed cm²/larva (Mean ± S.E.*)	Percent feeding	Antifeedant index (AI) ± S.E.
***M. oleifera* extract**			
7.81	12.28 ± 0.18	62.58	8.39±1.85c**
15.63	11.57 ± 0.41	58.92	11.34 ± 2.02c
31.25	4.13 ± 0.05	21.04	55.73 ± 1.54b
62.50	3.73 ± 0.29	19.00	59.14 ± 4.02b
125.00	3.09 ± 0.16	15.73	64.93 ± 2.61a
***M. paniculata* extract**			
7.81	7.67 ± 0.10	39.09	30.90±1.85e**
15.63	4.73 ± 0.09	24.07	50.88 ± 0.50d
31.25	2.5 ± 0.15	12.71	70.64 ± 3.00c
62.50	0.48 ± 0.03	2.44	93.60 ± 0.62b
125.00	0.08 ± 0.03	0.41	98.90 ± 0.67a
***P. nigram* extract**			
7.81	8.92 ± 0.18	45.42	23.92±0.76e**
15.63	6.15 ± 0.09	31.36	40.52 ± 0.65d
31.25	4.44 ± 0.13	22.60	53.18 ± 2.33c
62.50	2.45 ± 0.07	12.50	71.14 ± 0.83b
125.00	1.13 ± 0.10	5.73	85.57 ± 2.30a

*S.E., Standard Error. **AI along the same column followed by different letters differ significantly at alpha level 0.05. Control leaf area consumed 14.53 ± 0.19 cm² / larva.

Antifeedant index of plant foliages on S. litura *larvae*

In no choice method fourth instar larvae of *S. litura* were fed on *R. communis* leaves treated with different concentrations of *M. oleifera, M. paniculata* and *P. nigram* to check the antifeedant index. Feeding percentage of leaf treated with *M. oleifera* was significantly lower (P<0.0001,

F=368.92, DF= 4, 10) than the untreated leaf (Fig. 1). Significant difference (P<0.0001, F=368.92, DF= 4, 10) was observed between lower and higher concentrations of *M. oleifera* extract and area consumption by the larva of *S. litura*. Significantly maximum antifeedant index was recorded in 125.00 mg/ml (64.93±2.61), followed by 59.14±4.02, 55.73±1.54 and 11.34±2.02 antifeedant index was studied at 62.50, 31.25 and 15.63 mg/ml concentrations, respectively (Table I). While minimum antifeedant index was observed in 7.81 mg/ml *i.e.* 8.39±1.85.

Feeding percentage of leaf treated with *M. oleifera* was significantly lower (P<0.0001, F=2696.85, DF= 4, 10) than the untreated leaf (Fig. 1). The maximum antifeedant index was observed in 125.00 mg/ml *i.e.* 98.90±0.67. This was followed by 93.60±0.62, 70.64±3.00 and 50.88±0.50 at 62.50, 31.25 and 15.63 mg/ml, respectively. While minimum antifeedant index was recorded in 7.81 mg/ml *i.e.* 30.90±1.85. Significant difference were recorded in all the concentrations of *M. paniculata* extract and area consumption by the larva of *S. litura* (Table I).

Feeding percentage of untreated leaf was significantly higher (P<0.0001, F=1134.62, DF= 4, 10) than the leaf treated with *M. oleifera* (Fig. 1). The maximum antifeedant index was recorded in 125.00 mg/ml *i.e.* 85.57±2.30, followed by 71.14±0.83, 53.18±2.33 and 40.52±0.65 at 62.50, 31.25 and 15.63 mg/ml, respectively. While minimum antifeedant index was observed in 7.81 mg/ml *i.e.* 23.92±0.76. It was revealed that significant difference were recorded in all the concentrations of *P. nigrum* extract and area consumption by the larva of *S. litura* (Table I).

Antifeedant index under free choice method

The antifeedant index under free choice method was recorded by feeding larva of *S. litura* on *R. communis* leaves treated with 125.00 mg/ml concentration of three extracts (*M. oleifera, M. paniculata, P. nigrum*). Feeding percentage of *R. communis* leaves treated with *M. paniculata* extract was lower than that of treated with *P. nigrum* and *M. oleifera* (Fig. 1). Significantly (P=0.0147, F=11.43, DF= 2, 9) higher antifeedant index was observed in *M. paniculata* extract (83.64±12.51), while lower antifeedant index was recorded in *M. oleifera* extract *i.e.* 30.57±4.80 (Table II). The antifeedant index of *P. nigum* was recorded as 79.76±14.60. Significant difference was recorded between *M. paniculata* and *M. oleifera* extract (Table II).

In no choice method oviposition deterrent index (ODI) of *S. litura* female adults were calculated on *R. communis* leaves as ovipositional substrate treated with 125 mg/ml concentration of *M. oleifera, M. paniculata* and *P. nigrum* separately. Significantly (P=0.0368, F=10.63, DF= 2, 6) maximum oviposition deterrent index was calculated in *M. paniculata* extract (87.32±0.77), followed by *P. nigrum* extract *i.e.* 82.58±2.14 (Table III). While minimum oviposition deterrent index was observed in *M. oleifera* extract *i.e.* 77.25±1.92 (Table IV). Significant difference was recorded between *M. paniculata* and *M. oleifera* (Table III).

Table II.- Antifeedant index under free choice method against fourth instar larvae of *S. litura*.

Plants extract	Leaf area consumed cm²/larva (Mean ± S.E.*)	Percent feeding	Antifeedant Index (AI) ± S.E.
M. oleifera	7.70 ± 0.80	39.22	30.57±4.80b**
M. paniculata	1.29 ± 1.21	6.56	83.64 ± 12.51a
P. nigrum	1.63 ± 1.50	8.28	79.76 ± 14.60a

*S.E., Standard Error. **AI along the same column followed by different letters differ significantly at alpha level 0.05. Control leaf area consumed 14.48 ± 0.14 cm² / larva. Extracts concentration was 125.00 mg/ml.

Table III.- Oviposition deterrent index under no choice method against *S. litura* female adults.

Plants extract	Treated leaf disc: No of eggs laid/pair (Mean±S.E.*)	Untreated leaf disc: No of eggs laid/pair (Mean±S.E.)	Oviposition deterrent index (ODI) ± S.E.
M. oleifera	118.67±12.17	924.67 ± 6.12	77.25±1.92b**
M. paniculata	64.67 ± 03.48	955.00 ± 10.39	87.32 ± 0.77a
P. nigrum	89.33 ± 11.70	936.00 ± 12.17	82.58 ± 2.14ab

*S.E., Standard Error. **ODI along same column followed by different letters differ significantly at alpha level 0.05. Extracts concentration was 125.00 mg/ml.

Table IV.- Oviposition deterrent index under free choice method against *S. litura* female adults.

Plants extract	No of eggs laid / pair (Mean ± S.E.*)	Oviposition deterrent index (ODI) ± S.E.
M. oleifera	171.67 ± 10.27	69.53 ± 1.80c**
M. paniculata	42.00 ± 09.81	91.57 ± 1.92a
P. nigrum	84.67 ± 06.98	83.71 ± 1.13b

*S.E., Standard Error. **ODI along same column followed by different letters differ significantly at alpha level 0.05. Number of eggs laid / Pair at control was calculated 955.00 ± 10.39. Extracts concentration was 125.00 mg/ml.

Ovipositional deterrent index

In free choice method oviposition deterrent index (ODI) of *S. litura* female adults were recorded on *R. communis* leaves as ovipositional substrate treated with 125 mg/ml concentration of *M. oleifera, M. paniculata* and *P. nigrum*. Significantly (P=0.0044, F=31.91, DF= 2, 6) maximum oviposition deterrent index was calculated in *M. paniculata* extract (91.57±1.92), followed by *P. nigrum* extract *i.e.* 83.71±1.13 (Table IV). While minimum oviposition deterrent index was observed in *M. oleifera* extract *i.e.* 69.53±1.80 (Table IV). Significant difference was recorded between *M. paniculata* and *M. oleifera*.

DISCUSSION

Feeding and oviposition are the most important behavioral responses for establishment of insect population on a plant surface (Saxena, 1969). It was concluded that *M. oleifera* extract had antifeedant effect on *S. litura* larva. According to Alao and Adebayo (2015), *Moringa* sp. extract had 62% reduction of *P. cruciferae*. In *M. oleifera* higher concentration (125.00 mg/ml) was more antifeedant effect than the lower (7.81 mg/ml) *i.e.* 64.93±2.61 and 8.39±1.85, respectively similar to Alao and Adebayo (2015), as the effectiveness of the *Moringa* plant extracts were concentration dependent. The reason of antifeedant index was that *M. oleifera* evoked special chemicals of antifeedant property against insect pest.

In *M. paniculata* extract higher concentration exhibited maximum antifeedant index as compared to lower concentration. The result match with Senrung *et al*. (2014), Hexane extract of *M. koenigii* showed feeding deterrence activity in a concentration dependent manner due to many phytochemicals that inhibits the feeding of *S. litura* larvae. These observations clearly indicate that *Murraya sp.* foliage contains some phytochemicals that have antixenotic effect on insects. Non-polar foliage extract from *P. coarctata* (Ulrichs *et al*., 2008), *Clerodendron* spp. (*C. inerme* and *C. infortunatum*) (Krishna-Kumari *et al*., 2003), and pulp of *M. dioica* have also been observed to show antifeedant effect against *S. litura* larvae (Narasimhan *et al*., 2005). Phytotoxicity has been observed in another species of *Murraya*, *M. exotica* against maize weevil, *S. zeamais* and red flour beetle, *T. castaneum* (Li *et al*., 2010).

In *P. nigrum* extract higher antifeedant index was recorded at higher concentration, while lower antifeedant index was observed at lower concentration. The results showed similarity with (Li *et al*., 2014) that *P. nigrum* (both black pepper and white pepper), *P. longum* and *A. dahurica* evoked the strongest and equivalent feeding deterrence. The potent feeding deterrent activity of *Piper* species may be a common characteristic at genus level.

In free choice method *M. paniculata* extract showed higher antifeedant index as compare to *P. nigrum* and *M. oleifera*. According to Plamoottil and Abraham (2014), extract of *Z. limonella* resulted maximum antifeedant effect. This was concluded from the lower food consumption utilized by the caterpillar on castor leaves containing solvent residues of these botanicals. Also because of the toxicity of these botanicals and malnutrition, larval mortality was also tested when the caterpillars were fed on treated castor leaves. The results were similar because *Z. limonella* have same family as that of *M. paniculata i.e.* Rutaceae. Both species have many phytochemicals that control *S. litura* larvae.

In both no choice and free choice method oviposition deterrent index was maximum in *M. paniculata* extract, while minimum was recorded in *M. oleifera*. The results were similar to Senrung *et al*. (2014), that extract of *M. paniculata* suppressed the oviposition of gravid *S. litura* females. This suppression in egg laying may be due to the presence of repellent or deterrent chemical in extract. Such oviposition deterrence effect against *S. litura* was also observed in hexane extract of *Acorus calamus* (Raja *et al*., 2003).

CONCLUSION

It is concluded that *M. oleifera*, *M. paniculata* and *P. nigrum* leaf extract have an effect on the larvae of *S. litura* as antifeedant and ovipositional deterrent. Among these three extracts it is very obvious that leaf extracts of *M. paniculata* has the potential for use in the management of *S. litura*. The antifeedant and oviposition deterrent effects together would play a significant role in restricting population build-up of *S. litura* in the field. The use of these botanicals would of great significance in the management of lepidopteron pests, still work is required to identify the exact compound responsible for the repellent or deterrent effects with some field trials.

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Statement of conflict of interest

The authors declare no conflict of interest.

REFERENCES

Alao, F. and Adebayo, T., 2015. Comparative efficacy of *Tephrosia vogelii* and *Moringa oleifera* against insect pests of watermelon (*Citrullus lanatus* Thumb). *Int. Lett. Nat. Sci.,* **35**: 71-78.

Anuradha, A., Rajan, K. and McConnell, M., 2010. Feeding deterrence activity of *Adhatoda vasica* L. against *Spodoptera litura* (Fab). *J. Biopest.,* **3**: 286-288.

Awoyinka, O., Oyewole, I., Amos, B. and Onasoga, O., 2006. Comparative pesticidal activity of dichloromethane extracts of *Piper nigrum* against *Sitophilus zeamais* and *Callosobruchus maculatus*. *Afr. J. Biotechnol.,* **5**: 1-4.

Brown, E. and Dewhurst, C., 1975. The genus *Spodoptera* (Lepidoptera, Noctuidae) in Africa and the Near East. *Bull. entomol. Res.,* **65**: 221-262. https://doi.org/10.1017/S0007485300005939

Dhir, B., Mohapatra, H. and Senapati, B., 1992. Assessment of crop loss in groundnut due to tobacco caterpillar, *Spodoptera litura* (F.). *Indian J. Pl. Prot.,* **20**: 215-217.

Erdogan, P., Yildirim, A. and Sever, B., 2012. Investigations on the effects of five different plant extracts on the two-spotted mite *Tetranychus urticae* Koch (Arachnida: Tetranychidae). *Psyche*, **2012**: 1-5. https://doi.org/10.1155/2012/125284

Farrar, R.R., Barbour, J.D. and Kennedy, G.G., 1989. Quantifying food consumption and growth in insects. *Annls. entomol. Soc. Am.,* **82**: 593-598. https://doi.org/10.1093/aesa/82.5.593

Gautam, M., Gupta, A., Vijaykumar, M., Rao, C. and Goel, R., 2012. Studies on the hypoglycemic effects of *Murraya paniculata* Linn. extract on alloxan-induced oxidative stress in diabetic and non-diabetic models. *Asian-Pac. J. trop. Dis.,* **2**: S186-S191. https://doi.org/10.1016/S2222-1808(12)60149-2

Huang, X. and Renwick, J., 1994. Cardenolides as oviposition deterrents to two *Pieris* species: structure-activity relationships. *J. chem. Ecol.,* **20**: 1039-1051. https://doi.org/10.1007/BF02059740

Isman, M.B., Koul, O., Luczynski, A. and Kaminski, J., 1990. Insecticidal and antifeedant bioactivities of neem oils and their relationship to azadirachtin content. *J. Agric. Fd. Chem.,* **38**: 1406-1411. https://doi.org/10.1021/jf00096a024

Jandel, J., 1995. *Sigma Stat Statistical User's Manual*. Version 2.0. Jandel, San Rafael, CA.

Kranthi, K., Jadhav, D., Wanjari, R., Ali, S.S. and Russell, D., 2001. Carbamate and organophosphate resistance in cotton pests in India, 1995 to 1999. *Bull. entomol. Res.,* **91**: 37-46.

Krishna-Kumari, G., Balachandran, J., Aravind, S. and Ganesh, M., 2003. Antifeedant and growth inhibitory effects of some neo-clerodane diterpenoids isolated from *Clerodendron* species (Verbenaceae) on *Earias vitella* and *Spodoptera litura*. *J. Agric. Fd. Chem.,* **51**: 1555-1559. https://doi.org/10.1021/jf025920a

Li, W., Hu, J., Yang, J., Yuan, G., Guo, X. and Luo, M., 2014. Feeding deterrence of common spices against *Helicoverpa armigera* larvae. *Adv. Biosci. Biotechnol.,* **5**: 1025. https://doi.org/10.4236/abb.2014.513117

Li, W.Q., Jiang, C.H., Chu, S.S., Zuo, M.X. and Liu, Z.L., 2010. Chemical composition and toxicity against *Sitophilus zeamais* and *Tribolium castaneum* of the essential oil of *Murraya exotica* aerial parts. *Molecules,* **15**: 5831-5839. https://doi.org/10.3390/molecules15085831

Maqsood, S., Afzal, M., Anjum, M.A., Raza, A.B. M., Wakil, W. and Babar, M.H., 2017. Efficacy of nuclear polyhedrosis virus and flubendiamide alone and in combination against *Spodoptera litura* F. *Pakistan J. Zool.,* **49**: 1783-1788.

Narasimhan, S., Kannan, S., Ilango, K. and Maharajan, G., 2005. Antifeedant activity of *Momordica dioica* fruit pulp extracts on *Spodoptera litura*. *Fitoterapia,* **76**: 715-717. https://doi.org/10.1016/j.fitote.2005.07.001

Plamoottil, M. and Abraham, N.P., 2014. *Mystus keralai* (Siluriformes: Bagridae), a new fish species from Kerala, India. *Int. J. Pure appl. Zool.,* **2**: 1-4.

Raja, N., Elumalai, K., Jayakumar, M., Jeyasankar, A., Muthu, C. and Ignacimuthu, S., 2003. Biological activity of different plant extracts against armyworm, *Spodoptera litura* (Fab.) (Lepidoptera: Noctuidae). *J. entomol. Res.,* **27**: 281-292.

Ramachandran, R., Mukherjee, S. and Sharma, R., 1989. Effects of food deprivation and concentration of Azadirachtin on the performance of *Achoea janata* and *Spodoptera litura* on young and mature leaves of *Ricinus communis*. *Ent. Exp. Appl.,* **51**: 29-35. https://doi.org/10.1111/j.1570-7458.1989.tb01210.x

Saxena, K., 1969. Patterns of insect-plant relationships determining susceptibility or resistance of different plants to an insect. *Ent. Exp. Appl.,* **12**: 751-766. https://doi.org/10.1111/j.1570-7458.1969.tb02569.x

Senrung, A., Singh, J., Sharma, S., Bhutia, T.N. and Singh, A.K., 2014. Effect of *Murraya koenigii*

extracts on feeding and ovipositional response of *Spodoptera litura* (Fab.)(Lepidoptera: Noctuidae). *J. Ent. Zool. Stud.,* **2**: 27-31.

Shad, S.A., Sayyed, A.H., Fazal, S., Saleem, M.A., Zaka, S.M. and Ali, M., 2012. Field evolved resistance to carbamates, organophosphates, pyrethroids, and new chemistry insecticides in *Spodoptera litura* Fab. (Lepidoptera: Noctuidae). *J. Pest. Sci.,* **85**: 153-162. https://doi.org/10.1007/s10340-011-0404-z

Sharker, S.M., Shahid, I.J. and Hasanuzzaman, M., 2009. Antinociceptive and bioactivity of leaves of Murraya paniculata (L.) Jack, Rutaceae. *Rev. Bras. Farmacogn,* **19**: 746-748. https://doi.org/10.1590/S0102-695X2009000500016

Srinivasan, K., 2007. Black pepper and its pungent principle-piperine: A review of diverse physiological effects. *Crit. Rev. Fd. Sci. Nutr.,* **47**: 735-748. https://doi.org/10.1080/10408390601062054

Tong, H., Su, Q., Zhou, X. and Bai, L., 2013. Field resistance of *Spodoptera litura* (Lepidoptera: Noctuidae) to organophosphates, pyrethroids, carbamates and four newer chemistry insecticides in Hunan, China. *J. Pest. Sci.,* **86**: 599. https://doi.org/10.1007/s10340-013-0505-y

Ulrichs, C., Mewis, I., Adhikary, S., Bhattacharyya, A. and Goswami, A., 2008. Antifeedant activity and toxicity of leaf extracts from *Porteresia coarctata* Takeoka and their effects on the physiology of *Spodoptera litura* (F.). *J. Pest. Sci.,* **81**: 79-84. https://doi.org/10.1007/s10340-007-0187-4

Waldbauer, G., 1968. The consumption and utilization of food by insects. *Adv. Insect Physiol.,* **5**: 229-288. https://doi.org/10.1016/S0065-2806(08)60230-1