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BIONOMICS AND EVALUATION OF DIFFERENT BIO PESTICIDES AGAINST *HELICOVERPA ARMIGERA* (HUBNER) HARDWICK INFESTING GROUNDNUT

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ABSTRACT
Studies on bionomics of *Helicoverpa armigera* (Hubner) Hardwick on groundnut under laboratory conditions revealed that freshly laid eggs were nearly hemispherical round shaped with flattened base, giving a shining yellowish white at first and changing to dark brown prior to hatching. The incubation period of egg was 2 to 4 days. There were five larval instars length of completely developed larva was 26 to 30 mm and larval period was 3 to 7 days. The pre-pupal period was 1 to 4 days. The pupal period was different for both male and female, it was 15 to 18 and 14 to 20 days, respectively. The sex of adult moths were differentiated in the pupal stage by examining the location of genital slit in relation to anal slit. The total life span for male and female was 49.40 ± 5.21 and 52.40 ± 7.03 days, respectively. The fecundity was 255.88 ± 43.21 eggs per female. The sex ratio (male : female) was 1 : 1.12 and 1 : 1.13 under laboratory and field condition, respectively. Out of the nine bio pesticides evaluated against *H. armigera* infesting groundnut, HaNPV (450 LE/ha) was noticed most effective against *H. armigera* and also registered highest yield among all treatments.

INTRODUCTION

Groundnut (*Arachis hypogaea* Linnaeus) is an annual legume crop and belongs to family Leguminoceae. It is grown in tropical and sub-tropical regions and in the continental part of temperate countries. The crop is suffer many problems from sowing to harvesting among them insect pest problems is very serious day after day. The crop is mainly attacked by 500 species of arthropod. Among all insect pests *H. armigera* is cause very saviour damage to the groundnut crop. It causes 40 to 50 per cent damage to tomato fruits (Srivastava, 1970). Earlier, different workers Bhatt and Patel (2001), Parmar (2006), Koshiya (1984) and Thakor *et al.* (2009) studied on biology of this pests on different crops. For control of this pests know about the life cycle, feeding behaviour and nature of damage. The use of different chemical insecticides pests developed resistance against insecticides. Keeping this in view, study were under taken on bionomics and evaluation different bio pesticides against this pests.

MATERIALS AND METHODS

Initially, the *H. armigera* larvae were collected from the unsprayed groundnut field of Anand Agricultural University, Anand and mass reared in the laboratory on leaves of groundnut variety GG 20. The larvae were reared individually in round plastic tube (3.8 cm diameter x 5 cm height) providing fresh and tender leaves of groundnut. The plastic tube closed individually with lid having small aeration holes on a lid. Such plastic tubes were prepared for mass rearing. Groundnut leaves and plastic tubes were changed daily to maintain sanitation. After pupation of larvae, the pupae were kept in petri dish. The sex of adult moths were differentiated in the pupal stage by examining the location of genital slit in relation to anal slit with the help of binocular microscope. The male and female pupae were kept in separate acrylic rearing cage (30 × 30 × 30 cm) for emergence of adults. Male and female adults emerging out from pupae were collected with the help of plastic tube and released in separate acrylic rearing cage for mating and egg laying. The groundnut plant with young leaves will be placed inside the cage for egg laying purpose. Absorbent cotton dipped in 5 % honey solution was served as food for the adults. The data on morphometrics *viz.,* the size of eggs, larva, pre-pupa, pupa with help of Magnus-Pro software while male and female adults body length were measured with the help of millimeter scale. For evaluation of different bio pesticides against *H. armigera* infesting groundnut crop raised in Randomized Block Design with three replications. The first spray of respective biopesticides was applied when *H. armigera* larval population found more than one larva per five plants and subsequent sprays were given at 15 days interval. The observations on number of *H. armigera* were recorded from randomly selected five plants from each net plot. Similarly, total and damaged leaves by *H. armigera* were observed from three branches of each selected plants prior to 1 day as well as 1, 3, 7, 10 and 15 days after each spray application. Statistical analysis of all the recorded data were subjected to analysis of variance in randomized

block design with the procedure followed by Steel and Torrie (1980). The avoidable losses due to *H. armigera* was calculated with the help of formula described by Poul (1976). The economics of each bio-pesticides was calculated.

RESULTS AND DISCUSSION

The female moths laid the eggs singly on tender parts of the plant. The freshly laid eggs were nearly hemispherical round shaped with flattened base, giving a shining yellowish white at first and changing to dark brown prior to hatching.

Duration of different life-stages

The life stages of *H. armigera* (Table 1) indicated that the egg period ranged from 2 to 4 days with an average of 2.96 ± 0.54 days. There were five distinct instars. Average duration of first, second, third, fourth and fifth instar larvae was 2.84 ± 0.37, 2.80 ± 0.76, 4.16 ± 0.69, 5.20 ± 0.87 and 5.44 ± 0.96 days, respectively. This finding is in close agreement with the reports of Parmar (2006) on okra and the nearest incubation period (3 to 5 days) was observed by Manolache *et al*. (1959) on chickpea, 4 days by Bilapate *et al*. (1982) on gram.

The total larval period varied from 15 to 26 days with an average of 22.44 ± 2.75 days. The duration of pre-pupal stage varied from 1 to 4 days with an average of 2.68 ± 0.85 days. The duration of male pupae varied from 15 to 18 days with an average of 16.60 ± 1.12 days, while duration of female pupae varied from 14 to 20 days with an average of 17.36 ± 1.75 days, which was slightly higher than male pupal duration. Average pre-oviposition, oviposition and post oviposition period of females (Table 2) was 2.60 ± 0.76, 7.04 ± 0.61 and 1.08 ± 0.70 days, respectively. This findings on larval period corroborates with the results of Dubey *et al*. (1981) recorded 18 and 20 days larval period on chickpea and pigeon pea, respectively. Bhatt and Patel (2001) stated the average larval period as 20.60 ± 1.78 days when larvae reared on chickpea Parmar (2006) mentioned the total larval period varied from 15 to 27 days with an average of 22.49 ± 4.42 days when larvae reared on okra. Pandey and Kumar (2007) reported total larval was 24.40 ± 1.50 days. Patel *et al*. (2011) reported larval period varied from 19 to 28 days on rose plants. Average pupal period recorded in present study is in agreement with the finding of Patel (1978) reported that the pupal period lasted for 18 to 25 days when larvae were reared on chickpea. Parmar (2006) mentioned that the duration of male pupae varied from 16 to 18 days with an average of 16.94 ± 0.81 days, while duration of female pupae varied 16 to 19 days with an average of 17.00 ± 1.05 days on okra.

Longevity of male and female (Table 2) was 7.64 ± 0.49 and 9.08 ± 0.70 days, respectively. It showed that females survived longer than males. Average longevity of male and female of *H.*

Table 1: Morphometry and duration of different stages of *H. armigera*

Stage	Particulars	Measurement (mm)		Periods (days)			
		Minimum	Maximum	Mean ± S.D.	Minimum	Maximum	Mean ± S.D.
Egg	Length	0.44	0.50	0.47 ± 0.02	2	4	2.96 ± 0.54
	Breadth	0.46	0.53	0.49 ± 0.02			
Larva							
I instar	Length	1.56	1.92	1.80 ± 0.11	2	3	2.84 ± 0.37
	Breadth	0.28	0.35	0.31 ± 0.02			
	Head capsule	0.25	0.29	0.28 ± 0.01			
II instar	Length	4.00	5.20	4.69 ± 0.38	2	4	2.80 ± 0.76
	Breadth	0.56	0.68	0.62 ± 0.04			
	Head capsule	0.47	0.55	0.51 ± 0.02			
III instar	Length	7.80	9.30	8.46 ± 0.47	3	5	4.16 ± 0.69
	Breadth	0.70	1.22	1.01 ± 0.17			
	Head capsule	0.66	0.75	0.70 ± 0.03			
IV instar	Length	15.90	18.70	17.60 ± 0.83	3	6	5.20 ± 0.87
	Breadth	2.00	2.41	2.21 ± 0.15			
	Head capsule	1.12	1.30	1.25 ± 0.04			
V instar	Length	26.50	30.30	28.76 ± 1.05	3	7	5.44 ± 0.96
	Breadth	3.00	4.20	3.68 ± 0.33			
	Head capsule	2.55	2.63	2.60 ± 0.02			
Total larval period		15	26	22.44 ± 2.75			
Pre-pupa	Length	21.50	26.80	24.12 ± 1.58	1	4	2.68 ± 0.85
	Breadth	2.70	4.30	3.51 ± 0.52			
Pupa							
Male	Length	18.20	22.10	21.09 ± 1.12	15	18	16.60 ± 1.12
	Breadth	4.90	6.20	5.54 ± 0.46			
	Distance between genital and anal pore	0.58	0.65	0.60 ± 0.02			
Female	Length	19.30	23.70	21.37 ± 1.74	14	20	17.36 ± 1.75
	Breadth	4.95	6.60	5.80 ± 0.49			
	Distance between genital and anal pore	1.66	1.79	1.74 ± 0.04			
Total life span: Egg to adult death							
Male	Length	16.40	18.50	17.55 ± 0.52	40	61	49.40 ± 5.21
	Breadth(wing expanded)	31.70	36.50	34.62 ± 1.49			
Female	Length	17.90	22.50	21.09 ± 1.28	43	65	52.40 ± 7.03
	Breadth(wing expanded)	37.60	42.10	40.77 ± 1.68			

Table 2: Fecundity, longetivity sex ratio, pre-oviposition, oviposition, post oviposition, hatching (%), growth index of *H. armigera*

Particulars	Minimum	Maximum	Mean ± S.D.
Fecundity (Eggs/female)	163	318	255.88 ± 43.21
Hatching (%)	50	75	59.40 ± 6.56
Longevity			
Male	7	8	7.64 ± 0.49
Female	8	10	9.08 ± 0.70
Growth index	-	-	2.23
Pre-oviposition	2	4	2.60 ± 0.76
Oviposition	6	8	7.04 ± 0.61
Post-oviposition	0	2	1.08 ± 0.70
Sex ratio (Male: Female)			
Laboratory	1 : 1.08	1 : 1.15	1 : 1.12
Field	1 : 1.09	1 : 1.18	1 : 1.13

Table 3: Effectiveness of biopesticides against *H. armigera* on Groundnut

Treatments		No. of larvae per five plants after sprays			Damage (%) after spray		
		First	Second	Pooled over sprays	First	Second	Pooled over sprays
NSKE @ 5 %		1.69 (2.36)	1.53(1.84)	1.61(2.09)	22.56(14.72)	23.70(16.16)	23.13(15.43)
Neem oil @ 0.3%		1.65(2.22)	1.49(1.72)	1.57(1.96)	21.80(13.79)	22.66(14.84)	22.23(14.31)
SNPV @ 250 LE/ha		2.01(3.22)	2.02(3.07)	2.00(3.15)	27.26(20.98)	29.35(24.02)	28.30(22.48)
HaNPV @ 450 LE/ha		1.53(1.84)	1.35(1.32)	1.44(1.57)	19.91(11.60)	20.82(12.63)	20.37(12.12)
NLE @ 10 %		1.80(2.67)	1.74(2.53)	1.77(2.63)	23.94(16.47)	24.97(17.82)	24.45(17.13)
Azadiractin @ 0.4 %		1.56(1.93)	1.40(1.46)	1.48(1.69)	20.95(12.78)	21.76(13.74)	21.35(13.25)
Beauveria bassiana @ 0.4%		1.84(2.89)	1.74(2.53)	1.79(2.70)	25.51(18.55)	25.94(19.13)	25.73(18.85)
Bacillus thuringiensis @ 0.2%		1.80(2.74)	1.73(2.49)	1.76(2.60)	24.84(17.65)	25.73(18.85)	25.28(18.24)
Tobacco decoction @ 2 %		1.72(2.46)	1.65(2.22)	1.69(2.36)	23.13(15.43)	24.38(17.04)	23.75(16.22)
Control		2.09(3.87)	2.11(3.95)	2.10(3.91)	27.69(21.59)	29.88(24.82)	28.79(23.19)
Mean		1.76	1.66	1.72	23.76	24.92	24.4
SEm ±	T	0.03	0.03	0.46	0.54	1.04	0.06
	P	0.03	0.02	0.01	0.37	0.45	0.19
	S	-	-	0.01	-	-	0.12
	T × P	0.08	0.08	0.02	1.16	1.42	0.37
	P × S	-	-	0.04	-	-	0.59
	T × S	-	-	0.02	-	-	0.26
	T × P × S	-	-	0.05	-	-	0.83
CD at 5 %	T	0.09	0.09	1.28	1.51	3.09	0.18
	P	0.08	0.06	0.03	1.11	1.35	0.51
	S	-	-	0.02	-	-	0.32
	T × P	NS	NS	NS	NS	NS	NS
	P S	-	-	NS	-	-	NS
	T × S	-	-	0.05	-	-	NS
	T × P × S	-	-	NS	-	-	NS
CV%		8.00	7.71	5.50	8.49	9.84	5.90

NLE - Naffatia leaf extract, NSKE - Neem seed kernel extract, SNPV - *Spodoptera* nuclear polyhedrosis virus, HaNPV : *Helicoverpa* nuclear Polyhedrosis virus. Figures outside the parenthesis are $\sqrt{X+0.5}$ transformed values, those inside are retransformed values
Figures outside the parenthesis are arc sine transformed values, those inside are retransformed values

armigera registered in present study corroborates with the reports of Parmar (2006) who mentioned that the longevity of mated female moths ranged from 8 to 13 days with an average of 11.40 ± 1.95 days, while the longevity of male moths ranged from 7 to 9 days with an average of 8.08 ± 0.81 days on okra.

The total life cycle (Table 1) of *H. armigera* occupied on an average of 49.40 ± 5.21 days ranging from 40 to 61 days in case of male, while 52.40 ± 7.03 days ranging from 43 to 65 days in case of female. Present study is in agreement with the finding of Thakor *et al*. (2009) observed the total life cycle of *H. armigera* occupied on an average of 47.40 ± 0.84 days ranging from 46 to 49 days in case of male, while 50.00 ± 2.26 days ranging from 46 to 52 days in case of female on cabbage. The egg laying capacity of female (Table 2) varied from 163 to 318 eggs with an average of 255.88 ± 43.21 eggs. Average egg laying potential of the *H. armigera* recorded in present investigation is more or less similar to those of the reports of Parmar (2006) mentioned that the egg laying capacity of female on okra crop was recorded from 167 to 317 eggs with an average of 240.2 ± 62.06 eggs. Parmar (2006) stated that hatching per cent of *H. armigera* eggs ranged from 55 to 85 on chickpea and 57 to 89 on okra. Patel *et al*. (2011) reported that egg laying capacity These reports tally with the present findings. Growth index value under laboratory condition was 2.23. Mehta (1993) stated that growth index value was 1.06, 1.58 and 2.80 on tomato fruits, pigeon pea pods and chickpea pods, respectively.

Morphometry of different life-stages of *H. armigera*

Table 4: Effect of biopesticides on yield and its economics of groundnut due to *H. armigera*

Treatments	Pod Yield (kg/ha)	Increased yield over control(%)	Avoidable losses(%)	Haulm Yield (kg/ha)	Increased yield over control (%)	Avoidable losses(%)	ICBR
NSKE @ 5 %	813.89	27.39	28.71	3333.33	9.09	6.98	1 : 2.26
Neem oil @ 0.3 %	936.11	46.52	18.01	3261.11	6.72	9.00	1 : 8.52
SNPV @ 250 LE	866.67	35.65	24.09	3333.33	9.09	6.98	1 : 5.44
HaNPV @ 450 LE	1141.67	78.69	0.00	3583.33	17.27	0.00	1 : 6.40
NLE @ 10 %	680.56	6.52	40.39	3138.89	2.72	12.40	1 : 0.11
Azadiractin @ 0.15 %	1030.56	61.30	9.73	3500.00	14.54	2.32	1 : 4.91
Beauveria bassiana @ 0.4	758.33	18.69	33.58	3222.22	5.45	10.08	1 : 1.45
Bacillus thuringiensis @ 0.2 %	797.22	24.78	30.17	3263.89	6.81	8.91	1 : 0.69
Tobacco decoction @ 2%	694.44	8.69	39.17	3222.22	5.45	10.08	1 : 0.59
Control	638.89	-	44.04	3055.56	-	14.73	-
SEm ±	85.98	-	-	98.98	-	-	
CD at 5 %	255.48	-	-	294.08	-	-	
CV%	17.81	-	-	5.19	-	-	

NSKE - Neem seed kernel extract, SNPV - *Spodoptera* nuclear polyhedrosis virus, NLE - Naffatia leaf extract, HaNPV - *Helicoverpa* nuclear polyhedrosis virus.
Labour charge - skilled @ 170 Rs/day, ordinary @ 100 Rs/day, Market price of groundnut pod and stover 30 and 2 Rs/kg, respectively

Length and breadth of eggs were 0.47 ± 0.02 and 0.49 ± 0.02 mm, respectively (Table 1). Average length of first, second, third, fourth and fifth instar larvae was 1.80 ± 0.11, 4.69 ± 0.38, 8.46 ± 0.47, 17.60 ± 0.83 and 28.76 ± 1.05 mm respectively. The corresponding values for their breadth were 0.31 ± 0.02, 0.62 ± 0.04, 1.01 ± 0.17, 2.21 ± 0.15 and 3.68 ± 0.33 mm, respectively. Present finding is in agreement with the report of Parmar (2006) who reported length and breadth of first, second, third, fourth and fifth instar larvae were 1.74 ± 0.12 and 0.30 ± 0.01, 4.85 ± 0.42 and 0.49 ± 0.02, 8.46 ± 0.47 and 1.01 ± 0.17, 17.42 ± 0.75 and 2.21 ± 0.10, 28.76 ± 1.05 and 3.56 ± 0.14, respectively. The width of head capsule of first, second, third, fourth and fifth instar larvae were 0.28 ± 0.01, 0.51 ± 0.02, 0.70 ± 0.03, 1.25 ± 0.04 and 2.60 ± 0.02, respectively. More or less similar observation reported by Patel (1976) and Parmar (2006).

Length, breadth and head capsule of pre-pupa (Table 1) was 24.12 ± 1.58, 3.51 ± 0.52 and 2.63 ± 0.06, respectively. Length, breadth and Distance between genital and anal pore was 21.09 ± 1.12, 5.54 ± 0.46 and 0.60 ± 0.02, respectively while in female pupa was 21.37 ± 1.74, 5.80 ± 0.49 and 1.74 ± 0.04, respectively. Bhatt and Patel (2001) reported that the average length and breadth of pupa was 20.09 + 1.18 mm and 5.54 + 0.27 mm in case of male, while in case of female it was 21.66 ± 1.38 mm and 6.06 ± 0.17 mm, respectively. Parmar (2006) mentioned that the length of male pupae ranged from 18.50 to 22.50 mm with an average of 20.32 ± 1.31 mm. The length of female pupae varied from 19.50 to 24.00 mm with an average of 21.76 ± 1.41 mm, which was slightly more than male pupa. The breadth of male pupae ranged from 5.00 to 6.50 mm with an average of 5.68 ± 0.57 mm. Similarly, it was 5.50 to 7.00 mm with an average of 5.90 ± 0.51 mm in case of female pupae which was slightly more than male pupae.

Length and breadth of adult male moth was 17.55 ± 0.52 and 34.62 ± 1.49, respectively while in case of female moth it is 21.09 ± 1.28 and 40.77 ± 1.68, respectively. Parmar (2006) stated that the length of male moths ranged from 16.50 to 19.00 mm with an average of 17.70 ± 1.03 mm, while the breadth with wing expanded varied from 32.00 to 37.00 mm with an average of 34.20 ± 1.92 mm. The length of the female moths ranged from 18.00 to 22.50 mm with an average of 20.10 ± 1.74 mm, while the breadth with wing expanded varied from 38.00 to 43.00 mm with an average of 40.20 ± 1.92 mm. Thakor *et al*. (2009) stated that the length and breadth of the male moth was 16.45 ± 0.78 and 34.65 ± 1.14 mm, whereas it was 19.30 ± 0.79 and 39.01 ± 1.64 mm in case of female moth, respectively.

Evaluation of different bio pesticides against *H. armigera*

Larval population

The plots treated with HaNPV (Table 3) was found more effective and it was at par with azadiractin, neem oil and NSKE. The treatments of tobacco decoction, *Bt,* NLE and *Bb* exhibited larval population of 2.36, 2.60, 2.63 and 2.70 per five plants, respectively. Among the evaluated biopesticides, the highest (3.15) *H. armigera* larvae was counted in plots treated with SNPV followed by *Bb* and NLE on groundnut crop.

Leaf damage

The data (Table 3) clearly indicated that the treatment of HaNPV registered the lowest (12.12 %) leaf damage by *H. armigera* on groundnut and it was at par with azadiractin (13.25 %), neem oil (14.31 %) and NSKE (15.43 %). The plots treated with tobacco decoction and NLE showed 16.22 and 17.13 per cent leaf damage, respectively. In contrast to this, the treatments of *Bt* (18.24 %), *Bb* (18.85 %) and SNPV (22.48 %) proved inferior in checking the *H. armigera* infestation in groundnut crop. The superiority of HaNPV among all evaluated bio pesticides for efficient control of *H. armigera* on groundnut crop proved in present study is strongly supported by Narayan (1979), Pawar *et al*. (1987), Sharma *et al*. (1987) and Singh *et al*. (2009). The significantly highest 1141.67 and 3583.33 kg/ha pod and haulm yield recorded in plots treated with HaNPV (Table 4). Among the tested bio-pesticides, the lowest yield was recorded in plots treated with NLE followed by tobacco decoction and *Bb*. Looking to the NICBR, highest (1 : 7.52) return was obtained with the treatment of neem oil. The treatments of HaNPV, SNPV, azadiractin and NSKE gave NICBR

of 1 : 5.40, 1 : 4.44, 1 : 3.91 and 1 : 1.26, respectively. The remaining bio-pesticides viz., *Bb*, *Bt*, tobacco decoction and NLE exhibited poor or negative NICBR (-0.89 to 0.45).

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