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Biology and Management of Bud Borer (*Helicoverpa armigera* Hub.) on Rose in South Gujarat

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Biology of *Helicoverpa armigera* Hubner was studied on rose under laboratory condition at 24.03 ± 1.75 ^{0}C and average relative humidity of 53.9 ± 3.04 per cent during November - December 2006. The egg, larval, pupal and adult periods were 3.72 ± 0.79, 24.16 ± 2.25, 10.44 ± 1.36 and 5.40 ± 1.04 days for male and 8.84 ± 1.91 days for female, respectively. The life cycle was completed in 39.40 ± 2.33 days for male and 42.96 ± 2.47 days for female, respectively. The pre-oviposition, oviposition and post-oviposition periods were 2.76 ± 0.83 , 5.36 ± 0.99 and 0.84 ± 0.85 days, respectively. The female moth laid an average of 631.8 ± 208.3 eggs during its life span. The sex ratio (female: male) of 1: 0.72 was recorded in laboratory. Indoxacarb 0.0075 and spinosad 0.002 per cent were effective in checking the bud borer population with 1.29 and 1.57 larva*l* plant and net CBR 1:6.00 and 1:8.34, respectively. The ascending order of remaining treatments in effectiveness was; novaluron, endosulfan, imidacloprid, thiamethoxam, clothianidin and acetamiprid.

Keywords: *H. armigera* , biology, rose, indoxacarb, spinosad.

Rose (*Rosa* sp.), the king of flowers, in polyhouse and under open field conditions are grown in Karnataka, Maharashtra, Delhi and Gujarat in India for domestic and export market as cut flowers (Reddy,1999). In South Gujarat rose cultivation in greenhouse is increasing day by day. Rose plant is attacked by number of insect pests among them, *Helicoverpa armigera* Hubner, is more severe on rose buds. Due to the presence of sweet fragrance, absence of bitter principles, moths are attracted for oviposition on tender rose buds. Infestation of the *Helicoverpa* bud borer was observed on open cultivated roses in severe form during January to March. Female moth lays cream colored eggs singly on young buds. Newly hatched larva bore into buds by making holes and feeds on growing petals. Caterpillars also damage flowers by eating petals and leaving excreta. In south Gujarat, it is considered to be a major limiting factor in production of good quality rose flowers. Its attack coincides with bud and flower stage and in their absence, it also feed on leaves and reduces the market value of flowers. Hence, the present experiment was carried out during the year 2006-07.

Materials and Methods

Biology

Initially, larvae of *H.armigera* collected from Horticultural farm were used for mass multiplication. For this purpose, rose (cv. Gladiator) plants grown in pots were used.

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Rearing

In the laboratory, larvae were reared separately on host in transparent plastic tubes of 2.5 cm diameter and 7.5 cm length. The open end of plastic tubes was covered with the perforated lids to facilitate aeration. In case of rose variety Gladiator rose buds were provided as food daily till pre-pupal stage. At the time of pre pupal stage, 1/3 part of each plastic tube was filled with moist soil to facilitate pupation. The pupae formed were transferred to jars for emergence of the adults.

Newly emerged male and female moths were transferred to a glass jar (23 cm diameter x 10 cm height). Cutting of tender shoots of respective host plant having buds and leaves were dipped in fresh water filled in conical flask (4.5 cm diameter at bottom and 8.0 cm height) to maintain turgidity of bud and leaves. The shoots thus prepared, were provided to the moths inside the rearing jars for resting and oviposition. The open end of glass jar was covered with fine muslin cloth, secured in a position with the help of rubber band. Cotton swabs dipped in five per cent honey solution were placed in rearing jar for food to the moths. The shoots were substituted daily with fresh one. The eggs were collected from the shoots and used for further study.

Egg

Colour and morphology of egg was determined by the help of stereobinocular microscope at a magnification of 6.3 X 1.6. A standard ocular

micrometer fitted to microscope was used for measuring the size of eggs.

Freshly laid 25 eggs were separately kept on rose leaf kept in petrishites (10 cm diameter). The eggs were observed twice a day (8.0 AM and 4.00 PM) until the emergence of larvae and incubation period was recorded.

Larvae

With a view to determining the number and duration of different larval instars and total larval periods, the newly emerged larvae (first instar) were placed individually with the help of fine camel hair brush in plastic culture tubes (3.5 cm diameter x 4.0 cm height) and rose buds were provided to the larvae. In order to determine the number of larval instars, the size of individual larvae were observed daily. Exuvium as well as casted off head capsules were also observed. The moulting was confirmed by the presence of casted off head capsule of the larvae of the subsequent instars. The larvae in each instar were studied for their colour and size. Observations on number of instars, duration of instars and total larval period were recorded. Measurements of immature stages were recorded under microscope with the help of stage and ocular micrometer and mature stages of larva and adults was measured with the help of standard scale.

Pre-pupa

To record the pre-pupal period, the larva was observed from the time when it stopped feeding and became sluggish to the time when it turned to pupa.

Pupa

Freshly formed pupae were collected and placed individually in plastic tubes (21.5cm diameter x 7.5 cm height). Observations on pupal duration, colour and size were recorded.

Adult

A male and a female moth of the same age paired and reared separately in glass jar (23 cm diameter x 10 cm height).They were provided with five per cent honey solution as food and fresh buds of rose were provided for resting and oviposition. The observation on adult period as well as colour and size of the adults were recorded. The length and breath with their expanded wings were measured directly with the help of standard scale.

Pre-oviposition, oviposition and post-oviposition period, fecundity and longevity

In order to study the pre-oviposition, oviposition, post-oviposition period, fecundity and adult longevity, the newly emerged adults of *H. armigera* were reared separately in rearing cage on rose plant. Pre-oviposition period was calculated from the date of emergence of female adult to the date of starting of egg laying. Date of starting egg laying to stopping of egg laying were noted as oviposition period. A period between the date of stopping egg laying and the date of death of female was recorded as post-oviposition period. Longevity of male and female adult was calculated separately from the date of emergence and date of death, separately. The fecundity was worked out by noting total number of eggs laid by individual adult. Total life cycle was considered as the period between date of egg laying and the date of death of adult. Sex ratio was recorded as male : female in laboratory.

Management

Field experiment was conducted to evaluate the effectiveness of nine insecticides against *Helicoverpa* of rose during the year 2007 (Table-3). From each net plot five plants were selected and tagged. Observations on *Heliothis* (larva), damaged buds were recorded one day before treatment (pre treatment) and 1, 3, 5, 7 and 14 days (post treatment) after each application.

Benefit to Cost Ratio

Benefit to cost ratio (BCR) was worked out for each treatment. For this purpose, gross realization was worked out for all the treatments including control by deducting the cost of insecticide as well as the cost of labour required for spray, from the total income of the marketable flower yield. Net gain over control was calculated by deducting realization of each treatment. At the end the benefit to cost ratio for each treatment was calculated by dividing the net gain over control by total cost of insecticides including cost of labour for spray.

Results and Discussion

Biology

Egg

The eggs were laid singly on buds as well as on tender leaves. The female mostly preferred egg lying on buds. The freshly laid egg was yellowish white which changed to deep yellow after one day and became dark brown prior to hatching. Eggs were hemispherical with flat base and prominently sculptured with ridges running from one polar end to another. These ridges persisted until hatching. After emergence of the larvae, the egg shell became transparent with a tiny emergence hole made by the larva. The eggs, measuring from 0.45 to 0.51 mm with an average 0.49 ± 0.04 mm in length and from 0.50 to 0.58 mm with an average of 0.54 ± 0.02 mm in width (Table 1). Incubation period of egg varied from 3 to 5 days with an average 3.72 ± 0.79 days (Table 2). Earlier, the incubation period of eggs was found to be 4 days on pigeon pea, groundnut and cotton and 5 days on tomato, gram, cabbage and potato (Anon., 1990). Thus, the present finding on incubation period in confirmation with those reported in past. The hatching percentage of eggs of *H. armigera* on rose varied from 64.00 to 96.00 per cent with an average of 84.27 ± 10.00 per cent.

Table 1. Morphomatrics of life stages of *H. armigera*

Stage	Measurement in mm (n = 25)	Mean ± S.D.
Egg	Length	0.49±0.04
	Width	0.54±0.02
Larva1st instar	Length	1.47±0.02
	Width	0.51±0.02
2nd instar	Length	3.52±1.08
	Width	0.82±0.01
3rd instar	Length	9.74±0.66
	Width	2.81±0.02
4th instar	Length	23.02±1.36
	Width	3.24±0.01
5th instar	Length	34.50±1.29
	Width	5.11±0.07
6th instar	Length	43.89±1.24
	Width	6.59±0.56
Pre-pupa	Length	25.01±1.56
	Width	4.96±0.02
Pupa	Length	20.93±1.09
	Width	6.09±0.08
Adult(Male)	Length	17.09±0.77
	Width	36.20±1.55
Adult(Female)	Length	20.57±1.22
	Width	41.61±2.86

S.D. = Standard deviation

Larva

First instar

The freshly emerged larvae were semi-translucent, yellowish white with yellowish orange longitudinal lines on the dorsal surface of the body. The head, thoracic and anal shields and legs were brown. The newly emerged larvae became active after 2 -3 hours on buds. The larvae preferred to remain on bud of rose. They moved to underneath the calyx and entered in the buds. Thus, entry hole was found underneath the calyx in most of the buds. However, in some cases, the larvae entered in the bud from other side also. The body length of first instar larva varied from 1.42 to 1.50 with an average 1.47 ± 0.02 mm while, the width varied from 0.49 to 0.55 mm with an average 0.51± 0.02 mm Table-1. The duration of first instar larva varied from 2 to 3 days with an average of 2.16 ± 0.37 days (Table-2).

Second instar

Second instar larva was morphologically closely resembled that of first instar larva. In this instar, the larva was yellowish brown in colour with some what darker head than the general body colour. The second instar larvae measured 3.50 to 3.55 mm with an average of 3.52 ± 1.08 mm in length and 0.78 to 0.84 mm with an average of 0.82 ± 0.01mm width (Table- 1). Duration of second instar larva varied from 2 to 3 days with an average of 2.84 ± 0.37 days Table-2.

Third instar

Third instar larvae were longer than second instar larvae. The body colour turned to yellowish brown. Many scattered black spots were observed on the body length of the third instar larvae varied from 8.71 to 11.00 mm with an average of 9.74 ± 0.66 mm while, the width of body varied from 2.78 to 2.84 mm with an average of 2.81 ± 0.02 mm Table - 1. The duration of third instars larva varied from 2 to 6 days with an average of 3.80 ± 1.00 mm (Table-2).

Table 2. Duration of life stages of *H. armigera*

Stage	Duration in days (n = 25) Mean ± S.D.
Incubation (egg period)	3.72±0.79
Larva 1st instar	2.16±0.37
2nd instar	2.84±0.37
3rd instar	3.80±1.00
4th instar	4.60±0.76
5th instar	4.16±0.69
6th instar	6.60±1.22
Total larval period	24.16±2.25
Pre-pupa	2.28±0.61
Pupa	10.44±1.36
Adult (Male)	5.40±1.04
Adult (Female)	8.84±1.91
Pre-oviposition	2.76±0.83
Oviposition	5.36±0.99
Post-oviposition	0.84±0.85
Total life cycle (Male)	39.40±2.33
Total life cycle (Female)	42.96±2.47
Hatching percent	83.67±9.21
Fecundity	631.84±208.34
Sex Ratio	1:0.72

S.D. = Standard deviation

Fourth instar

In fourth instar larva, there was variation in colour and number of longitudinal stripes. Generally the lateral stripes on all the fourth instar larvae were yellowish brown but dorsal stripes were variable in colour. The fourth instar larva measured 23.02 ± 1.36 mm in body length while, width varied from 3.23 to 3.26 mm with an average of 3.24 ± 0.01mm (Table 1). Duration of fourth instar larva ranged from 3 to 6 days with average of 4.60 ± 0.76 days (Table 2).

Fifth instar

The fifth instar larva was pale brown with broken larval stripes and continuous dorsal stripes. Head was reddish brown The body length of fifth instar larva varied from 31.60 to 36.50 mm with an average of 34.50 ± 1.29 mm while, the width of body varied from 4.95 to 5.20 mm with an average of 5.11 ± 0.07 mm (Table 1). Duration of fifth instar larva ranged from 3 to 6 days with an average 4.16 ± 0.69 days (Table 2).

Sixth instar

The sixth instar larva was flat ventrally but convex dorsally. The body was pale brown with scattered short hairs on it. The head of the larva was reddish whereas thoracic and anal shields and thoracic legs were brown. The larva measured 40.80 to 46.90 mm with an average of 43.89 ± 1.24 mm in body length while, width varied from 5.95 to 8.40 mm with an average of 6.59 ± 0.56 mm (Table-1). Duration of larva ranged from 4 to 8 days with an average of 6.60 ± 1.22 days (Table-2).

Total larval period

Total larval period varied from 19 to 28 days with an average of 24.16 ± 2.25 days (Table-2). Earlier, the larval periods of 24.18,31.50,24.94 and 30.00 days were recorded on potato, tomato, cabbage and gram, respectively (Anon., 1990).

Pre-pupa

In the pre-pupal stage, the full grown larva of sixth instar becomes sluggish and suspended feeding and movement. The full grown larva became brownish and later turned lighter with less prominent stripes before formation of pupa. The larva contracted its length and appendages and became quiescent and then the pupa formation took place The length of pre-pupa varied from 22.42 to 28.38
mm with an average of 25.01 ± 1.56 mm while the width of the body varied from 4.92 to 4.98 mm with an average of 4.96 ± 0.02 mm (Table-1). The duration of pre-pupa ranged between 1 to 3 days with an average of 2.28 ± 0.61 days (Table-2). Singh and Singh (1975) reported that pre-pupal period ranged from 1 to 2 days on tomato.

Pupa

Pupae were broadly rounded interiorly but tapering posteriorly. The newly formed yellowish green pupa became light brown within 24 hours and further darkened prior to emergence of moth. Abdomen was distinctly marked into ten segments and well defined dark brown spiracles were visible on 4th to 9th abdominal segments. Similar description of pupa was given by Singh and Singh (1975). The length of pupa ranged between 19.95 to 23.10 mm with an average of 20.93 ± 1.09 mm while, the width of pupa varied from 5.90 to 6.15 mm with an average of 6.09 ± 0.08 mm (Table-1). The duration of pupal stage varied from 9 to 14 days with an average 10.44 ± 1.36 days (Table-2). Pupal period was recorded as 9.50 days on cotton and 22.64 days on tomato (Anon., 1990).

Adult

Moths were medium in size, possessing yellowish brown fore wings with series of the dots on margin. There was black kidney shaped mark on underside of each fore wing. Hind wings were transparent and each possessed a dark colour patch at the apical end. Morphologically, both male and female were closely resembled to each other except female had tuft of hairs on the tip of the abdomen. Body length of male moths ranged from 15.40 to 18.75 mm with an average of 17.09 ± 0.77 mm. whereas the width varied from 33.40 to 39.15 mm with an average of 36.20 ± 1.55 mm. In case of female, the body length ranged from 18.40 to 22.20 mm with an average 20.57 ± 1.22 mm and width from 38.39 to 49.90 mm with an average of 41.61 ± 2.86 mm (Table-1). Similar measurements were recorded by Singh and Singh (1975).

Table 3. Mean number of larvae, percent bud damage and Net CBR at NAU, Navsari during 2007

Treatment	Dose (%)	Mean no. of larvae/plant			Percent bud damage			CBR
		1st spray	2nd spray	Pooled	1st spray	2nd spray	Pooled	
Acetamiprid 20% SP	0.004	2.73	2.64	2.69	19.25	19.45	19.35	1:3.31
Imidacloprid 17.8% SL	0.005	2.60	2.69	2.65	24.06	22.15	23.11	1:3.63
Clothianidin 50% WDG	0.003	2.73	2.63	2.68	17.88	19.24	18.56	1:3.01
Novaluron 10% EC	0.0075	2.20	1.95	2.07	14.63	14.34	14.49	1:2.43
Spinosad 2.5% SC	0.0020	2.04	1.09	1.57	11.71	12.04	11.88	1:8.34
Thiamethoxam 25% WG	0.005	2.63	2.71	2.67	26.41	25.42	25.92	1:1.97
Endosulfan 35% EC	0.075	2.33	2.23	2.28	17.70	16.16	16.93	1:5.71
Profenofos 50% EC	0.075	2.36	2.08	2.22	16.47	15.16	15.81	1:7.78
Indoxacarb 15% SC	0.0075	1.33	1.24	1.29	12.49	13.44	12.97	1:6.00
Control	-	3.50	3.84	3.67	26.97	32.18	29.58	-
SE..m ±		0.08	0.09	0.07	0.27	0.31	0.28	
C.D. at 5%		0.26	0.27	0.23	0.82	0.94	0.84	
C.V.%		9.06	9.74	8.22	10.97	12.50	11.26	

Pre-oviposition, oviposition and post-oviposition

Pre-oviposition period varied from 2 to 4 days with an average of 2.76 ± 0.83 days. The oviposition period was found to be ranging from 4 to 7 days with an average 5.36 ± 0.99 days. The post-oviposition

Fecundity

The egg laying capacity of the female varied from 290 to 910 eggs with an average 631.84 ± 208.34 eggs (Table-2).

Longevity of adult H. armigera

Average longevity of male varied from 4 to 8 days with an average of 5.40 ± 1.04 days, whereas in case of female, it varied from 5 to 11 days with an average of 8.84 ± 1.91 days (Table-2). Thus, the females lived longer than the males. Singh and

period was observed to varying between 0 and 2 days with an average 0.84 ± 0.85 days (Table-2).

Singh (1975) reported that the longevity of male and female varied from 3.13 ± 0.78 to 6.63 ± 0.85 days,

respectively on rose. Thus present finding are more or less in agreement with the results reported by above workers.

Total life cycle

The total life period of *H. armigera* (egg to death of adult) recorded on rose in laboratory are presented in (Table -2). Total life cycle of male ranged from 35 to 45 days with an average of 39.40
± 2.33 days and in case of female it was 37 to 48 days with an average of 42.96 ± 2.47 days (Table-2). Thus, the duration of female was longer than male. The life span of male were 33.16, 57.71 and 66.50 days and female 35.36, 59.48 and 70.71 days in cotton, potato and tomato, respectively (Anon.,1990).

Sex ratio

The sex ratio of male: female recorded in laboratory was 1: 0.72 (Table-2). Singh and Singh reported that the sex ratio (male: female) was 1: 0.67 for laboratory reared adults on tomato which is in agreement with present findings.

Management

Data on population of larvae pooled over two sprayings of observation indicated that all the insecticidal treatments were significantly superior over untreated control (3.67 larvae/plant). Significantly lower larval population was recorded in indoxacarb (1.29 larvae/plant) with net BCR (1:6.00). Spinosad (1.57 larvae/plant) was the best treatment with the highest net BCR (1:8.34). It was followed by novaluron (2.07 larvae/plant), profenofos (2.22 larvae/plant) and endosulfan (2.28 larvae/ plant). Rest of the treatments *viz.*, imidacloprid (2.65 larvae/plant), thiamethoxam (2.67 larvae/plant), clothianidin (2.68 larvae/plant) and acetamiprid (2.69 larvae/plant) were less effective (Table-3).

Data on per cent bud damage pooled over two spraying indicated that all the insecticidal treatments were significantly superior over untreated control (29.58 %). However, significantly the lowest per cent bud damage was recorded in spinosad (11.88 %). The next best treatment was indoxacarb (12.97 %). It was followed by novaluron (14.49 %), profenofos (15.81 %) and endosulfan (16.93 %). Rest of the treatments *viz.*, clothianidin (18.56 %), acetamiprid (19.35 %), imidacloprid (23.11 %) and thiamethoxam (25.92 %), were found less effective. Gowda *et al*. (2003), Karbhatanal and Awanavar (2004), Vadodaria *et al*. (2001) and Gowada *et al*. (2006) found spinosad effective against *Helicoverpa* whereas Patil *et al*. (2004) and Abid and Cagnieul (2003)found indoxacarb as most effective against *Helicoverpa* on different crops. Thus, the present findings are more or less in conformity with the observations recorded by the above workers.

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