Pest Management in Horticultural Ecosystems
Vol. 24, No.2 pp 241-246 (2019)

Efficacy of an insect growth regulator on Amaranthus leaf caterpillar, *Spoladea recurvalis* (Fab.) (Lepidoptera; Crambidae)

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ABSTRACT: Insect growth regulator (Novaluron) at different concentrations was evaluated against amaranthus leaf caterpillar for their survival, growth and development on amaranthus leaves in leaf dip bio-assay and contact bio-assay method. Effect of novaluron against *Spoladea recurvalis*using contaminated food bio-assay showed that the larvicidal action was observed at 36 hours of treatment and at 60 hours of treatment the maximum mortality (80.00%) was at 3.0 per cent concentration whereasthe lowest pupation, highest pupal mortality and pupal malformation wereat 0.08 per cent concentration. In thecontact bio-assay, all the test concentration data recorded larvicidal effect and pupal malformation.

Keywords: Novaluron, Insect Growth Regulator*, Spoladea recurvalis*

INTRODUCTION

Amaranthus which is native of tropical America, has been widely distributed throughout the tropics and considered a popular leafy vegetable which isrich in protein, calcium, phosphorus, folic acid, potassium, iron and vitamins A, B and C but fairly low in carbohydrate and recommended as a good food with medicinal properties for pregnant women, lactating mothers and patients with constipation, fever, haemorrhage and anaemia. (Martirosyan *et al*. 2001 and Martirosyan *et al.*, 2003; Quinton, 2006 and Okpara *et al*., 2013).Many insect pests are associated with amaranthus, among them Amaranthus leaf caterpillar *Spoladearecurvalis*was considered a destructive pest and was widely distributed in tropical and subtropical regions including Africa, Asia and Australia (Bailey, 2007;Arivudainambi*et al*., 2010;James *et al*., 2010; Garcia *et al.,*2011). In the Indian sub-continent, it was found throughout the year but more active during warmer, rainy and early winter months.Besides Amaranthus, it was also recorded as a major pest of grasslands (Kedar and Kumaranag, 2013). Insecticide application for the past two decades not only engaged the insect to develop resistance and caused environmental pollution related problems (Srinivasan, 2012; Sharma and Singhvi 2017). A new approach to insect pest control is the use of insect hormone mimics or insect growth regulators (IGRs). They are quite selective in their mode of action and potentially act only on target species. The action of IGRs, however, should not be confused with other synthetic insecticides, such as organophosphates and carbamates, since these chemicals interfere with other physiological processes but do not regulate the development of normal insects (Tunaz and Uygun, 2004). This experiment was carried out to find out the effect of novaluron using different method of treatment for the management of Amaranthus leaf caterpillar.

MATERIALS AND METHODS

Insect rearing

Adults of amaranthus leaf webber*S.recurvalis*collected from the unsprayed amaranthuscropwere confined in ovipositioncages of 60X60X60 cm size. The adults were released at a sex ratio of 1: 2 (M : F). They were provided with 10 per cent honey solution dipped in cotton. Ten days old amaranthus plants raised in the nursery were kept in small plastic cups and were placed inside the ovipositioncage as a substrate for egg-laying.The females laid pale green coloured eggs on either surface of leaves. The emerged first instar larvae were feed on the plant itself. The greenish second instar larvae, above 4mm long, were transferred to a plastic container and supplied with young, fresh plants of amaranthus. The container was closed with a muslin cloth and fresh plants were supplied daily. The larvae were reared in such plastic containers up to third instars in batches and were utilized for the experiments.

Evaluation of Novaluron against amaranthus leaf caterpillar:

Insect growth regulatory activities of Novaluran against *S.recurvalis*was evaluated in laboratory maintained hosts.Third instar larvae were used for the experiment and experiments were replicated thrice under completely randomized design under laboratory conditions of 28±2^{0}C and 90 per cent relative humidity.

Leafdip bio-assay

Amaranthus leaves (uniform sized) were taken from healthy, unsprayed plants and were treated with the corresponding treatments (Novaluron-0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 1.0, 3.0% and Diflubenzuron-0.06%) using leaf dip method (10 seconds) and were shade dried. Treated leavesafter shade drying were placed in a petridish @ five per plate to which five pre-starved(four hour) larva were released into eachpetridish. The insects were allowed to feed on novaluron treated leavesfor 24 hours and then fresh untreated leaves were provided after 24 hours and the experiment was continued upto three days.

Contact bio-assay

Different concentrations *viz*., 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 1.0 and 3.0 per cent were prepared from stock solution and were treated on top throxic region four hour prestarved larva placed in the petri plates @ five per plate provided with five amaranthus leaves as per the method described by Sundaramurthy (1996).The experiment was continued upto three days. Observations were made on Larval and pupal mortality, pupation and adult emergence percentage. The data were statistically analysed and tabulated.

RESULTS AND DISCUSSION

Evaluation of Novaluron against amaranthus leaf caterpillar using contaminated food bio-assay

Data showed that the larvicidal action was observed at 36 hours of treatment. The mortality of larva at 36 hours ranged between 0 and 73.33 per cent with maximum by standard check – diflubenzuron(73.33%) whereas the minimum (0%) was noticed in control. Among the treatments 3.0 per cent attributed maximum larvicidal action (66.67%) followed by 0.4 per cent (40.00%) and 0.5 per cent, 1.0 per cent (33.33%).During the course of the experiment, the mortality rate increased and at 48 hours of treatment, the data on mortality revolved between 0 and 80 per cent with a maximum of 80 per cent by both Diflubenzuron-0.06 per cent and novaluron 3.0 per cent was statistically on par with each other. The next best treatment was 0.4 followed by 0.1, 0.5, 1.0 and 0.3 per cent which exhibited the mortality of 60.00, 53.33, 46.67, 46.67 and 40.00 per cent respectively with statistical significance. Further, at 60 hours of treatment, data collected on the larvicidal action of novaluron at higher dose revealed that the maximum mortality was exhibited by 3.0% and Standard check (Diflubenzuron-0.06%) (80.00%) and was on par with each other whereas the minimum was in control. IGR as noted byElsworthip and Martinez (2001) who reported that diflubenzuron and its derivatives were effective against insect pests.El-Khayat*et al*. (2012) tested the stomach poisonous impact of some IGR's and biocides under laboratory conditions against cotton leaf worm, *S. littoralis* and revealed that the second instar larvae reflected a higher level of susceptibility towards all the tested insecticides.Reda *et al*. (2013) studied the larval susceptibility of *S.littoralis*to IGRs, tebufenozide, lufenuroninand reported that lefenuronin was very effective on lethal and sub-lethal concentrations.

Pupation data revealed that 100 per cent pupation was recorded only in control whereas in other treatments and check considerable death was noticed. Among the treatments the lowest pupation was exerted by 3.0 per cent (20.00%) which was on par with Diflubenzuron-0.06 per cent followed by 0.4 per cent (26.67%), 1.0 per cent (40.00%) and 0.1 per cent (46.67%)(Fig. 1).Pupal malformation data revealed that maximum was in diflubenzuron and in all the doses as expressed by Ratnaand Krishna (1986) reported the toxicity and development disturbance of IGRs on *S.litura*Fab.

Pupal malformation data revealed that maximum was in check and 1.0 per cent (80.00%) followed by 3.0per cent(73.33%), 0.6per cent (60.00%) and minimum was in control (0.00%).Data observed for adult emergence showed that in all treatments including check there was zero per cent adult emergence and the maximum adult emergence was occurred in control (100 %)(Fig. 2). Sundaramurthy (1996) reported that IGR prevent successful pupation (larval-pupal mosaic) and cause mortality in *S.litura*.

Evaluation of Novaluron against amaranthus leaf caterpillar using contact bio-assay

The experimental results from contact bio-assay revealed that the mortality of larva at that the mortality was recorded at 12 hours of treatment. 100 per cent mortality recorded in Check (Diflubenzuron - 0.06%) followed by 3 per cent (46.67 %), 1 % (26.67 %) whereas the minimum (0%) was noticed in control. Result of 24 hours data showed that among the different doses of novaluron 3per cent concentration recorded with maximum mortality (46.67%) followed by 1per cent (33.33%),0.6per cent (20.00%)and 0.1 per cent (6.67%) with statistical significance (Table 1). The similar trend observed in after 36hours of treatment. During the course of experiment the mortality rate increased and at 48 hours of treatment the data on mortality revolved from 0 to 100 per cent with a maximum of 100 per cent T9 check (Diflubenzuron - 0.06%) and among the treatments maximum mortality recorded at 3per cent (66.67%) The

next best treatment was 1per cent followed by 0.6, 0.5, 0.4, 0.3, 2 and 1per cent which exhibited the mortality of 60.00, 46.67, 40.00, 33.33, 33.33, 26.67 and 26.67 per cent respectively with statistical significance. 0.2per cent and 0.5per cent on par with each other. Among the different concentration of novaluron the maximum per cent mortality recorded in 3per cent (66.67 %) followed by 1per cent (60.00%) comparatively less per cent mortality recorded in 0.1per cent (26.67%).Cutler *et al.*(2006) reported the several effects of Novaluron on egg, larval and pupal stages of important insect pests with less effects on non-targetted organisms and supported by the investigations of Christopher *et al.*(2007).

Effect novaluron affected the pupation of *S.recurvalis*after 60hours resulted that maximum pupation percentage was recorded in 0.1per cent(73.33%) followed by 0.2per cent,0.4per cent (66.67%), 0.3 per cent, 0.5 per cent (60.00%), 0.6 per cent, 3.0per cent (40.00%) whereas cent percent pupation recorded in the control (0%).Carton *et al*. (2003) studied the effect diflubenzuron on Asian lady beetle, *Harmonia axyridis*andreported pupal mortality and adult malformation.Data on pupal malformation displayed maximum in 0.3per cent (73.33%) followed by 0.4per cent (60.00%), 0.2per cent (53.33%) and 0.5per cent (33.33%) whereas 3.0per cent pupal malformation was 20 per cent and in control no malformation was recorded. Data observed for adult emergence showed that in all the treatment including check. There was cent percent adult emergence recorded in control (Fig. 2).Sundaramurthy (1996) reported that topical application of insect growth regulators to freshly moulted sixth-instar larvae of *Spodopteralitura* prevented their differentiation into pupae and resulted in the formation of a larval-pupal mosaic and of supernumerary larvae. The experimentalresults suggested that novaluron could be a valuable tool in Amaranthus leaf caterpillar management.

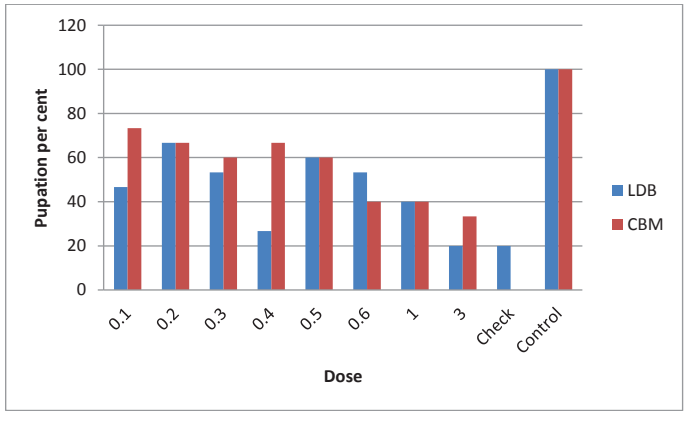

Fig 1. Effect of Novaluron treatments on the Pupation of Amaranthus caterpillar

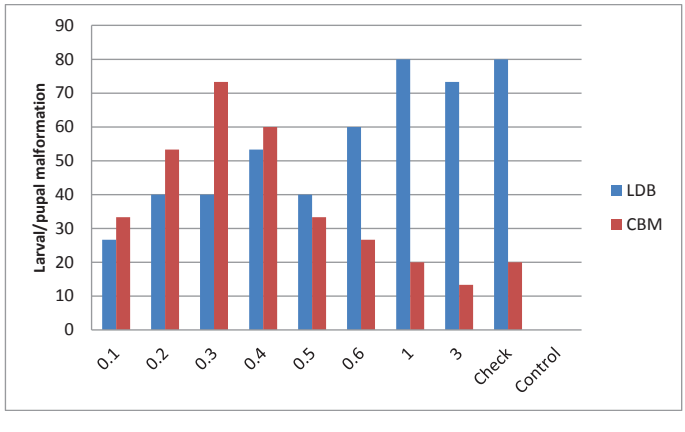

Fig 2.Larval and pupal malformation per cent in Leaf Dip Bio-assay and Contact bio-assay

Treatment	Dose (%)	Per cent mortality of larvae after 12H* LDM	12H* CBA	24H* LDM	24H* CBA	36H LDM	36H CBA	48H LDM	48H CBA	60H LDM	60H CBA
T_1	0.1	0.00	0.00^{d} (1.28)	0.00	6.67^{d} (9.70)	26.67^{c} (30.78)	20.00^{bc} (26.56)	53.33^{bc} (43.45)	26.67^{e} (30.78)	53.33^{bc} (47.30)	26.67^{c} (33.61)
T_2	0.2	0.00	0.000^{d} (1.28)	0.00	0.00^{d} (1.28)	20.00^{c} (26.56)	20.00^{c} (22.36)	33.33^{c} (36.19)	33.33^{de} (35.01)	33.33^{d} (35.01)	33.33^{c} (36.19)
T_3	0.3	0.00	0.00^{d} (1.28)	0.00	0.00^{d} (1.28)	26.67^{c} (26.58)	26.67^{bc} (30.78)	40.00^{bc} (38.41)	40.00^{de} (39.23)	46.67^{bcd} (43.07)	40.00^{c} (38.78)
T_4	0.4	0.00	0.00^{d} (1.28)	0.00	0.00^{d} (1.28)	$40.00b^{c}$ (39.23)	20.00^{bc} (26.56)	60.00^{ab} (45.67)	26.67^{e} (30.78)	60.00^{b} (51.14)	33.33^{c} (36.19)
T_5	0.5	0.00	0.00^{d} (1.28)	0.00	0.00^{d} (1.28)	33.33^{c} (35.01)	20.00^{bc} (22.36)	46.67^{bc} (41.00)	33.33^{de} (35.01)	46.67^{cd} (39.23)	40.00^{c} (38.41)
T_6	0.6	0.00	0.00^{d} (1.28)	0.00	20.00^{c} (26.56)	20.00^{c} (22.36)	26.67^{c} (30.78)	33.33^{c} (36.19)	46.67^{cd} (43.07)	46.67^{bcd} (43.07)	60.00^{b} (45.44)
T_7	1.0	0.00	26.67^{c} (30.78)	0.00	33.33^{bc} (35.01)	33.33^{c} (35.01)	40.00^{bc} (38.85)	46.67^{bc} (41.00)	60.00^{bc} (50.77)	60.00^{bc} (50.77)	60.00^{b} (45.44)
T8	3.0	0.00	46.67^{b} (43.07)	0.00	46.67^{b} (43.07)	66.67^{ab} (54.99)	46.67^{b} (43.07)	80.00^{a} (52.79)	66.67^{b} (54.99)	80.00^{a} (63.43)	66.67^{b} (47.89)
T9 (Check)	Diflubenzuron - 0.06%	0.00	100.00^{a} (88.72)	0.00	100.00^{a} (88.72)	73.33^{a} (59.21)	100.00^{a} (88.72)	80.00^{a} (52.79)	100.00^{a} (88.72)	80.00^{a} (63.43)	100.00^{b} (70.37)
T10 (Control)	Water	0.00	0.00^{d} (1.28)	0.00	0.00^{d} (1.28)	0.00^{d} (1.28)	0.00^{d} (1.28)	0.00^{d} (6.50)	0.00^{f} (1.28)	0.00^{e} (1.28)	0.00^{d} (6.50)
SEd		-	**4.22**	-	**5.16**	**10.33**	**10.33**	**11.15**	**7.30**	**9.43**	**7.89**
CD (p=0.05)		-	**8.79**	-	**10.77**	**21.54**	**21.54**	**23.27**	**15.23**	**19.67**	**16.45**

LDM-Leaf Dip Method; CDM-Contact Bio-assay; Values are mean of three replications; values in the parentheses are arcsine transformed values; in a column means followed by a common letter are not significantly different at 95% level by LSD; * Non-significant

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MS Received 21 August 2019
MS Accepted 14 October 2019