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Studies on biology and preference of *Helicoverpa armigera* (Hubner) on different hosts and evaluation of botanicals for its management

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ABSTRACT: The biology and fitness of *Helicoverpa armigera* (Hubner) was studied on bottle gourd, lady's finger, chilli and tomato. The total larval duration was found to be 20, 22.5, 20.3 and 18.3 days on tomato, chilli, lady's finger and bottle gourd respectively. The total life cycle was of 35.25, 40.7, 34.2 and 31.3 days on tomato, chilli, lady finger and bottle gourd respectively. Shortest life cycle was observed on bottle gourd and longest on chilli. Feeding preference and fitness of *H. armigera* revealed that it preferred bottle gourd over other host plants. On bottle gourd, the pest recorded highest mean larval weight gain (0.112g/ day), while the lowest was on chilli (0.090g/ day). The feeding period was 8.073 days on bottle gourd and 8.266 days on chilli. Average food ingested on bottle gourd, lady finger, chilli and tomato were 3.083, 2.347, 2.076 and 1.988g respectively. Bioefficacy of botanicals (5 % aqueous extracts of periwinkle, giloy, tulsi and lantana) against *H. armigera* by leaf dip bioassay using leaves of tomato showed that the average food ingested in periwinkle, giloy, tulsi, lantana and control was 0.644, 0.944, 1.038, 0.985 and 2.297g respectively. This is the first report evidencing the insecticidal properties of aqueous extracts of giloy against *H. armigera.* © 2023 Association for Advancement of Entomology

KEY WORDS: Host preference, life cycle, insecticidal activity, periwinkle, giloy, tulsi, lantana

INTRODUCTION

Helicoverpa armigera (Hubner) is a polyphagous and cosmopolitan pest that affects important crops including cotton, pigeon pea, chickpea, corn, tomato, sorghum, millet, okra and sunflower (Manjunath *et al.*, 1989; Sharma, 2001). *H. armigera* is widely distributed all over Asia, central and southern Europe, America, Africa, and Australia (Tay *et al.*, 2013). In India, this pest has been reported to cause 14-50 per cent damage on cotton (Kaushik *et al.,* 1969) and around 90 per cent damage in pulses (Patil *et al.*, 2018). Even though there are numerous methods for reducing pests, each has its own set of advantages and disadvantages. Commercially available synthetic pesticides are reported to inflict severe environmental repercussions. Phytochemicals, mainly botanicals are currently a part of interest because of their successful application in plant protection as potential biocontrol

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agents. Hence the current study focuses on studies on biology and behavior of *H. armigera* on different host plants and to screen the bioefficacy of botanicals from commonly available plant species in managing *H. armigera* in laboratory bioassays.

MATERIALS AND METHODS

Mass culturing and biology of *Helicoverpa armigera* on different host plants

H. armigera culture was established with eggs purchased from NBAII, Bangaluru. Eggs were maintained at 25±2°C and 65±5 per cent relative humidity (RH). On hatching the neonates were placed in separate cups (7cm diameter x 15cm height) containing feed material (leaves of host plants under study [tomato (*Solanum lycopersicum* Linn.), bottle gourd (*Lagenaria siceraria* (Molina) Standl.), chilli (*Capsicum annuum* Linn.) and ladys finger (*Abelmoschus esculentus* (Linn.) Moench)] to avoid cannibalism and the cups were covered with muslin cloth. The insect was mass cultured using standard procedure with few modifications (Boopal *et al*., 2014). When larvae entered pre pupal stage, one-third of plastic cups were filled with moist sand, which provides optimal condition for pupation. When adults emerged, they were allowed into oviposition cage (20 x 20 x 20cm) for mating and egg laying. Honey solution (10 %) with few drops of vitamin E was provided as adult feed.

Evaluation of the biology of *H. armigera* on tomato, bottle gourd, chilli and ladys finger was carried out. Host plants were raised in plastic pots (60 x 30 x 30cm) without application of any agrochemicals for crop protection. Healthy plants of uniform growth and age 30 days after sowing (DAS) was provided as feed for first instar larvae in the cups. Total of three replications for each treatment and 10 larvae per replication were maintained. The insect was observed for their larval duration, pupal period, percent adult emergence, sex ratio and adult longevity.

Fitness analysis of *H. armigera* on different hosts

To study the host fitness, fully opened leaves from four hosts (tomato, bottle gourd, chilli and ladys finger) of uniform age 30 days after sowing (DAS) were taken weighed and placed in plastic cups. Three replications were maintained for each treatment with 10 larvae per replication. First instar larvae were weighed and released into individual cups and covered with muslin cloth. Twelve hours once fresh feed was provided and observations were made on larval weight gain, amount of feed consumed, weight of feces excreted etc. Also relative growth rate, approximate digestibility and consumption index was calculated as per the standard protocol (Waldbauer, 1968).

1. Relative Growth Rate (RGR) =

$$\frac{\text{Weight gained by the larva}}{\text{Mean larval weight} \times \text{feeding period (days)}}$$

2. Approximate Digestibility (AD) =

$$\frac{\text{Weight of food ingested - Weight of faeces} \times 100}{\text{Weight of food ingested}}$$

3. Consumption index (CI) =

$$\frac{\text{Weight of food ingested by the larva}}{\text{Mean larval weight} \times \text{Feeding period (days)}}$$

4. Efficiency of conversion of ingested food to body substance (ECI) =

$$\frac{\text{Weight gained by larva} \times 100}{\text{Weight of food ingested}}$$

5. Efficiency of conversion of digested food to body substance (ECD) =

$$\frac{\text{Weight gained by larva} \times 100}{\text{Weight of food ingested} - \text{Weight of feces}}$$

Bioefficacy of botanicals against *H. armigera* in laboratory bioassay

Fourth instar larvae of *H. armigera* were used for the bioassays. Leaves of giloy (*Tinospora cordifolia* (Willd.) Miers), periwinkle (*Catharanthus roseus* Linn.), tulsi (*Ocimum tenuiflorum* Linn.), and lantana (*Lantana camara* Linn.) were shade dried and grinded into powder. 2.5g powder of each plant was soaked in 50ml of water overnight to prepare 5 per cent of solution and then it was filtered with muslin cloth to get aqueous extract of the botanicals used for study. Host plant leaves were weighed and dipped in each extract of botanicals by leaf dip method for bioassays and provided as feed to the larvae. In each treatment, four replications with one larva per replication were maintained. After every 24h remaining feed was weighed and replaced with new feed and the process was continued and observations were made until larval mortality to evaluate bioefficacy of the aqueous extract (5%) of each botanical tested.

Statistical analysis: Completely randomized design (CRD) was adapted for all the laboratory experiments. All the data obtained was subjected to an analysis of variance (ANOVA). The means were separated by Duncan's New Multiple Range Test (DMRT) and statistical analysis was carried out using SPSS v.26.

RESULTS AND DISCUSSION

Biology of *H. armigera* on different host plants

Observations for larval development of each instar, total larval period, per cent pupation, pupal period, per cent adult emergence, adult longevity and sex ratio were recorded (Table 1). Growth index of *H. armigera* was 2.66, 1.48, 2.955 and 3.311 on tomato, chilli, ladys finger and bottle gourd respectively

Fitness of *H. armigera* on different host plants

Studies showed that weight gained by larvae was maximum on bottle gourd and ladys finger, followed by tomato and chilli. However, the mean larval weight on bottle gourd, ladys finger, chilli and tomato were on par with each other. Food ingested was found to be highest on bottle gourd and weight of

Table 1. Biology of *H. armigera* on different hosts

Life stages*	Tomato	Chilli	Ladys finger	Bottle gourd
Larval period				
1st Instar	2.07±0.061	2.2 ± 0.040	1.9 ± 0.081	1.76 ± 0.028
2nd Instar	2.8 ± 0.040	3.02 ± 0.20	2.62 ± 0.102	2.65 ±0.122
3rd Instar	3.65± 0.04	3.95 ± 0.085	3.9 ± 0.081	3.35 ±0.122
4th Instar	3.3 ± 0.081	3.82 ± 0.102	3.75 ± 0.040	3.17 ± 0.020
5th Instar	3.87 ± 0.20	4.87 ± 0.061	4.13 ± 0.012	3.85 ± 0.040
6th Instar	4.15 ± 0.04	4.7 ± 0.081	4.06 ± 0.053	3.55 ± 0.122
Total period	20 ± 0.60	22.5 ± 0.721	20.3 ± 0.623	18.3 ± 0.516
Pupation(%)	53.3	33.3	60	60.6
Pupal period	12.6 ± 0.081	13.6 ± 0.204	11.6 ± 0.040	10.3 ± 0.081
Adult emergence%	25	20	27.7	30
Male longevity	9 ± 4.5	8 ± 4	10 ± 5	11 ± 5.5
Female longevity	10.3±0.408	10 ± 5	10.5 ± 0.353	11.4 ± 0
Sex ratio	3:1	1:1	4:1	5:1
Life cycle	35.25±0.93	40.7 ± 0.081	34.2 ± 1.306	31.3 ± 0.326
Growth index	2.66±0.269	1.48 ± 0.028	2.955 ± 0.018	3.311 ± 0.086

Mean ± SE/ period (days); each treatment was replicated three times with 10 larvae per replication faeces excreted was found to be lowest on chilli. The consumption index (CI), relative growth rate (RGR) and efficiency of conversion of ingested food to body (ECI) were statistically similar on all the hosts. Efficiency of conversion of digested food to body (ECD) was lowest in chilli and highest in bottle gourd and approximate digestibility (AD) was highest in chilli (Table 2).

Bioefficacy of botanicals against *H. armigera* in laboratory bioassays

Studies on bioefficacy of aqueous extracts of periwinkle, giloy, lantana and tulsi by leaf dip bioassay using tomato leaves showed that the larvae consumed less on plants treated with botanical extracts. Mean larval feeding per day was 0.140, 0.144, 0.165, 0.179 and 0.366g on periwinkle, giloy, tulsi, lantana and control respectively. Larval mortality in days recorded in each treatment showed mortality occurred earlier in larvae forced to feed on diet containing periwinkle extract (5.2 days), followed by those on lantana, giloy, tulsi which were 6.0, 6.25, 6.7 days respectively while the larvae feeding on untreated leaves survived and also pupated (Table 3). In addition to larval mortality, larvae fed on tomato leaves treated with botanicals

Table 2. Effect of different host plants on the growth parameters (mean ± SE) of *Helicoverpa armigera*

Host*	Wt. gained (g)	Larval wt.(g)	Food ingested (g)	Wt. of faeces(g)	Feeding days	CI	RGR	ECI	ECD	AD
Bottle gourd	1.081± 0.070 (1.257)[b]	0.112± 0.004 (0.782)[a]	3.083± 0.169 (1.892)[b]	0.816± 0.982 (1.024)[b]	8.073± 0.322 (2.927)[a]	9.577± 2.935 (3.174)[a]	0.977± 0.029 (1.215)[a]	28.518± 1.225 (5.386)[a]	40.970± 3.124 (6.439)[b]	78.168± 1.386 (8.869)[a]
Lady finger	0.885± 0.059 (1.170)[ab]	0.08± 0.003 (0.766)[a]	2.347± 0.095 (1.687)[a]	0.468± 0.032 (0.983)[ab]	7.5± 0.173 (2.828)[a]	12.105± 0.670 (3.550)[a]	1.080± 0.118 (1.256)[a]	27.880± 1.147 (5.327)[a]	35.316± 1.702 (5.984)[ab]	80.778± 3.093 (9.015)[ab]
Chilli	0.703 ± 0.096 (1.096)[a]	0.090± 0.024 (0.768)[a]	2.076± 0.159 (1.604)[a]	0.127± 0.018 (0.791)[a]	8.266± 0.612 (2.960)[a]	8.647± 0.844 (3.024)[a]	1.014± 0.005 (1.230)[a]	27.251± 2.048 (5.267)[a]	29.439± 2.635 (5.471)[a]	94.899± 0.051 (9.767)[c]
Tomato	0.796± 0.148 (1.138)[a]	0.076±0 (0.75)a	1.988± 0.0527 (1.577)[a]	0.317± 0.174 (0.903)[ab]	7.133± 0.163 (2.762)[a]	11.337± 1.115 (3.440)[a]	1.019± 0.006 (1.232)[a]	26.905± 1.222 (5.234)[a]	36.355± 1.637 (5.866)[ab]	85.844± 0.530 (9.292)[b]

In column, means followed by a common letter are not significantly different by DMRT (P=0.05); Figures in parentheses are square root transformed values; *Replicated three times with 10 larvae per replication

Table 3. Bioefficacy of botanicals (5% aqueous extracts) on *H. armigera* (Mean± S.E.)

Treatments	Total food ingested (g)*	Food ingested per day (g)*	Mortality (Days)*
T1 (Periwinkle)	0.664 ± 0.123(1.078)[a]	0.140 ± 0.035(0.8)[a]	5.2 ±1.767(2.397)[b]
T2 (Giloy)	0.944 ± 0.009(1.201)[a]	0.144 ± 0.009(0.802)[a]	6.25 ±0.353(2.598)[b]
T3 (Tulsi)	1.038 ± 0.353(1.240)[a]	0.165 ± 0.014(0.815)[a]	6.7 ± 2.121(2.692)[b]
T4 (Lantana)	0.985 ± 0.072(1.218)[a]	0.179 ± 0.035(0.824)[a]	6 ± 1.414(2.549)[b]
Control	2.297 ±0.211(1.672)[b]	0.366 ± 0.067(0.930)[b]	0 ± 0(0.707)[a]

In column, means followed by a common letter are not significantly different by DMRT (P=0.05) ; Figures in parenthesis as square root transformed values; * Mean of four replications.

also showed abnormalities like swollen body, early pupation and malformation in pupal stage.

Studies on biology showed that the eggs of *Helicoverpa* was hemispherical in shape and yellowish white in color and later turns darker before hatching. Similar findings have been reported by Ali *et al*. (2009), Patel *et al*. (2011), Sharma *et al*. (2019). In the present investigation it was observed that the larvae underwent six larval instars which were similar to Gandhiya *et al*. (2014) and Sharma *et al*. (2019). The total larval period on chilli found as 22.5 days which was on par similar to findings of Patil *et al*. (2018) where they observed total larval period of 21-25 days on chilli. Total larval period of ladys finger, tomato, and bottle gourd was found to be 20.3, 20.0, and 18.3 days respectively. In the experiments the initial color of pupa was light green to yellow which later turned into dark brown which is similar to the report of Singh (2014). The pupal period was highest on chilli (13.6 days), followed by tomato (12.6 days), lady finger (11.6 days) and bottle gourd (10.3 days). Percent pupation and adult emergence were higher in bottle gourd and lady finger followed by tomato and chilli. Similar trend was observed with respect to adult longevity where that reared-on bottle gourd had highest adult longevity in case of both males and females and females lived longer than males. Previous studies also reported variations in total larval period, pupal period, percent pupation, adult emergence and adult longevity of *Helicoverpa* grown on different hosts (Ali *et al*., 2009; Patel *et al*., 2011). In the current study, *Helicoverpa* fed on bottle gourd had shortest life cycle of 31.3 days and those fed on chilli had the longest lifecycle with 40.7 days. Also the larval weight gain was greater on bottle gourd with 1.081 g and lowest on chilli with 0.703 g. The value of ECI was higher on bottle gourd with 28.518 per cent followed by lady finger, chilli and tomato with 27.880, 27.251 and 26.905 per cent respectively. ECD was found higher on bottle gourd (40.97%) and lower on chilli (29.439%). In this study, the RGR of the test insects was on par on all the host plants used for the study. However, AD was highest in chilli (94.899%) and lowest on bottle gourd (78.168%). Hemati *et al*. (2012) also reported AD of *Helicoverpa* varied with host plants. *Helicoverpa* preferred bottle gourd than other hosts. This might be because bottle gourd leaves are more succulent and remains moist than tomato, chilli and lady finger for long time and provides adequate amount of moisture and nutrition to the larvae and help them to complete their life cycle early. Chilli was the least preferred host as it showed high larval mortality and less larval weight gain with longer life cycle (egg to adult emergence). This might be because of xenobiotic resistance or plants metabolites present. Based on larval weight gained, feeding period with shorter life cycle of *Helicoverpa* reared on bottle gourd, it was observed to be the most preferred host among the plants tested. Thus, it is evident that host plant composition affects insect biology and duration of various biostages.

In the current study aqueous leaf extracts (5%) of all the four plants namely periwinkle, giloy, tulsi, and lantana tested gave better reduction in larval feeding over control. *Helicoverpa l*arvae feeding on treated leaves consumed two times less than those on control. Optimal feeding (2.297g) with no mortality in total experimental period was recorded on untreated leaves while leaves treated with periwinkle extract recorded lowest feeding (0.664g) and early mortality (5.2 days) followed by Giloy where larval feeding per day was 0.944g and mortality occurred in 6.25 days. This was followed by tulsi and lantana. This is the first report on insecticidal properties of aqueous extract of giloy against *H. armigera*. Simmonds *et al*. (2001) reported high antifeeding compounds which are extracted from different plants and used against *Helicoverpa* larvae. Ramya *et al*. (2008) reported 90 per cent feeding resistance on host plant treated with *Datura stromonium* and *Calotropis procera* aqueous extracts. Insecticidal properties of neem have been well established against many insects including *Helicoverpa*. In the current study there were reduced larval feeding, larval edema, larval mortality, pupal malformation and pupal mortality of insects fed with food poisoned with botanicals. This is due to the presence alkaloids, steroids, sesquiterpenes, saponins, tannins, flavonoids, aliphatics with vincristine and vinblastine like compounds present in these botanicals which has multiple mode of action on insects such as feeding and ovipositional deterrents, acting as antimetabolies, molting inhibitors etc., meddling with insect, growth, metamorphosis and reproduction (Wahengbam *et al*., 2021). Current investigation provides with basic understanding of biology and host preference of *Helicoverpa* so as to use them appropriately in crop rotation and integrated pest management programs. The study shows that aqueous extracts of periwinkle, giloy, tulsi and lantana could effectively be used to manage *Helicoverpa* thereby providing farmers with a simple extraction technique which is a cheaper and ecofriendly option of pest management.

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