Antifeedant effect of some plant extracts on the Asian armyworm, *Spodoptera litura* (Fabricius)

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Plant extracts of *Azadirachta indica* A. Juss, *Citrus sinensis* Linn., *Vitex negundo* Linn. and *Zingiber officinale* Rosc were evaluated for their antifeedant and growth inhibitory activities against last instar larvae of *Spodoptera litura* (Fabricius) causing defoliation in groundnut. The results indicate existence of deterrent effect in all the botanicals and the highest general deterrent action was found in *Vitex negundo*. It was reflected from the very low food consumption, approximate digestability, faecal pellets production, and reduction percentage in body weight. The percentage of deformity in pupal as well as adult stages was considerably higher in *Z. officinale* followed by *A. indica* and *C. sinensis*, respectively. All the plant extracts were found to be antifeedant and growth inhibitory in nature.

IN India, groundnut (*Arachis hypogea* L.) is cultivated on 8.5 m ha, where it produces 9.5 m tonnes. The major constraint in the production of groundnut is the infestation by *Spodoptera litura* (Fabricius), the most serious insect pest, particularly in Andhra Pradesh, Karnataka, Tamil Nadu and Maharashtra. It causes significant loss of pod (25 to 27%) and haulm (31 to 44%) of groundnut[1,2]. Several plants and their insecticides have been reported to possess substances which serve as protective barrier to infestation[3–7]. The present investigation was, therefore, undertaken to study the effect of four different botanicals on food consumption and utilization efficiency and growth in the lepidopteran polyphagous pest *S. litura*.

A culture of *S. litura* was maintained in the laboratory on field-collected groundnut leaves. All the plant extracts tested here were prepared according to Nandagopal[6] and Sahayaraj and Sekar[7]. 10 g each of the leaves of *Azadirachta indica* A. Juss and *Vitex negundo* Linn., rind of *Citrus sinensis* Linn. and rhizome of *Zingiber officinale* Rosc (washed well 3–5 times with tap water and once with distilled water) were macerated individually in an all-glass pestle and mortar and extracted with small quantities of hot distilled water. The extract was passed through muslin cloth and the final volume made up to 100 ml to get 10% extracts. For evaluation of anti-feedant effect of botanicals on food consumption and assimilation in the laboratory, groundnut shoots were dipped in the different extracts to give a thorough wetting and shade-dried for 15 minutes. Ten final instar larvae of *S. litura* (uniform age and size) were placed in plastic trays (40 × 28 × 10 cm) and replicated six times. They were provided with weighed botanicals-treated groundnut shoots for a day for experimental individuals. The groundnut shoots devoid of extracts served as control. After a day, the larvae were removed from the treatment and released into plastic trays containing untreated groundnut shoots. The shoots were replaced every 24 h. All the individuals were maintained at 27 ± 2°C, 75 ± 5% relative humidity and 13 h photoperiod, respectively. The weight of larvae and that of excreta and unconsumed food were recorded daily for a period of four days. The anti-feedant efficacy of different botanicals was determined by comparing the approximate digestability (AD), conversion efficiency of ingested (ECI) and digested (ECD) food. In order to find out the toxic effect of plant extracts, mortality, reduction percentage in body weight[8] and deformity in the test larvae were recorded during the remaining life of *S. litura*. The larvae which did not pupate and pupae from which adults did not emerge, were considered as dead. Net mortality was also calculated[9].

Table 1. Effect of different botanicals on AD, conversion efficiency of ECI and ECD into body substance of larvae *S. litura*

Parameter	Control	Botanicals treated			
		A. indica	*Z. officinale*	*C. sinensis*	*V. negundo*
Animal initial weight (mg)	271.60	287.59	298.41	289.28	286.51
Food consumed (mg)	588.00	367.66^{a}	317.64^{b}	400.32^{c}	282.98^{cd}
AD (%)	94.09	85.77^{a}	81.19^{ab}	82.46^{bc}	70.09^{bcd}
ECI (%)	3.45	–53.48	-51.87^{b}	-41.49^{bc}	-47.79^{bcd}
Faecal matter (mg)	11.89	13.86^{a}	12.21^{ab}	15.38^{abc}	11.42^{abcd}
Amount of food converted (mg)	184.12	81.23^{a}	64.36^{ab}	84.69^{ac}	55.68^{bcd}
ECD (%)	3.68	–59.52	-63.36^{b}	–46.62	-69.68^{ad}
Animal final weight (mg)	259.42	87.96	100.52	80.67	95.33
Weight gain/loss (mg)	26.34	-129.22^{a}	-168.43^{b}	-208.68^{abc}	-181.80^{abcd}

Values given are mean of six replicates.
In horizontal row, means followed by the same letters are not different significantly (p = 0.05) by ANOVA.

Table 2. Morphogenetic effects of some plant extracts against last instar larvae of *S. litura*

Parameter	Control	Plant extracts			
		A. indica	*Z. officinale*	*C. sinensis*	*V. negundo*
No. of larvae tested	60	60	60	60	60
No. of larvae (pre-pupated)	60	12	18	10	6
No. of larvae (pupated)	56	10	15	8	2
No. of adults emerged	56	5	3	6	0
Total mortality (%)	6.66	58.33	83.33	40.00	100.00
Net mortality (%)	6.66	55.35	82.14	35.72	100.00
No. of deformed pupae	0	1	3	1	–
No. of deformed adults	0	2	3	1	–
Deformitiy (%)	0	25.00	33.33	20.00	–

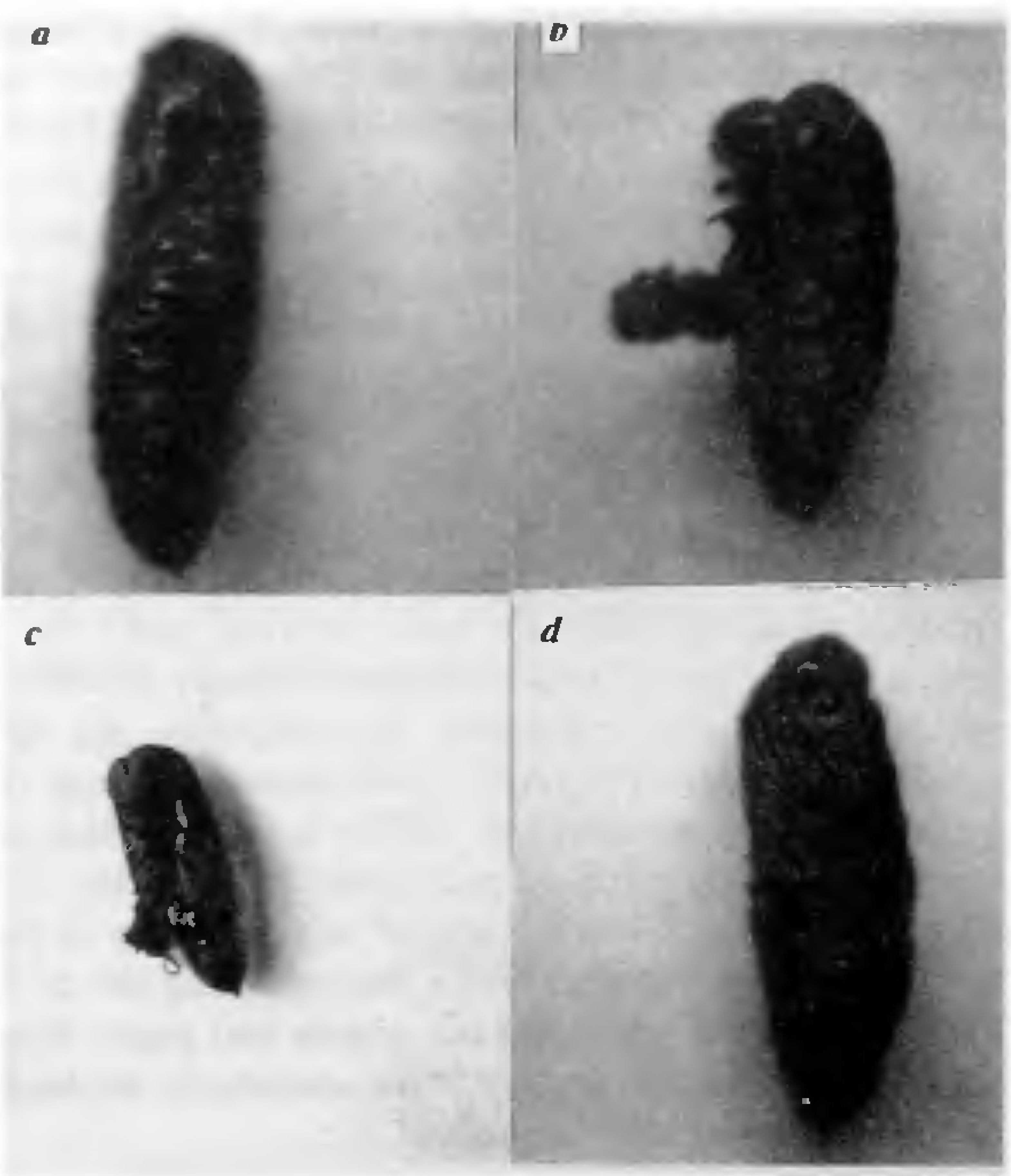

Figure 1. Asian armyworm showing various degrees of morphological abnormalities induced by different plant extracts: ***a***, Normal pupa; ***b***, A partially deformed pupa with vestigial thoracic legs, produced by *A. indica*. The larva moult is incomplete in that the cast integument is still attached to the thorax; ***c***, Pupal deformity caused by *V. negundo*; ***d***, Pale and soft pupa and the cuticle contained little chitin produced by *Z. officinale*.

Effects obtained from treatment of *S. litura* larvae with different botanicals are presented in Table 1. Observations reveal that the shoots in the control category were completely defoliated and stems eaten away, whereas the shoots in the plant extracts-treated categories (PETCs) were not consumed fully.

The average food consumption in control category was 588.00 mg as against 400.32, 367.66, 317.64 and 282.98 mg, respectively in *C. sinensis, A. indica, Z. officinale* and *V. negundo* sprayed leaf-fed larvae. Irrespective of the plant extracts, treatment decreased food intake and probably the passage of food through the gut. However, the food intake was more or less similar among the categories fed with groundnut leaf treated with botanicals. Individuals of *Helicoverpa armigera* Hubner when reared on a semisynthetic diet incorporated with certain plant antibiotic substances showed a reduction in food consumption[10]. Many of the earlier reports suggested that lepidopterans are generally insensitive to botanicals[11]. However, others[7,12] demonstrated in *S. litura* that botanicals induce mortality. In all the PETCs, the daily food consumption and AD were gradually decreased from the first day to the fourth. The AD was highest and lowest in the control and *V. negundo*-treated leaf fed larvae. Among the PETCs, the AD was higher in *A. indica* and similar in *C. sinensis* and *Z. officinale* categories ($P < 0.05$) (Table 1).

The *V. negundo*-sprayed category produced less faecal pellets followed by *Z. officinale, A. indica* and *C. sinensis*, respectively. Similar studies conducted in the management of rice pests by neem products are on record[13,14]. The efficiency of utilization of food by animals is measured by the ECI and ECD values. Interestingly, in the present study, significantly negative ECI and ECD values were observed in all PETCs and this indicated that the utilization of food for conservation of energy for various life activities was challenged by the chemicals present in the plant extracts. This is in acccordance with the other report[5] where the neem-based insecticides (margocside OK and CK) suppressed the *S. litura* damage in groundnut. Furthermore, negative ECI and ECD values might be due to the adverse effect on the hormonal system which controls the utilization of food.

The feeding deterrent effect in this study was also judged by the relative loss in body weight (RLBW) of the larvae. The maximum mean reduction per cent in body weight was found in the *V. negundo* treated category (73.69%) followed by *Z. officinale* (58.99%), *A.*

indica (52.63%) and *C. sinensis* (47.79%), respectively. This might be due to less/slow feeding of the foliage and diversion of energy from production of biomass to detoxification of plant extracts. Further, it suggests that the amount of botanicals consumed in 24 h was sufficient to disrupt the feeding mechanism of *S. litura*. Ismann[15] compared the efficacy of azadirachtin via dietary incorporation against six species of noctuids. His results indicate that *S. litura* was the most sensitive to the antifeedant effect of azadirachtin. Furthermore, he reported that it decreased the growth (body weight), diet consumption and utilization.

It was observed that pupal formation with *Z. officinale* treatment was greater, followed by *A. indica*, *C. sinensis* and *V. negundo*. This result indicates that the existence of toxic principles in *V. negundo* was higher, as reflected by less pupal formation (2) and more total and net mortalities (100%) observed in this category. Various parts of this plant contain ecdysteroids[16] and this might be the reason for 100% mortality. All the plant products tested in this experiment produced a number of deformities in pre-pupa, pupa and adult stages. Most of the deformities were in the form of larva–pupa intermediates and were recorded in *Z. officinale*, *A. indica* and *C. sinensis*. A great deal of mortality occurred in the intermediates between larvae and pre-pupae. A maximum and minimum of 33.33 and 20.00% deformity were recorded in *Z. officinale* and *C. sinensis* treatments respectively (Table 2).

Typical effects of the material are illustrated in Figure 1. Larvae that are marginally affected appear chimeric, with a mixture of larval and pupal features (Figure 1 *b*). In the pupal deformity, the anterior part completely pupated and the posterior part did not moult properly but shrank (Figure 1 *c*). Furthermore, there was inhibition of chitin synthesis. The moulting phase results in mortality at ecdysis. The newly-formed cuticle lacks chitin and is pale (Figure 1 *d*). In the case of pupal–adult intermediate deformity, moulting process was not complete. Difubenzuron[17], diamine-furyl-s-triazine[18] interferes with the deposition and biosynthesis of chitin, inhibits moulting and finally leads to the death of *Spodoptera littoralis* (Boisd.) and *Euproctis icilia* Stoll larvae. Adults derived from treated *S. litura* larvae appeared weaker and smaller in size than those in control. These larvae too, did not show any sign of malformations.

All the botanicals tested were found to be anti-feedant and growth inhibitory in nature. Since *Spodoptera litura* is a polyphagous pest on 112 species of plants like cotton, tobacco, chilli, castor, pulse crops, groundnut, tomato and minor spice crops, these extracts can be exploited for the control of this pest. However, the utilization of these plant extracts for the control of this insect can only be determined through actual field trials.

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