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Effect of insect growth regulator, Novaluron and Chlorfluazuron on growth and development of *Antigartra catalaunalis* Duponchel

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ABSTRACT
As regards the influence of the insect growth regulators on the biomass accumulation in Antigastra catalaunalis larva, the related results have shown that both fourth generation insecticides considered under this investigation has potential to reduce the growth in this insect even at very low concentration. In context of the efficiency of the insect growth regulator's reducing the accumulation of the biomass in larva, as per results of this investigation, considering concentrations from 0.0001 to 1.00 per cent the insecticides screened under this investigation proved effective and found novaluron is more effective than chlorfluazuron. Pupa obtained from the untreated adults acquired 152.60 mg. biomass which was considerably more than that of the pupa obtained from the adults/larvae treated earlier by all methods. Weight of the pupa varied from 69.56 mg. to 153.82 mg. in response to different concentrations of both insect growth regulators used for treatment by adult feeding method and it was detected to differ with the concentration and decrease with the increasing concentrations. The male obtained from the untreated pupa/adult was heavier (106.47 mg.) than that obtained from pupae treated by adult feeding method with any concentration of both fourth generation insecticides used in this research study. Weight of the male varied from 48.36 to 101.86 mg. in response to the adult feeding treatment with different concentrations of the insecticides and as per analysis of variance, the weight of the male depended on concentration of the insecticide with a clear tendency to decrease with increasing concentration. Like the accumulation of the biomass of the larva, the acquisition of biomass in pupa and adult is also reduced by both insecticides under the both methods of treatment but both methods which applied in this study are not identically effective in causing reduction in the biomass of pupa and adults.
Key words: Antigartra catalaunalis, Novaluron, growth regulators, growth and development

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INTRODUCTION

Sesame (*Sesamum indicum* L., Pedaliaceae) is one of the oldest cultivated plants in the world. The major sesame producing countries are the United Republic of Tanzania, India, Sudan and China, followed by Myanmar, Nigeria, Burkina Faso, Ethiopia, Chad and Uganda. Its seeds contain 52- 57 percent oil and 25 percent protein. The important sesame growing countries are India, China, Sudan, Burma and Mexico. In India, the cultivation is mainly confined to Uttar Pradesh, Rajasthan, Madhya Pradesh, Andhra Pradesh, Odisha, Gujarat, Tamil Nadu and Karnataka. In India, production of sesame was estimated to be 8.11 lakh tonnes during 2014- 15 [5].

Sesame leaf webber and capsule bore, *Antigastra catalaunalis* Duponchel is a major pest of oil crop (*Sesamum indicum*) and causing heavy loss (25- 90%) in seed yield [4]. Among 67 insect pests damaging sesame crop, the leaf insect pests, viz., leaf and capsule borer, *Antigastra catalaunalis* (Dup.); jassid, *Orosiusal bicinctus* Distant; whitefly, *Bemisia tabaci* (Genn.) and mirid bug, *Nesidiocoris tenuis* (Reuter) are considered to be key pests [1]. The *A. catalaunalis* is an important pest because this attacks the crop in all the growth stages after about two weeks of emergence [32]. Sesame leaf webber and capsule bore, *A. cataunalis*is a species of tropical origins, widespread in the Mediterranean region such as Spain, France, Italy, Malta, Greece and Cyprus [30, 9]. *A. cataunalis* infests the crop at leaf, flower and capsule stage and cause yield loss upto 90% [24, 3]. *A. catalaunalis*is considered a serious pest of sesame in India [2, 22]. Due to its ability to develop rapidly dense populations and its aggressive feeding behavior on sesame, macroscopic crop inspections at regular intervals are crucial for early detection of this species. *A. catalaunalis* attack on sesame is more severe during dry seasons and after initiation of flowering. It feeds on tender foliage by webbing the top leaves, bores into the pods and shoots [26]. On the other hand, in most of the Central European countries, *A. catalaunalis* occurs only as a very rare migrant [29, 30]. *A. catalaunalis* causes 10-70 percent infestation of leaves, 34-62 percent of flower buds/ flowers and 10-44 percent infestation of pods resulting in upto 72 percent loss in yield [2].

Owing to the socioeconomic importance of *A. catalaunalis*, the insect is subject to extensive research, much of which is envisioned to finding new ways to control it as a pest and to improve the effects of known pest control methods. At present, using insect growth regulators (IGRs) is considered as the possible alternative way of synthetic insecticides for controlling this pest. Insect Growth Regulators differ widely from the commonly used insecticides, as they exert their insecticidal effects through their influence on development, metamorphosis and reproduction of the target insects by disrupting the normal activity of the endocrine system [20, 21, 27]. These compounds are effective suppressors of development for the entire life cycle of insect pests [33, 12]. Novaluron is a relatively new benzoylphenyl urea IGR with low mammalian toxicity [6, 18]. These compound has no appreciable effect on parasitoids and phytoseiids and has probably a mild effect on other natural enemies [19, 20]. Their comprehensive effects and high selectivity as well as lower toxicity to non-target animals and the environment provide new tools for integrated pest management [9, 10, 17]. Chitin synthesis inhibitors (CSIs) are usually classified in IGRs interfering with chitin biosynthesis in insects [28, 15, 11] and thus prevents moulting, or produces an imperfect cuticle [16, 23, 24]. Novaluron and Chlorfluazuronhes very little impact on natural enemies and pollinators insects.

The possible use of insect growth regulators present an intriguing and exciting area for research. In view of already proved efficacy of insect growth regulators as control measure in good number of insects and the notoriety of *Antigastra catalaunalis*. It was thought desirable to apply Novaluron and Chlorfluazuron against this pest hence this investigation. The work embodies the results relating to two insecticides (insect growth regulators) with reference to their effects on growth and development of *Antigastra catalaunalis.*

MATERIALS AND METHODS

Culture of Test Insect

Male and Female, *Antigastra catalaunalis* Dup. were collected in second week of July from sesame field. The insect was reared and maintained in the laboratory in order to ensure regular supply of the insect and its developmental stages during whole tenure of the present investigation. To begin with, the stock was established with the help of field collected moths. These moths were maintained on 10 per cent sugar solution in glass chimneys with tender sesame leaves (*Sesamum indicum*). Eggs obtained from them were kept as such for hatching. Larvae hatched from eggs were transferred on tender sesame leaves in petridishes (15 cm dia) and reared on them till pupation. The food supply to larvae was renewed twice a day in view of evaporation of water, which proceeds fast when leaves are detached from plants. The sesame leaves were treated with KM_nO_4 solution for five minutes followed by washing in running water. These leaves were dried under shade and provided to the experimental larvae. The larval period lasted for about 15.25 days. All possible precautions were taken to save larvae from bacterial and fungal infections. The first and second instars were reared in pertidishes but from third instar to pupations they were reared in pneumatic troughs (25 cm dia.) in small groups. When larvae acquired full growth and stopped feeding, they were transferred in separate pneumatic troughs having 6 inches thick moist soil layer on their bottoms. The larvae pupated in leaves made coverings. Pupae, thus obtained were kept as such for eclosion. Moths emerged from pupae were reared in pneumatic troughs as described above. In this way the progeny of moths of succeeding generations were reared generation after generation continuously till the tenure of the investigation. The laboratory reared insects and larvae were maintained throughout the tenure of investigation.

Sex identification

In size, the males and females are near about similar but sexual dimorphism is marked. The male moth show disk like puffy structure at the distal end of the femur of its fore legs.

Methods of application of insect growth regulators:

The present investigations were done under laboratory conditions of temperature and relative humidity. The insect was treated with different concentrations ie. 0.0001, 0.001, 0.01, 0.10, 0.50 and 1.00 per cent of insect growth regulators (Novaluron and Chlorfluazuron) used in this investigation by two methods namely- Adult feeding method (AFM) and Residue film method (RFM).

Residue Film Method (R.F.M.): In this method of treatment 1 to 2hr old adults were exposes to a thin film of residue of a concentration of a particular insect growth regulator. For obtaining the thin film of the chemical as residue, about 10 ml of a concentration of a chemical was poured in a petridish (10 cm dia.) and the petridish was tilted in different ways to spread the chemical on the whole floor area of the petridish and its raised periphery. Thereafter, the petridish was kept in the air for the evaporation of the solvent. This led to the formation of a thin film of a concentration of a insect growth regulator in the petridish as residue. Adults were left in petridishes having thin film of the insect growth regulator for 24 hours. The petridishes were covered by thin muslin cloth to prevent the escape of the adults. Such treated adults were employed in the different experiments as described later on. This method of treatment will be designated as RFM in the text from here onwards.
Adult Feeding Method (A.F.M.): In this method of treatment a concentration of a particular insect growth regulator was mixed in 20 per cent sugar solution which was supplied to adults for feeding. From here onwards this method of treatment will be referred as AFM in the text.

RESULTS
Effect of Novaluron on Biomass Accumulation in Larva of *A. catalaunalis* Under A.F.M.:
Results revealed in table 1 and figure1 that larva of the control experiment accumulated 4.32 mg. biomass on the 5th day of development. Whereas the larval biomass on the same day varied from 1.68 to 3.81 mg. under influence of different concentrations of Novaluron. The control larva acquired significantly more biomass (4.32 mg.) than that of the larva under influence of any strength of the Novaluron used ($p<0.01$). The larva under the effect of 0.0001 Novaluron had more weight (3.81 mg.) than that obtained under the influence of 0.001% concentration of Novaluron (2.74 mg: $P<0.05$). Further, analysis of variance revealed that 0.01% and 0.10% concentrations has almost similar effect on the biomass accumulation (2.43 to 2.25 mg) on the 5th day of the larval period. But at any of these concentrations, the larva had more biomass than that of the larva under the influence of either 0.50% or 1.00% (1.76 mg, 1.68 mg) concentration ($P<0.05$). Further, 0.50 and 1.00% had almost identical effect on the biomass accumulation ($P<0.05$). Thus, on the basis of the biomass accumulation in the larva on the 5th day, the tested concentrations of the Novaluron could be arranged as 0.0001% > 0.001, 0.01 & 0.10 > 0.50 and 1.00%.
On the 10th day of its life, the control larva had 22.66 mg, biomass which was significantly more than that of the larva on the same day under the influence of any strength of Novaluron from 0.0001 to 1.00% ($P<0.01$). In response to treatment of different concentrations of Novaluron earlier by adult feeding method, the larval mass varied from 6.81 to 15.74 mg. and the analysis of variance test revealed that the biomass of the larva on this day differed significantly with the strength of the Novaluron ($P<0.05$). The biomass of the larva exhibited the tendency of decrease with increase in concentration of the Novaluron on the 10th day of the larval period.
The biomass of the control larva was 110.94 mg. on the 15th day and it was significantly more than that of the larva on the same day under influence of any concentration of the Novaluron used ($P<0.01$). In response to treatment with different concentrations of Novaluron by adult feeding method, the biomass of the larva on the 15th day varied from 20.84 to 67.61 mg. and it differed significantly with the strength of the Novaluron ($P<0.01$). The biomass decreased with increase in the concentration of the insect growth regulator (Table 1; Fig.1).
Effect of Chlorfluazuron on Biomass Accumulation in Larva of *A. catalaunalis* Under A.F.M.:(Table 2 and Fig.2)
On the 5th day, except 0.0001 per cent any other concentration of the chlorfluazuron applied earlier to the adults, by feeding method, caused reduction in the larval biomass as compared the untreated moths ($P<.01$). In response to parent's treatment with different concentrations of this insect growth regulator (0.001 to 1%), the larval biomass on this day varied from 1.84 to 4.14 mg, decreasing with the increasing concentration but as per computation of the critical ratio for the significance of difference between means showed that 0.001% and 0.01% concentrations behaved alike in affecting the larval biomass and like-wise 0.5% and 1% concentrations also behaved identically and found more effective than 0.01% and 0.10% concentrations ($P<0.01$).
On the 10th day also, the larva of the earlier treated adults with any concentration of the chlorfluazuron was considerably lighter than that of the untreated adults ($P<0.01$). In response to earlier treated adults with different strengths of this fourth generation insecticide, the larva on this day accumulated 7.32 to 16.31 mg. biomass, decreasing with the increasing strength and it differed with the concentration of the chlorfluazuron ($P<0.01$).

Like the 10th day, on the 15th day also, the larva of the earlier treated parents with any concentration of the chlorfluazuron had less weight than that of the untreated parent moths (P<0.01). In response to the treatment of the parent moths with different strengths of chlorfluazuron, the larval biomass on this day varied from 28.32 to 75.24 mg. declining with the rise in the concentration of chlorfluazuron and it differed from concentration to concentration (Anova, P<0.001).

Effect of Novaluron on Biomass Accumulation in Larva of *A.catalaunalis* under R.F.M.

Data reveled in table 1 and figure 1 showed that larva of untreated adult acquired significantly more weight (4.32 mg.) on the 5th day in comparison to larva of treated adult with any concentration of Novaluron (P<0.05). Further, the biomass of the larva treated earlier at adult stage with 0.0001% concentration of the Novaluron (3.84 mg.) was more than that of the larva treated earlier at adult stage either with 0.001% (2.96 mg), or 0.01% (2.78 mg.) or 0.10% (2.43 mg.) concentration of the Novaluron (P<0.05) but the weight acquired by the larva at any of the latter three concentrations was almost identical (2.44 to 2.96 mg; P<0.05). However, the weight (2.05 mg.) acquired by the larva was considerably lesser at 0.50% concentration than that acquired at lower concentrations (P<0.05) but it was identical to that (1.85 mg.) acquired at 1% concentration of Novaluron.

On the 10th day also, the larva of the adult not treated with the Novaluron acquired more weight (22.66 mg.) than that which was treated earlier at adult stage with any of the concentration form used (P<0.05). In response to treatment with different concentrations from 0.0001 to 1%, the larval biomass varied from 6.85 to 15.72 mg. and it differed with the concentration (P<0.05) and decreased with increasing concentration.

The control larva on the 15th day accumulated 110.94 mg. biomass, whereas it obtained 23.89 to 72.46 mg. in response to treatment earlier at adult stage with different concentrations of Novaluron from 0.0001 to 1% and it differed with the concentration (P<0.001), tending to decrease with increasing concentration (Table-1).

Corresponding concentrations under both methods of treatment exerted similar influence on the larval biomass on the 5th and 10th day. Quite like this on the 15th day also each strength of Novaluron under R.F.M. exerted influence on the larval biomass which was identical to that at corresponding concentration either under A.F.M. or R.F.M. (Fig.1).

Effect of Chlorfluazuron on Biomass Accumulation in Larva of *A.catalaunalis* under R.F.M. (Table-2 and Fig.-2).

On the 5th day, the larva of the parents treated with the residue film of any concentration of the chlorfluazuron, except 0.0001 per cent was considerably lighter than that of the untreated parents (P<0.01). In response to parent's treatment with the residue film of the different concentrations of chlorfluazuron excluding that of the 0.0001 per cent strength, the larval biomass on this day, decreasing with the increasing concentration, varied from 2.23 to 4.37 mg. and it depended on the concentration with identical effect of 0.001% and 0.01% concentrations.

On the 10th day, the larva of the parents treated with the residue film of any concentration of chlorfluazuron accumulated less mass than that of the untreated parents (P<0.01). The treatment of the parents with the residue film of different concentrations of this fourth generation insecticide caused variation in the larval biomass on this day: it varied from 6.85 to 16.26 mg. among different concentrations with a tendency towards decrease with the advancing concentration of chlorfluazuron and as per analysis of variance, it differed from concentration to concentration significantly (P<0.01) (Table-2).

On the 15th day also, the larva of the untreated adults had more biomass (110.94 mg.) than that of the adults treated earlier with the residue film of chlorfluazuron (P<0.01). The larva acquired 30.26 to 77.92 mg. biomass in response to its parents treatment with the residue film of different concentrations of this insecticide with a tendency of reduction with the increasing concentration and, it was found to depend on the concentration (Anova, P<.01).

Effect of Novaluron on Biomass Acquisition in Pupae and Adults under A.F.M.

As perusal of Table 2 and Figure 2 observed that untreated adults resulted in heavier pupa (153.62 mg) than the treated adults with any concentration of the Novaluron under A.F.M. (P<0.01). Weight of the pupa varied from 69.57 to 142.02 mg. in response to different concentrations of the insect growth regulator under this method of treatment and it was detected to differ with the concentration (P<0.01) and decreased with the increasing concentration.

Like the pupa, obtained from the untreated adults, the male obtained from the untreated pair was heavier (104.43 mg.) than that obtained from the pupa treated with any concentration of the Novaluron. Weight of the male varied from 48.36 to 94.32 mg.in response to the treatment by AFM with different concentrations of the Novaluron and as per analysis of variance, the weight of the male moth depended

on the concentration of the insect growth regulator (P<0.01) with a clear tendency of decrease with increasing concentration.
Female obtained from untreated stock acquired more weight (110.12 mg.) than that obtained from the treated pair of moths with any concentration of the Novaluron. Further, the weight of the female varied from 52.38 to 103.46 mg. in response to adult treatment with different concentrations of the Novaluron and the statistical analysis revealed that it was dependent on the concentration of the insect growth regulator (P<.01) and it decreased with increase in the concentration (Fig.-2).
Effect of Chlorfluazuron on Biomass Acquisition in Pupae and Adults under A.F.M. (Table-4 Fig.-4):
The pupa of the untreated parent moths acquired more weight than that of the parent's treated with any concentration of the chlorfluazuron (P<.01). In response to the parent moth's treatment with the different concentrations of the chlorfluazuron, the pupal biomass, decreasing with the increasing concentration, varied from 102.45 to 149.63 mg and it depended on the concentration of the chlorfluazuron (P<.01).
The male and female adults of the untreated parent moths, acquiring 104.43 and 110.12 mg. biomass respectively, were heavier than those of the parents treated with any concentration of the chlorfluazuron (P<.01). In response to their parent's treatment by feeding method with different concentrations of this fourth generation insecticide, the biomasses of male and female adults, varying from 57.38 to 102.6 mg and from 63.12 to 107.82 mg. respectively and the both decreasing with the increasing concentration, were found to be strongly affected by the concentration of insecticide (P<.01).
Effect of Novaluron on Biomass Acquisition in Pupae and Adults under R.F.M.
The pupa obtained from the untreated adults acquired 153.62 mg. biomass which was considerably more than that of the pupa obtained from the adults treated with residue film of any concentrations of the Novaluron (P<0.01). In response to residue film treatment of adults with different concentrations of this insect growth regulator, weight of the pupa varied from 72.14 to 144.44 mg. and it was detected to differ with the concentration of the insect growth regulator (P<0.01). In this respect, data revealed that the acquisition of the biomass in pupa declined with increasing concentrations.
The male obtained from adults, not treated with the residue film of the Novaluron was heavier (104.43 mg.) than that obtained from adults exposed to residue film of any concentration of the Novaluron. In response to exposure of its parents to residue film of different concentrations of this insect growth regulator, the weight of male varied between 54.64 to 95.12 mg. and it appeared to decease with increase in the concentration, but as per statistical analysis, concentrations from 0.0001 to 0.01 per cent affected almost identically the biomass acquisition in male (P<0.05) but those from 0.10 to 1.0 per cent affected differently (P<0.01) and in this range, the biomass of the male declined with the increasing concentration of chemical.
The female obtained from the untreated adults acquired more biomass (110.12 mg.) than that obtained from adults treated with residue film of any concentration of the Novaluron (P<0.010. As regards the effect of the residue film of different concentrations of the Novaluron, the biomass accumulated by the female varied from 55.74 to 101.24 mg, decreasing with the increasing concentration of the residue film and the analysis of variance test revealed it to be dependent on the concentration of the residue film (P<0.01) (Table-2; Fig.-2).
Effect of Chlorfluazuron on Biomass Acquisition in Pupae and Adults under R.F.M. (Table-4 And Fig.-4):
The pupa of the untreated adults acquired more biomass (153.62 mg) than that of the adults treated with the residue film of the chlorfluazuron of any concentration (P<.01). In response to its parent adults treated with residue films of different concentrations of this insect growth regulator, the pupa obtained 106.60 to 154.82 mg. biomass, falling with the rising concentration and the pupal biomass, as per Anova test, was found to differ strongly with the concentration of this insecticide (P<.01).
The male of the untreated parent adults was considerably heavier (104.43 mg) than that of the parent adults treated with the residue film of any concentration of chlorfluazuron (P<.01). In response to its parents adult treatment with the residue film of different concentrations of this insect growth regulator, the biomass of the male adult varied from 64.14 to 103.21 mg decreasing with the increasing concentration and as per analysis of variance, it depended strongly on the concentration of the chlorfluazuron (P<.01).
The female adult of the adults treated with the residue film of the chlorfluazuron of any concentration acquired less biomass as compared to that of the untreated adults (P<.01). As regards the effect of the parent adults treated with the residue films of the different concentrations of this insect growth regulator on the biomass of the adult female, the weight of the female adult varied from 68.86 to 108.62 mg, tending to decrease with the rise in the concentration and it was affected differently by the different concentrations of chlorfluazuron (P<.01).

Effect of Novaluron on Food Consumption:

In the larval feeding treatment, the insect growth regulator suppressed the rate of food consumption in treated larvae at higher concentration level but at lower level (0.0001%), Itwas less effective in reduction of the food consumption. The maximum reduction in food consumption recorded was 43.40 per cent at 1.00 per cent concentration level and minimum being 20.95 per cent at 0.0001 per cent level in test. The food digested by the treated larvae was also reduced with the increase in concentration level and was recorded 67.75 per cent maximum at 0.0001 per cent, in comparison to control which showed food digestion of 70.93 per cent (Table-3).

Effect of Chlorfluazuron on Food Consumption:

Under the larval feeding treatment, the used insect growth regulator suppressed the rate of food consumption in treated larvae at higher concentration level, but at lower level, the used insecticide was less effective in reducing the food consumption. The maximum reduction in food consumption was recorded as 45.20 per cent at 1.0 per cent concentration level in test. The food digested by treated larvae was reduced with the increase in concentration level and was recorded 36.17 per cent maximum at 0.0001 per cent concentration level, in comparison to control which showed food digestion of 70.93 per cent (Table-6; Fig.-6).

The data shows that the food intake was considerably reduced by the treated larvae at various concentration levels. At lower levels of concentration, the used insect growth regulator was also effective in reducing the food consumption. Food digested at 1.00 per cent was reduced by 29.69 per cent i.e. much reduced in comparison with control (Table-6).

DISCUSSION

As regards the influence of the insect growth regulators on biomass accumulation in *A.catalaunalis* larva, the related results have shown that both insect growth regulators considered under this investigation has potential to reduce the growth in *Antigastra catalaunalis* even at a very low concentration. Chattoraj and Singh [7], Chattoraj & Dwivedi [8], Sharma [31], Zhong [34], Nakano and Romano [25]), Gupta *et.al*. [13] and Gupta and Khattri [14] have also observed similar influence of insect growth regulators in other insects. The effect of the different concentrations of insect growth regulators on the accumulation of the biomass in the larva, which may not be graded in early larval life, becomes quite distinct in the late larva, the biomass reducing potential of fourth generation insecticide increases with the increase in its concentration.

Furthermore, in respect of the influence of insect growth regulators on the biomass accumulation in *A. catalaunalis* under different modes of their application to this insect, the related results indicate that Novaluronvand chlorfluazuron tested during this investigation proved effective. Novaluron reduce the larval biomass almost identically in early larval life. The identical decline in the larval biomass at a corresponding concentration under both modes of their application only up to the mid-larval life but thereafter, their corresponding concentration exert different biomass curtailing influence under both modes of their application.

The Novaluron trans located to the sites of their action under the both methods of their application to the *A. catalaunalis*. Since adequate growth is an attribute of proper nutritional metabolism, it may be presumed that the Novaluron and chlorfluazuron, the insect growth regulators interfere this aspect of physiology in *A. catalaunalis.* Hence they reduce the accumulation of the biomass in larvae of this insect. In *Antigastra catalaunalis* also, the insect growth regulators used in this work may hinder the protein synthesis causing consequent reduction in the larval biomass but this needs confirmation. Like the accumulation of the biomass of the larva, the acquisition of biomass in pupa and adults is also reduced by Novaluron and chlorfluazuron under adult feeding and residue film methods of treatment but both methods are not identically effective in causing reduction in the biomass of the pupa and adults. Like the novaluron a concentration of the chlorfluazuron also becomes more effective in reducing the larval biomass under the adult feeding method as compared the application of the same as the residue film to the *Antigastra catalaunalis*. However, contrary to the novaluron, a concentration of the chlorfluazuron potent in declining the biomass of the late larva when it is administered orally than when it is applied as residue film; with the adult feeding method, it becomes more effective than as the residue film applied to the adult.

The novaluron and chlorfluazuron are not equally efficient under both methods of their application suggest that the former insect growth regulator is equally translocated to the sites of their action under the both methods of their application to the *Antigastra catalaunalis*. Since adequate growth is an attribute of proper nutritional metabolism, it may be presumed that the novaluron and chlorfluazuron, the insect growth regulators interfere this aspect of physiology in *Antigastra catalaunalis* hence they reduce the accumulation of the biomass in larvae of this insect. In *Antigastra catalaunalis* also, the insect growth regulators used in this work may hinder the protein synthesis causing consequent reduction in the larval biomass but this needs confirmation.

Further, the results in this context reveal that there is an indirect proportionality between the biomass of these stages of life cycle and concentration of insect growth regulators. As regards the pupal biomass reducing potential of the different insect growth regulators both can be arranged as novaluron and chlorfluazuron in descending order. These facts suggest that the biomass curtailing influence of the chlorfluazuron and novaluron in *Antigastra catalaunalis* depends on the sex.

Table 1: Effect of different concentrations of Novaluron under different modes of treatment on biomass accumulation in larvae of *A. catalaunalis* Dup.

Mode of treatment	Concentration %	Larval biomass (mg) Mean ± S.E. on		
		5th day	10th day	15th day
	.0001	3.81±0.04	15.74±0.24	67.61±0.44
	.001	2.74±0.15	13.83±0.33	58.22±0.45
AFM	.01	2.43±0.16	11.34±0.36	47.13±0.44
	.10	2.25±0.12	10.72±0.32	47.14±0.45
	.50	1.76±0.14	8.83±0.34	29.76±0.55
	1.00	1.68±0.12	6.81.0.25	20.84.0.42
	.0001	3.84±0.13	15.72±0.45	72.46±0.45
	.001	2.96±0.15	13.82±0.46	61.35±0.54
	.01	2.78±0.12	11.41±0.43	50.25±0.64
RFM	.10	2.44±0.11	10.38±0.43	39.45±0.14
	.50	2.05±0.00	8.89±0.34	31.98±0.62
	1.00	1.85±0.14	6.85±0.34	23.89±0.78
	Control	4.32±0.14	22.66±0.56	110.94±0.84

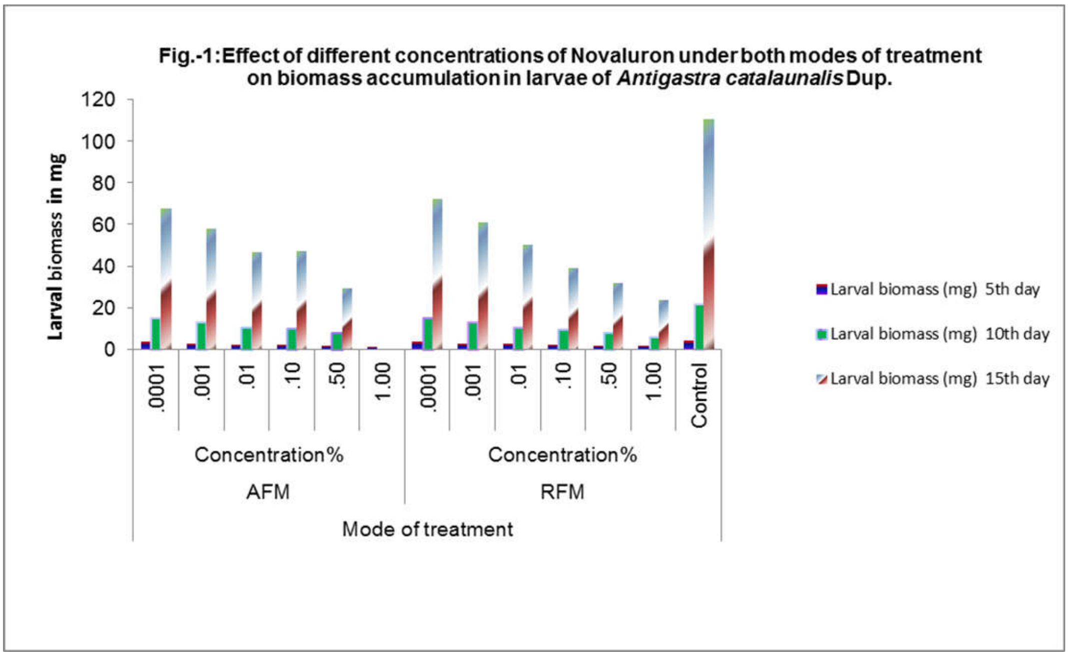


Table-2: Effect of different concentrations of Chlorfluazuron under different modes of treatment on biomass accumulation in larvae of *Antigastra catalaunalis* Dup.

Mode of treatment	Concentration %	Larval biomass (mg) ± S.E. on		
		5th day	10th day	15th day
	.0001	4.14±0.05	16.31.023	75.24±0.42
	.001	3.12±0.16	14.12±0.24	64.24±0.62
AFM	.01	2.83±0.17	12.53±0.25	54.24±0.74
	.10	2.54±0.13	10.66±0.24	42.82±0.53
	.50	1.96±0.12	9.44±0.13	34.26±0.63
	1.00	1.84±0.14	7.32±0.22	28.32±0.81
	.0001	4.37±0.11	16.26±0.15	77.92±0.67
	.001	3.24±0.02	14.16±0.26	67.93±0.46
	.01	3.13±0.13	12.54±0.16	56.25±0.65
RFM	.10	2.62±0.12	10.57±0.15	46.22±0.42
	.50	2.41±0.04	8.92±0.14	38.34±0.43
	1.00	2.23±0.14	6.85±0.13	30.26±0.50
	Control	4.32±0.14	22.64±0.56	110.94±0.84

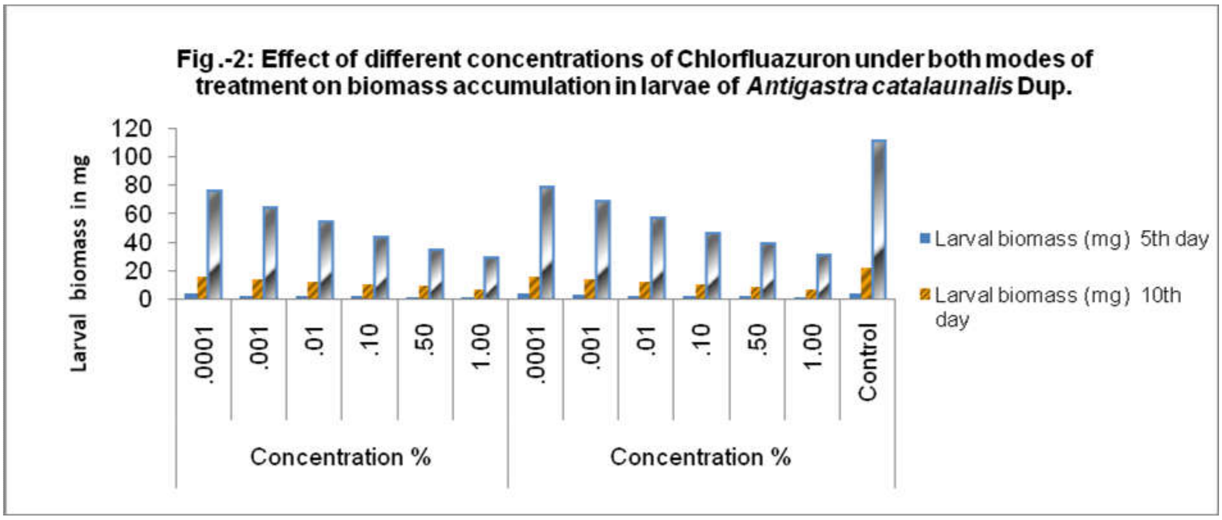


Table 3: Effect of different concentrations of Novaluron under different modes of treatment on biomass accumulation by pupa and adult of *A. catalaunalis* Dup.

Mode of Treatment	Concentration %	Larval biomass (mg) Mean ± S.E. on		
		Pupa	Male	Female
	.0001	142.02±0.44	94.32±0.44	103.46±0.82
	.001	133.52±0.64	92.11±0.48	97.10±0.82
AFM	.01	124.85±0.32	83.45±0.32	90.10±0.92
	.10	110.63±0.64	73.83±0.52	78.12±1.04
	.50	97.24±1.02	54.14±1.93	70.24±1.25
	1.00	69.57±1.45	48.36 ±2.34	52.38±0.72
	.0001	144.44±0.33	95.12±0.72	101.24±0.53
	.001	138.53±0.84	93.80±0.52	104.13±0.72
	.01	126.06±0.62	93.43±0.93	96.78±0.52
RFM	.10	109.24±0.83	88.42±1.12	82.46±1.13
	.50	94.78±1.12	73.26±0.82	76.42±1.06
	1.00	72.14±1.14	54.64±0.93	55.74±1.12
	Control	153.62±0.92	104.43±1.22	110.12±0.94

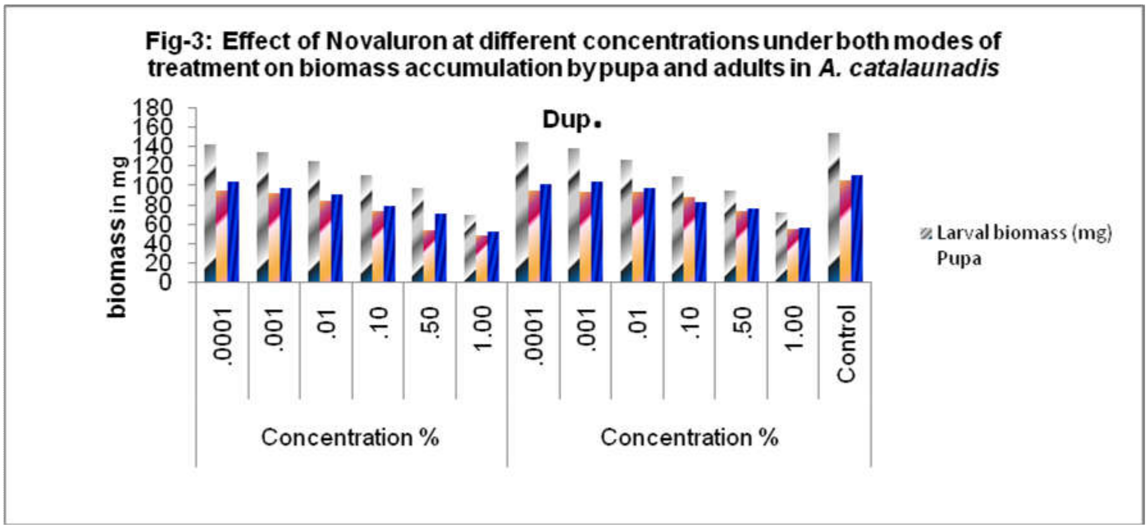


Table-4: Effect of Chlorfluazuron at different concentrations under different modes of treatment on biomass accumulation by pupa and adults in *Antigastra catalaunalis* Dup.

Mode of treatment	Concentration%	Larval biomass (mg) ± S.E. on		
		Pupa	Male	Female
AFM	.0001	149.63±1.14	102.86±0.82	107.82±1.04
	.001	143.64±0.96	92.42±0.96	100.10±0.96
	.01	134.64±0.82	85.66±0.78	93.44±0.88
	.10	129.46±0.16	76.92±0.84	82.00±0.69
	.50	124.25±0.83	70.64±0.62	73.66±0.64
	1.00	102.45±0.94	57.38±0.72	63.12±0.64
RFM	.0001	154.82±0.95	103.21±0.84	108.62±0.84
	.001	147.14±0.94	98.08±0.62	104.74±0.92
	.01	142.17±0.82	89.14±0.70	98.12±0.93
	.10	136.12±0.84	82.06±0.82	87.64±0.92
	.50	126.64±0.71	75.86.0.84	78.12±0.88
	1.00	106.60±0.94	64.14±0.63	68.86±0.62
	Control	153.62±0.92	104.43±1.22	110.12±0.94

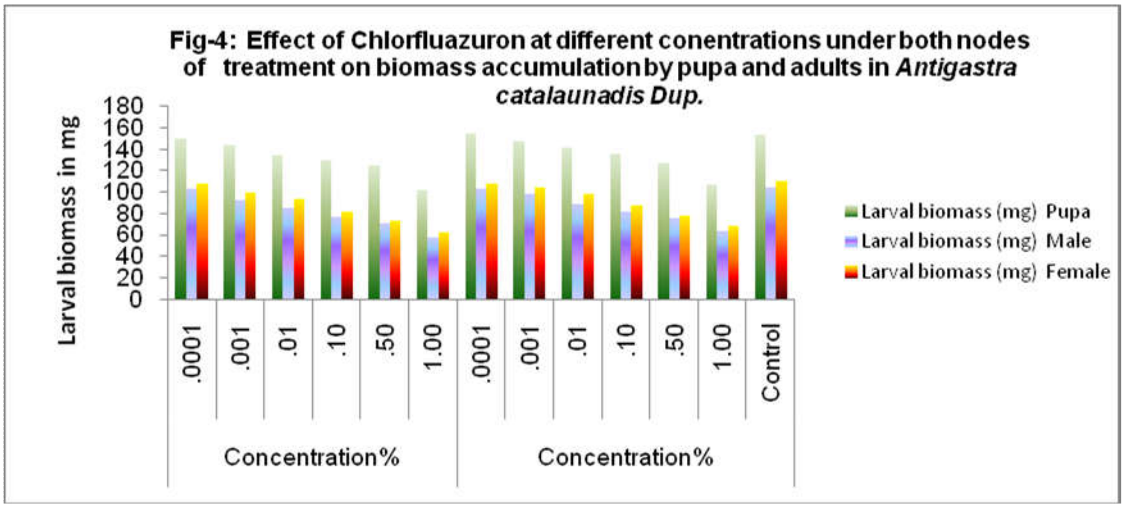


Table 5: Effect of Novaluron on food consumption and faecal matter of larvae in larval feeding treatment *A. catalaunalis* Dup.

Conc. %	Larval periods In days	Total amount of food consumed (fecal matter) per larvae (g)	Reduction in food consumption (g)	Food Digested %
.0001	12.5	2.924	0.356	67.75
		(0.933)		
.001	13.8	2.674	0.698	66.42
		(.856)		
.01	14.6	2.396	0.884	65.72
		(.824)		
.10	15.2	2.335	1.203	63.82
		(.823)		
.50	15.7	3.133	1.203	31.30
		(1.276)		
1.00	17.0	1.448	2.377	29.41
		(1.435)		
		3.275		
Control	11.00	(0.951)	---	70.93

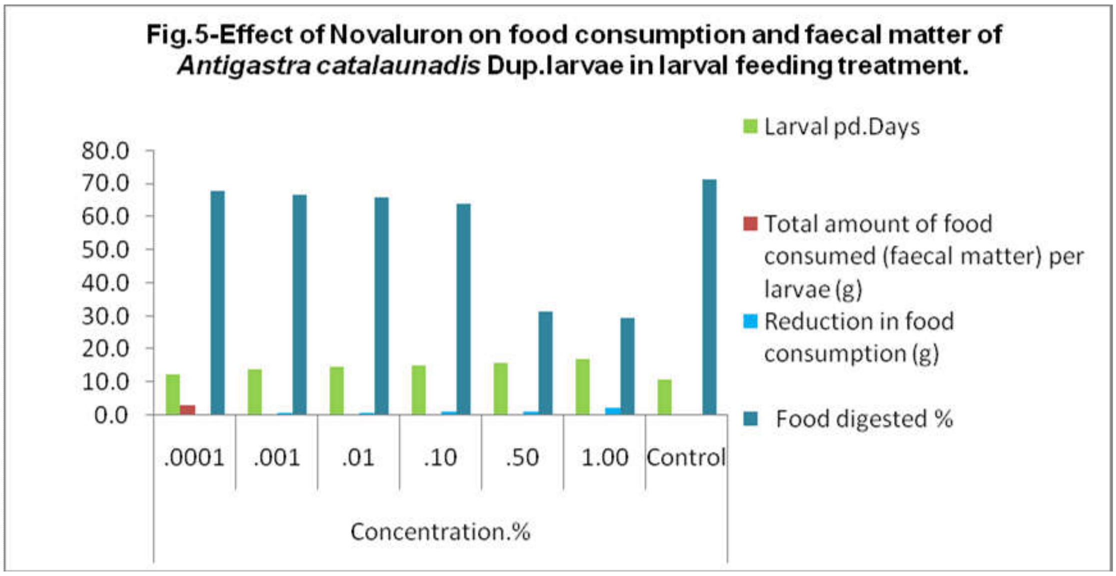
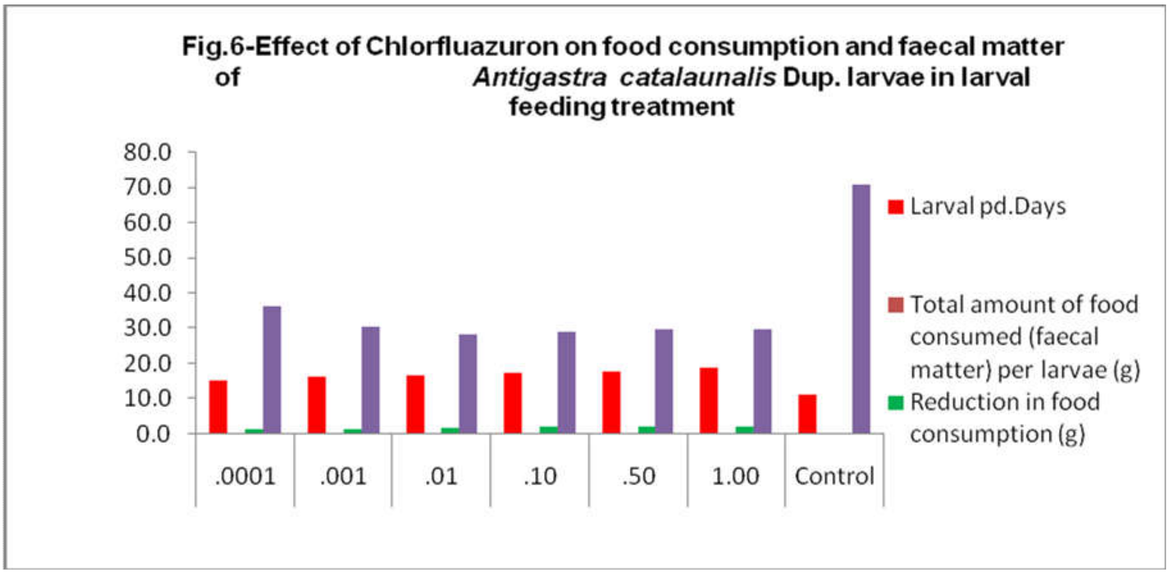


Table 6. Effect of Chlorfluazuron on food consumption and faecal matter of *Antigastra catalaunalis* Dup. larvae in larval feeding treatment

Concentration%	Larval Period in days	Total amount of food consumed (faecal matter) per larvae (g)	Reduction in food consumption (g)	Food digested %
.0001	15.0	3.671 (2.343)	0.950	36.17
.001	16.0	3.0363 (2.338)	1.258	30.47
.01	16.5	3.226 (2.314)	1.358	28.27
.10	17.0	2.750 (1.961)	1.871	28.69
.50	17.5	2.378 (1.683)	1.681	29.41
1.00	18.5	2.714 (1.908)	1.903	29.69
Control	11.00	3.275 (0.951)	---	70.93



CONCLUSION

Further, the results in this context reveal that there is an indirect proportionality between the biomass of these stages of life cycle and concentration of insect growth regulators. These facts suggest that the biomass curtailing influence of the Novaluron and chlorfluazuron in*A. catalaunalis* depends on the sex. The Novaluron and chlorfluazuron applied by the adult feeding method reduced the biomass of the late larva of *A. catalaunalis* more than when it is applied as residue film; this chemosterilants's different concentrations are equally effective in reducing the larval biomass under the both modes of the treatment. However, contrary to the Novaluron, a concentration was potent in declining the biomass of the late larva when it is administered orally than when it is applied as residue film; with the adult feeding method, it becomes more effective than as the residue film applied to the adult. Besides causing abnormal mortality of larvae, depending on Novaluron and chlorfluazuron concentration, it inhibit emergence of adults to considerable extent, the inhibition of the emergence under the influence of an insect growth regulator, it decreases with increase in concentration Novaluron. Usually the oral treatment with the insect growth regulator is more effective than its application through the residue film in context of the inhibition of the emergence of adults. In context of the efficiency of the insect growth regulators reducing the accumulation of the biomass in larvae, as per results of this investigation, considering concentrations from 0.0001 to 1.00 per cent the insect growth regulators screened under this investigation may be arranged as novaluron and chlorfluazuron in descending order.

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