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Ecofriendly techniques for the management of *Helicoverpa armigera* (Hubner) in tomato

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ABSTRACT

Tomato fruit borer, *Helicoverpa armigera* (Hubner) (Lepidoptera : Noctuidae) is one of most serious pest of tomato crop grown in Solan area of Himachal Pradesh. Studies were conducted to observe, the effect of Nimbecidine, NeemAzal and role of birds in the suppression of *H. armigera* larval population in the tomato field. Nimbecidine was sprayed at 0.30 and 0.60 ppm azadirachtin concentrations, whereas Neem Azal was sprayed at 10.00 and 20.00 ppm azadirachtin concentrations. The maximum larval reduction after three sprays recorded at 20.00 ppm concentration of Neem Azal (71.29 %) with higher fruit yield (20.42 kg) and lowest fruit infestation (7.18 %). Birds like *Acridotheres tristis, Cissa erythrorhyncha, Copsychus saularis, Corvus macrorhynchos, Dicrurus adsimilis, Parus major, Passer domesticus, Pycnonotus cafer, Pycnonotus leucogenys, Saxicola caprata* and *Turdoides striatus* were found feeding on *H. armigera* larvae in tomato crop. *Pycnonotus cafer* and *Acridotheres tristis,* used the T- shaped perches more frequently than other species. In plots where T- shaped perches were installed, the larval survival was less in comparison to netted and control plots. In netted plots where birds were excluded maximum larval survival (76.78 %) was observed in comparison to control plots (66.53 %) where bird had free access to *H. armigera* larvae. The reduction of 10.25 per cent *H. armigera* larvae was attributed to the bird predation alone. Due to higher survival of larvae in netted plots less fruit yield (8.83 kg) were recorded in comparison to control plots (11.33 kg).

Keywords: Tomato fruit borer, crop pest, Nimbecidine, NeemAzal, azadirachtin, insectivorous birds

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) is an important Solanaceous crop grown throughout the world. Tomato is cultivated as an important summer (April to October) vegetable crop in mid hill region of Himachal Pradesh. Being an off-season crop, the cultivators of Himachal Pradesh find ready made market in plains of Northern India thus fetching very remunerative price. However, the crop is attacked by as many as 21 different species of insect pests in Solan area of Himachal Pradesh (Sharma, 1975). Among these insect pests, tomato fruit borer, *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae) is one of the most serious pest. It causes as high as 70 per cent loss in fruit yield (Kakar *et al*., 1990). In the initial stage of the crop, it feeds on leaves and later bores into the fruit, rendering the fruit unfit for human consumption. Inseticides like endosulfan, fenvalerate, cypermethrin, deltamethrin and carbaryl (Atwal and Dhaliwal, 1997) are widely used to control this notorious pest.

Application of chemical insecticides cause adverse effects like toxicity to non-target organisms (predators, parasitoids and pollinators), development of insecticide resistance, pest resurgence, environmental pollution and health hazards. Now emphasis is now being given on integrated pest management which lays stress on minimal use of the insecticides and their integration with other control tactics. Simultaneously, the search for safe insecticides to substitute the existing synthetic toxic insecticides has been intensified all over the world.

In this changing scenario, the botanical insecticides can, to a large extant meet the demand for safe and environmentally sound crop protection measures. Botanicals can be characterized as environmentally non-persistent and therefore, are unlikely to result in environmental contamination. Neem, *Azadirachta indica* is held in esteem by Indian folks due to its medicinal and insecticidal properties. Mixing of neem leaves with grain during storage and keeping dried leaves between folds of cloths to protect them against insects is rather well practiced in India. Neem products have attracted the attention of agricultural scientists for their use as pesticides to provide a pollution free control of insect pests. Effects of neem are antifeedant, repellent, metamorphosis disruption, growth disruption, oviposition deterrent and anti-reproduction in insects (Mishra, 1994). Neem based formulations like Achook, Neemazal, Nimbecidine and Neem Jeevan Triguard have been used against the *Helicoverpa armigera* on various crops other than tomato and were found effective (Gupta and Birah, 2001). However, Dhaliwal and Arora (1996) reported the repellent and antifeedant effects of neem seed kernel extract against a wide range of insect-pests like desert locust, *Schistocerca gregaria* (Forskal), migratory locust, *Locusta migratoria* (Linnaeus), the rice plant hoppers, *Nilaparvata lugens* (Stal), the leaf folder, *Cnaphalocrocis medinalis* (Guenea) and the ear cutting caterpillar, *Mythimna separta* (Walker), Recently, Ovicidal activity of three plants against this pest has also been studied by Malarvannan *et al.* (2009). Birds are natural regulators of insect population and their mobility allows them to respond numerically to pest increase. In this respect they resemble insecticides and other catastrophes, which destroy a large proportion of a pest population quickly (Woods, 1974). In Chickpea, birds like Myna, Sparrow, Baya, Babbler, Black drongo, Cattle egret etc feed on *Helicoverpa armigera* larvae and cause significant reduction in pod damage which result in tremendous increase in the yield (Parasharya *et al.*, 2002). Birds have also been reported to reduce the larval population of *Spodoptera* and *Helicoverpa* significantly in groundnut crop (Rao *et al.*, 1998). However, the useful role of birds against *Helicoverpa armigera* in tomato crop has not been studied. Therefore, neem formulations *viz*. Nimbecidine and NeemAzal and insectivorous birds were evaluated against tomato fruit borer *Helicoverpa armigera* larvae in tomato.

MATERIALS AND METHODS

Tomato (*Lycopersicon esculentum* Mill.) (cv. Naveen 2000) seedlings were transplanted at 0.90 m X 0.40 m spacing in the beds (4 X 3 m) and crop was further maintained as per the cultural practices given in package and practices of vegetables crops, Directorate of Extension Education, UHF Nauni, Solan.

Evaluation of neem-based formulations

Two neem-based formulations were tested against tomato fruit bores. Nimbecidine containing 300 ppm azadirachtin was the product of M/S T. Stanes and Co. Ltd., Coimbatore, Tamil Nadu and NeemAzal, containing 10000 ppm azadirachtin was the product M/S EID Parry (India Ltd.), Chennai, Tamil Nadu. Nimbecidine was sprayed @ 1ml/l (0.30 ppm), 2ml/l (0.60 ppm) and NeemAzal, was sprayed @ 1ml/l (10.00 ppm), 2ml/l (20.00 ppm) on tomato crop with knapsack sprayer. Each treatment was replicated thrice. Tomato crop was sprayed three times at 15 days interval. The larval population of *Helicoverpa armigera* was counted on 10 randomly selected plants from each replication after 1, 3, 5, 7 and 10 days of treatment. The per cent reduction of the larval population was worked out by using the formula.

$$\text{Percent reduction in larval population} = \frac{\text{larval population in control plot - larval population in treated plot}}{\text{larval population in control plot}} \times 100$$

In order to concise the table/data, the mean per cent reduction in different days after each spray was used to compare the data.

Role of birds in suppression of *Helicoverpa armigera*

Three plots of tomato crop were covered with plastic anti bird net of mesh size (2.5 X 2.5 cm) to prevent the access of birds to their prey. This served as bird-free area (netted area) whereas the remaining area of the entire field served control plots where birds could freely prey upon *Helicoverpa* larvae. Net was installed in each bed to the height of 1.8 m with the help of wooden stick. Perches were erected in three plots just after transplanting of tomato seedling, one perch in one plot, so as to make the birds get accustomed to crop. Wooden sticks were arranged into a T-shaped perches having vertical stick length 1.65 m and horizontal stick length 0.6 m. Tomato plants were provided with stakes at 56 days after transplantation (DAT) which also acted as perches.

Activity of insectivorous birds was observed visually through 10 X 50 binocular at weekly interval. Birds visiting during morning (6.00-7.00), noon (13.00-14.00) and evening (18.00-19.00) hours were recorded. Birds which used perches and those made successful and unsuccessful attempts were also recorded. Bird which picked larva was considered making a successful attempt and which tried to pick larva but failed was considered as unsuccessful attempt.

Population of *Helicoverpa armigera* larvae in perch, control and netted plots were counted at weekly interval in 10 randomly selected plants and converted into percentage larval survival according to the Parasharya *et al.* (1996). Fruits were harvested at different flushes. At each flush weight of healthy fruits were recorded in each replication. Number of healthy and larval infested fruits were also recorded. At the end of experiment, weight of healthy fruits at all flushes was added and considered as yield per plot. Similarly, number of healthy and infested fruits were also pooled, respectively for each replication and converted into per cent fruit infestation. The data recorded on different parameters were subjected to analysis of variance through Randomised Block Design and Factorial Randomised Block Design (Gomez and Gomez, 1976)

RESULTS AND DISCUSSION

Nimbecidine and NeemAzal against *Helicoverpa armigera* larvae

Among the numerous plant botanicals studied during the last 20 years, extracts and components derived from various parts of neem tree (leaves, seeds kernel etc.) have shown promising results in insect suppression. Neem derivatives affect more than 105 species of insects in India belonging to 10 orders namely Orthoptera, Dictyoptera, Lepidoptera, Coleoptera, Hemiptera, Diptera, Hymenoptera, Isoptera, Siphenoptera and Thysanoptera (Singh and Kataria, 1991; Singh, 1993). Neem extracts are toxic to over 400 species of insect pests of which some already have developed resistance to conventional pesticides (Williams *et al.*, 1986). Application of neem-based formulations viz. Nimbecidine and NeemAzal reduced *Helicoverpa armigera* larval population in the tomato crop. The maximum larval reduction in three sprays recorded at 20.00 ppm concentration of NeemAzal was 71.29 per cent (Table 1) with higher fruit yield of 20.42 kg and lowest fruit infestation (7.18 %) (Table 6). Two sprays of NSKE (5 %) against *H. armigera* on Pigeon pea were reported to cause 63.39 and 53.48 per cent larval reduction and minimum pod damage of 49.86 and 43.95 per cent (Sarode *et al.* 1995). NeemAzal spray at 2ml/l dose caused maximum reduction in larval population (81.33 %) after 10 days of application in comparison to 65.80 % reduction in larval population in Nimbecidine treated plots @ 2ml/l (Sharma, 2001). Ranjan and Singh (2003) observed 38.3 per cent fruit infestation and 39.2 kg yield of litchi fruit after the application of Nimbecidine (0.2 %) against litchi fruit borer, *Conopomorpha cromerella* Snell, whereas in control 60.0 per cent fruit infestation and yield 28.9 kg/tree was observed. Similarly, Prasad (2003) studied the effect of Nimbecidine (1.0 %) against *Helicoverpa armigera* on linseed and observed 10.86 per cent capsule damage with yield of 688.63q/ha in comparison to control where capsule damage was observed to be 16.86 per cent with yield of 405.60q/ha.

Table 1. Field efficacy of NeemAzal and Nimbecidine against *Helicoverpa armigera*larvae on tomato crop

Treatment	Dosage (ppm)	Mean per cent reduction in larval population after treatment			
		1st spray	2nd spray	3rd spray	Over All mean
NeemAzal	10.00	59.60 (50.82)	61.00 (52.05)	63.20 (53.07)	61.27 (51.98)
NeemAzal	20.00	73.73 (59.71)	65.53 (54.14)	74.60 (60.24)	71.29 (58.03)
Nimbecidine	0.30	57.87 (49.64)	55.80 (48.37)	60.80 51.55	58.16 (49.86)
Nimbecidine	0.60	71.53 (58.32)	63.87 (53.21)	67.07 (55.27)	67.49 (55.60)
	Mean	65.68 (54.62)	61.55 (51.94)	66.42 (55.03)	

Values in parentheses are sin inverse transformed value, $CD_{0.05}$ Treatment(T) = 0.95, Spray(S) = 0.82, Interaction (T X S) = 2.60

Table 2. Use of T-shaped perch by bird species in tomato field (28 DAT to 56 DAT)

Species	Mean number of birds visit per hour	
	Inside the field	Alighted on the perch
Acridotheres tristis	7.43(2.72)	2.93(1.80)
Cissa erythrorhyncha	2.52(1.68)	0.67(1.00)
Copsychus saularis	2.97(1.78)	0.67(1.00)
Corvus macrorhynchos	3.55(1.90)	0.66(0.92)
Dicrurus adsimilis	5.25(2.31)	1.80(1.43)
Parus major	7.63(2.73)	1.67(1.36)
Passer domesticus	6.80(2.58)	2.33(1.54)
Pycnonotus cafer	8.05(2.81)	4.13(2.06)
Pycnonotus leucogenys	7.47(2.73)	2.67(1.67)
Saxicola caprata	3.09(1.78)	1.07(1.19)
Turdoides striatus	8.03(2.78)	1.60(1.33)
Mean	5.71(2.35)	1.84(1.39)

Values in parentheses are $\sqrt{x+0.5}$ transformed value

$CD_{0.05}$ Perch /field = 0.12

Interaction = 0.28

Role of bird against *Helicoverpa armigera* larvae

Many birds have a high rate of insect intake and the recognition of this fact lead to preliminary studies concerned either with relationship of birds to the suppression of noxious insects (Sweetman, 1958) or to their protection and encouragement in areas with a high risk for insects infestation (Bruns, 1955). Comman myna *Acridotheres tristis* (Sturnidae), Redbilled blue magpie *Cissa erythrorhyncha* (Corvidae), Magpie robin *Copsychus saularis* (Muscicapidae), Jungle crow *Corvus macrorhynchos* (Corvidae), Black drongo *Dicrurus adsimilis* (Dicruridae), Grey tit *Parus major* (Paridae), House sparrow *Passer domesticus* (Ploceidae), Redvented bulbul *Pycnonotus cafer* (Pycnonotidae), White cheeked bulbul *Pycnonotus leucogenys* (Pycnonotidae), Pied bush chat *Saxicola caprata* (Muscicapidae), and Jungle babbler *Turdoides striatus* (Muscicapidae), were found feeding on *Helicoverpa armigera* larvae in tomato crop. The birds like Myna, *Acridotheres* spp, Black drongo *Dicrurus adsimilis*, House crow, *Corvus splender*, House sparrow, *Passer domesticus* were also reported feeding on lepidopteron larvae (Rao *et al.*, 1998). Rao *et al.* (2002a)

Table 3. Foraging behaviour of insectivorous birds in tomato field

Species	Mean number of birds visit per hour		
	Inside field	Making successful attempt	Making unsuccessful attempt
Acridotheres tristis	8.08(2.82)	0.64(0.99)	1.33(1.28)
Cissa erythrorhyncha	4.10(2.03)	0.23(0.82)	0.54(0.96)
Copsychus saularis	3.05(1.83)	0.41(0.91)	0.71(1.04)
Corvus macrorhynchos	4.36(2.08)	0.10(0.76)	0.10(0.76)
Dicrurus adsimilis	6.82(2.59)	0.44(0.92)	0.77(1.05)
Parus major	8.38(2.84)	0.62(0.99)	1.26(1.23)
Passer domesticus	8.38(2.88)	0.56(0.96)	1.08(1.18)
Pycnonotus cafer	8.69(2.95)	0.67(1.03)	0.89(1.10)
Pycnonotus leucogenys	7.92(2.80)	0.85(1.09)	0.72(1.02)
Saxicola caprata	3.97(2.01)	0.59(0.97)	0.74(1.04)
Turdoides striatus	8.33(2.85)	0.26(0.83)	0.64(0.99)
Mean	6.56(2.52)	0.49(0.93)	0.80(1.06)

Figures in parenthesis are $\sqrt{x+0.5}$ transformed value

CD 0.05 Attempt = 0.57

Interaction = 0.13

recorded Blue jay, Drongo, Pied myna, Common myna, Cattle egret and Babblers predating on *H. armigera* larvae in cotton ecosystem. Activity of insectivorous birds was more during morning and evening hours compared to noon. House sparrow, Quaker babbler and Redvented bulbul invade the crops in the morning hours from 7.00 hours, and then from 16.00 hours to dusk (Jagdish *et al.*, 1998). Depredatory birds were also reported to cause high damage during morning and evening hours of the day (Fraser *et al*., 1998; Kler and Prasad, 2002).

Being a hilly terrain and presence of trees around the experimental field, less number of birds used T-shaped perches which were installed in the field to help bird predators for targeting insect pests. However, all the recorded bird species were found using artificially installed T-shaped perches. Ojha *et al*. (2001) found that out of total number of birds which visited the field, 70 per cent used perches which facilitated birds to locate pod borer larvae. Out of 5.71 bird species visited the field in one hour, 1.84 birds alighted on the T-shaped perches then either jumped on to the plant/ground for gleaning prey or left the field (Table 2). These birds remained on the T-shaped perch for few seconds, in some circumstances they just touched and then left. Providing perches in groundnut field helped in attracting drongos thereby facilitating effective natural insect control (Rao *et al.*, 1998). Patel *et al.* (2002) reported that 100 perches/ha alone or with food bait proved effective in reducing late instars large sized larvae which led to less pod damage. Rahman *et al.* (2002) reported that arranging of bird perches @ 20/ acre resulted in lower damage by *Helicoverpa armigera* in pigeon pea eco system. Considering the effective predatory zone economic and operational feasibility and adoptability of the perch, Gopali and Lingappa (2002a) suggested number of perches 2500/ ha for animate perch and 25-40/ha for inanimate perch.

Patil *et al.* (2002) recorded 21.76 gram/plant yield in chickpea, in perched area and 15.20 gram/plant in unperched area. They also reported that installation of

Table 4. Larval percentage survival of *Helicoverpa armigera* in net (bird free) perch and control plots in tomato field (35 DAT to 56 DAT)

Treatments	Per cent larval survival				
	35DAT	42DAT	49DAT	56DAT	Mean
Net plot	99.90(88.19)	89.93(77.72)	99.90(88.19)	99.90 (88.19)	95.98(83.65)
Perch plot	89.93(77.72)	96.60(82.65)	99.90(88.19)	69.17(56.34)	96.23(82.31)
Control plot	84.23(70.03)	61.67(51.92)	68.53(56.26)	77.67(65.93)	90.32(77.35)

Value in parentheses are sin inverse transformed values

$CD_{0.05}$ Treatment = 7.8389

Interaction = 11.0855

Table 5. Larval percentage survival of *Helicoverpa armigera* in net (bird free) & control plots in tomato field (63 DAT to 112 DAT)

Treat ments	Per cent larval survival								
	63DAT	70DAT	77DAT	84DAT	91DAT	98DAT	105DAT	112DAT	Mean
Net plot	77.70 (62.32)	70.30 (57.07)	68.47 (56.22)	88.80 (77.03)	94.37 (80.75)	70.30 (57.07)	83.27 (73.79)	61.07 (51.66)	76.78 (64.49)
Control	60.70 (51.21)	57.37 (49.29)	71.43 (57.77)	82.17 (68.77)	85.50 (67.95)	60.70 (51.21)	71.43 (57.77)	42.93 (40.88)	66.53 (55.61)

Value in parentheses are sin inverse transformed values
$CD_{0.05}$ Treatment = 5.528
Interaction = 11.055

inanimate bird perches (*i.e.* profused tree branches of 50 cm height) at a distance of 8 m reduced the pod borer density to an extent of 1.83 larvae per plant as against 4.27 larvae in unperched area. In present investigation also, the survival percentage of *Helicoverpa armigera* larvae was lower in perch plot (77.67 %) compared to unperched plot (90.32 %) (Table 4). Chavan *et al.* (2003) recorded less pod damage (15.10 %) in chickpea plots having perches, NPV and NSKE treatments in comparison to pod damage in untreated plots (33.82 %).

Acridotheres tristis feed on ground, moved by long jumping and stopped occasionally on spotting larvae on the tomato plant and tried to pick up the same. *Acridotheres tristis* population per hour in tomato field was 8.08 out of which in 0.64 cases it picked up the larvae either for own consumption or feeding nestlings. Chauhan *et al.* (1998) also found larvae of *Helicoverpa armigera* in the food materials of nestlings of *Acridotheres tristis*. A pair of starlings has been reported to bring food (caterpillar, grasshoppers, locusts etc) to their young ones 370 times a day and House sparrows brought food (caterpillars, soft bodied insects etc.) 220 to 260 times per day (Ali, 1996). Drongo mostly sat calmly on tree branches / T shaped perches suddenly made a flight to pick larvae and returned back. Gopali and Lingappa (2002b) observed that drongo spend 13.2-22.2 minute to get one larva from insecticide treated plot, 13.3 minute from NSKE treated plot and 9.2 minute from HaNPV treated plots. Drongo spend highest time in field (6.7 hour day^{-1}) and devoured highest number of larvae (7 $hour^{-1}$) and took less time (13 minute) to get one larva as compared to other birds (Gopali and Lingappa, 2002a). In tomato field drongos made 6.82 visits in one hour out of which in 0.44 cases drongos were able to pick up the *Helicoverpa armigera* larvae (Table 3). Jungle crow *Corvus macrorhynchos* population was 4.36/hour and made 0.10 successful attempts. Jungle crow reported to feed on white grubs (Parasharya *et al.*, 1994) and reduced 45 to 65 per cent grub population during 3 subsequent ploughing. House crow fed voraciously on castor semilooper larvae and a single bird could consume 30-40 larvae (Satyanaryana *et al.*, 2002). Collar bush chat *Saxicola terquata*, Pied chat *Oenanlhe picata*, House crow C*orvus splendens*, Jungle crow C*orvus macrorhynchos* were reported to feed on castor semilooper *Achaea janata* larvae (Parasharya *et al.*, 1988). Visits of Jungle babbler in one hour were 8.33 and made 0.26 successful attempts. Jungle babbler (*Turdoides striatus*) reported to prefer larvae of diamond back moth and aphids in cabbage (Bharucha *et al.*, 2002).

Table 6. Tomato fruit yield and per cent fruit infestation in different treatments

Treatments	Concentration (ppm)	Yield (Kg) per Plot.	% Infestation
NeemAzal	10.00	15.51(3.93)	9.06(3.01)
NeemAzal	20.00	20.42(4.50)	7.18(2.68)
Nimbecidine	0.30	13.32(3.64)	14.71(3.83)
Nimbecidine	0.60	18.33(4.26)	12.77(3.57)
Net Plot	-	8.83(2.97)	17.77(4.21)
Control	-	11.33(3.37)	16.55(4.06)
$CD_{0.05}$	-	0.52	0.13

Figures in parenthesis are $\sqrt{x}$ transformed value

The most active bird was recorded to be the Grey tit *Parus major* whose activity in the field was 8.38 per hour and have efficiency of 0.62 larvae per hour (Table 3). *Parus major* visited the field in small groups, carefully examined the plant and even lower side of leaves and fruits. It used all possible methods to locate the larvae. A single pair of tits with their progeny reported to destroy annually at least 120 million insect eggs or 1,50,000 caterpillars and pupae (Ali, 1996). Unno (2002) observed that long-tailed tit, use three foraging technique *viz.* perch gleaning, hang gleaning and hovering with almost the same frequency. Black-capped chickadees, *Parus alricapillus* and Dowing woodpeckers *Picoides pubescens* L feed on goldenrod stem galler *Eurosta solidaginis*, could assess a gall's content prior to pecking it open and preferring galls that are inhabited by both *Eurosta solidaginis* larvae and inquitine predator *Mordellistena convicta* (Poff *et al.,* 2002), perhaps by semio chemicals or auditory signals emanating from galls containing both of these larvae.

In netted plots where birds were excluded, the percentage of larval survival was higher (76.78 %) and low in control plots (66.53 %) where bird had free access to *Helicoverpa armigera* larvae (Table 5). The significant difference in larval survival was observed on 63rd, 91st and 105th DAT between netted and control plots. Since, the larval survival was 76.78 per cent in netted plot, 23.92 per cent reduction in larval population can be attributed to other biotic and abiotic factors. Considering 23.92 per cent reduction in netted plot as common factor in control plots, the additional reduction of 10.25 per cent was attributed to bird predation alone. Tomato fruit yield was less (8.83 kg) in netted plots in comparison to control (11.33 kg) plots. Parasharya *et al.* (1996) reported that at the end of experiment in wheat field 73.84 per cent of the *Helicoverpa armigera* larvae survived and pupated in the netted plot as against 40.03 per cent in the control plots, where birds feed freely. Birds reduced the larval population of *Spodoptera* and *Helicoverpa* by 15 per cent and 90 per cent in 7 days and 24 hours, respectively under experimental conditions (Rao *et al.,* 1998). In chickpea, Parasharya *et al.* (2002) reported that birds alone brought about 90 per cent control of *Helicoverpa armigera* larvae with tremendous increase in the yield. The birds control 45 to 65 per cent grubs of *Holotrichia* sp. during ploughing operation. The neonate larvae of *Helicoverpa armigera* got killed by predators (*Mecochilus sexamaculatus* and *Clubiona* spp.) whereas birds prefer large and medium size larvae (Rao *et al.,* 2002b).

Studies revealed that neem based formulation and insectivorous birds can be introduced in Integrated Pest Management Programme in tomato crop to bring *Helicoverpa armigera* larvae population below economic injury level. Insectivorous birds' population can be increased in the field by erecting perches or providing nests near the field.

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