

Laboratory Evaluation of the Insect Growth Regulator Lufenuron against *Helicoverpa armigera* on Cotton

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An insect growth regulator (IGR), lufenuron (Match 5EC), was tested for its toxicity to *Helicoverpa armigera* on cotton. Potency of the IGR against the larval stage of the pest was demonstrated with respect to larval instars; the LC₉₀ values of 1st, 2nd, 3rd, 4th and 5th instar larvae were 5.63, 7.89, 8.03, 11.39 and 14.76 mg a.i. l⁻¹, respectively. However, different larval instars did not differ significantly with respect to LC₅₀ and LC₁₀. IGR-treated larvae had swollen heads and were significantly smaller (1.5–2.3 mm) than the untreated control (2.9 mm). Larval weight was significantly reduced from 190 mg in the control to 50–70 mg in the lufenuron treatment. IGR treatment in the larval stage significantly affected both pupal length and pupal weight. Pupal duration of the test insect was significantly extended by IGR treatment. Pupal deformities, including an inability to shed the last larval skin and formation of larval–pupal intermediates, occurred following treatment. A significant reduction in adult emergence was recorded. In addition, abnormalities in the form of development of cavities in the forewings of adult were evident. A significant decline in fecundity was noted in the studies.

KEY WORDS: Cotton; *Helicoverpa armigera*; insect growth regulator.

Insect pests belonging to the categories of sucking pests and bollworms are known to inflict serious damage to cotton in India. The loss in yield due to the bollworm complex alone has been estimated at between 50% and 60% (13). *Helicoverpa armigera* Hübner is considered a key bollworm. Hitherto, chemical control with conventional insecticides, including synthetic pyrethroids, was the only weapon to tackle the menace of this dreaded pest in cotton. Despite the extensive use of potent pesticides, the pest could not be controlled to a desired level as it has developed resistance to most of the recommended insecticides (8). In Punjab, a high level of resistance in this pest to all groups of pesticides (chlorinated hydrocarbons, organophosphates, synthetic pyrethroids and car-

bamates) has been demonstrated (9). Due to frequent failures of cotton in the country with the use of available conventional insecticides, other options were sought. In this context, insect growth regulators (IGRs) inhibiting the synthesis of chitin in insects were considered to be the most appropriate (2). Taking into consideration the potential of such compounds, studies were planned with a view to evaluate a new IGR, namely, lufenuron (Match 5EC), against *H. armigera* on cotton in the laboratory at Punjab Agricultural University, Ludhiana, India.

To determine toxicity against the insect, larvae were first collected from cotton fields and reared in the laboratory on cotton leaves in specimen tubes until the emergence of adults. The moths were kept in muslin-lined glass jars to

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collect eggs. Toxicity to different larval instars was determined as follows. Soft cotton leaves were dipped in the test solution of lufenuron (prepared by diluting the IGR with distilled water) for 5 sec and then air-dried for 3 h. They were then fed to 1st, 2nd, 3rd, 4th and 5th instar larvae, separately for 24 h. Subsequently, the larvae were fed on untreated cotton leaves and cumulative larval mortality until pupation was recorded. Preliminary experiments were conducted to determine the concentration range of IGR suitable for estimating toxicity to different larval instars. For this purpose, micropipette (0–5 ml) and disposable needles were used to prepare the chemical solution. LC_{10} , LC_{50} and LC_{90} were computed by probit analysis using the Polo computer program (5). To examine the sub-lethal effects of IGR, 3rd instar larvae were treated with the respective LC_{10} , LC_{50} and LC_{90} doses of the IGR. Observations on feeding behavior, larval period, weight and length of larvae, pupal period and length, and adult emergence were recorded. Following treatment of the larvae, adults which emerged in the respective LC_{10} , LC_{50} and LC_{90} treatments were immediately sexed and kept in pairs to record fecundity. In order to have a sufficient number of moths under LC_{90} , a separate experiment was conducted to record adult abnormality in the test insect.

After experimentation, the data were analyzed statistically using a completely randomized design (3). Before the analysis, the data in percentages were subjected to angular transformations ($1/4 n$ for 0 and $100-1/4 n$ for 100%) as per the standard procedures (6). For the purpose of analysis of data pertaining to adult abnormalities, nil emergence was taken as 100% abnormal. The data were further subjected to analysis of variance and the means were separated using least significant difference at 5% probability level (12).

The data on lufenuron potency against the larvae of *H. armigera* are presented in Table 1. LC_{90} values of 1st (5.63 mg a.i. l^{-1}), 2nd (7.89 mg a.i. l^{-1}), 3rd (8.03 mg a.i. l^{-1}), 4th (11.39 mg a.i. l^{-1}) and 5th (14.76 mg a.i. l^{-1}) instar larvae rose with an increase in the larval instar. Final (fifth) instar larvae required a significantly higher dose of lufenuron to cause 90% mortality than did the 1st instar larvae. On the other hand, LC_{50}

and LC_{10} did not differ significantly with respect to larval instars. In the present study, somewhat high doses of lufenuron were needed to obtain the desired level of mortality of different larval instars, since the test insect possessed a high level of resistance to various groups of insecticides under Punjab conditions (9). Complete (100%) mortality of neonates (1st instar) of maize stalk borer (*Sesamia cretica*) and *Ephestia cautella* with lufenuron (200 ppm) has been reported (1,14). A higher dose of lufenuron was required to cause the desired level of mortality of final instar larvae of these insects. The IGR caused a significant reduction in larval length of the test insect (Table 2). The treated larvae were significantly smaller (1.5–2.3 mm) than the larvae in the untreated control (2.9 mm). The treated larvae had swollen head capsules. LC_{90} and LC_{50} were statistically on a par with respect to larval length. The treatment also reduced the weight of larvae under laboratory conditions significantly. Larval weight was 50 (LC_{90}), 60 (LC_{50}), 70 (LC_{10}) and 190 mg (control) in different treatments. The IGR used in the present study caused a significant reduction in larval weight of beet armyworm (*Spodoptera exigua*) as well (7). Larval duration, however, did not differ significantly.

Like the larvae, pupae (weight, length and duration) also were affected when the test insect was treated with an IGR in the larval stage (Table 2). A mean pupal length of 10.5 mm was measured in the LC_{90} vs 19 mm in the untreated control. Likewise, mean pupal weight was 100 mg in the LC_{90} vs 270 mg in the untreated control. Pupal duration was significantly extended to 10 days in LC_{90} vs 9.2, 8.1 and 8 days in the LC_{50} , LC_{10} and control treatments, respectively. Pupal deformities, viz., pupae unable to shed the last larval skin, and the formation of larval–pupal intermediates, were evident in the studies. Maximum pupal deformities (97.1%) were recorded in the LC_{90} as compared with other treatments. Pupal abnormalities related to ecdysial failures, formation of larval–pupal intermediates and defective pupae have been reported in *Spodoptera mauritia* (8) and *H. armigera* (10) when treated with diflubenzuron.

No adult emergence was noticed in the LC_{90} , whereas in the LC_{50} and LC_{10} treatments, adult emergence was 30.4% and 72%, respectively.

The complete inhibition of adult emergence in *Spodoptera litura* with diflubenzuron at 50 ppm (4) and in *Culex quinquefasciatus* with 23 diphenylureas chitin inhibitors at one ppm has been reported (4,11). In the surviving individuals, the extent of adult abnormality (development of deep cavities in forewings) was 28.6% (LC₅₀) and 5.6% (LC₁₀). The treatment of 2nd instar larva of *H. armigera* with diflubenzuron (10–1000 ppm) caused 24.8% adult abnormalities (10). Formation of adultoids in *S. mauritia* upon treatment with diflubenzuron has been reported previously (9). However, in the present studies, 3rd instar larvae were treated with lufenuron.

TABLE 1. Toxicity of lufenuron to different larval instars of *Helicoverpa armigera* on cotton (Data are averages of three replicates of ten larvae each, 30 larvae per instar)

Treatments	I	II	III	IV	V	LSD (<i>P</i> =0.05)
	Instar					
LC ₉₀	5.63 ^z (2.51-13.89) ^y	7.89 (3.52-29.24)	8.03 (3.75-29.24)	11.39 (6.20-54.11)	14.76 (6.67-54.20)	0.86
LC ₅₀	0.38 (0.16-0.75)	0.32 (0.16-0.67)	0.54 (0.20-1.70)	0.61 (0.28-1.30)	0.61 (0.28-1.32)	NS
LC ₁₀	0.02 (0.0-0.09)	0.03 (0.0-0.05)	0.04 (0.0-0.15)	0.03 (0.0-0.04)	0.03 (0.0-0.10)	NS

^zLC values are expressed in mg a.i. per liter.

^yIn parentheses, fiducial limits at 95%.

TABLE 2. Effect of lufenuron on larval and pupal parameters of *Helicoverpa armigera* on cotton (Data are averages of three replicates of ten larvae each)

Treatments	Mean larval length (mm)	Mean larval weight (mg)	Mean larval duration (days)	Mean pupal length (mm)	Mean pupal weight (mg)	Pupal de- formities (%)	Mean pupal duration (days)
LC ₉₀	1.5	50.0	24.2	10.5	100.0	47.1 (43.3) ^z	10.0
LC ₅₀	1.9	60.0	24.1	14.0	150.0	34.7 (36.1)	9.2
LC ₁₀	2.3	70.0	23.5	16.0	240.0	16.0 (23.6)	8.1
Control	2.9	190.0	23.0	19.0	270.0	0.0 (1.2)	8.0
LSD (<i>P</i> =0.05)	0.6	7.2	NS	2.2	10.4	2.7	0.6

Third instar larvae were fed for 24 h on treated food.

^zParentheses are arc-sine transformations

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