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BIOECOLOGY AND MANAGEMENT OF BUD WORM, *HELICOVERPA ARMIGERA* (HUBNER) ON FCV TOBACCO

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ABSTRACT

Tobacco, a cash crop and is profitable to the farmers if grown with suitable management practices. Budworm is the major pest in tobacco during grand growth and reproductive period of the crop. In the present study an effort was made to study the bio ecology of budworm and its management on KST-19, a popular FCV tobacco variety at Agricultural college, Shimoga during 2010-11. Under laboratory condition, the total developmental periods of male and female were 47.40 ± 0.80 and 50.13 ± 1.23 days, respectively. The size and life span of female is comparatively more than male. Investigations on population dynamics of bud worm using pheromone traps indicated the scattered activity of moth throughout the year. However, maximum number of moth activity was observed from 35th to 43rd standard week. Rainfall and minimum temperature had positive and significant association with trap catches. Whereas, negative and non significant correlation was observed with maximum temperature and relative humidity. Studies on the efficacy of insecticides against bud worm showed that all the treatments were significantly superior over control. Novaluron application yielded better result by controlling cent per cent larval population within seven days, followed by chlorpyriphos (90.0 %) and indoxacarb (87.59 %). Azadirachtin (71.67 %), *Nomuraea rileyi* (71.67%), HaNPV (80.0 %) and NSKE (83.0 %) were also effective in controlling the pest and recorded significantly lower larval population over control.

KEY WORDS: Tobacco, Bud worm, *Helicoverpa*, Insecticides

INTRODUCTION

Tobacco (*Nicotiana tobaccum* L.) is a leading commercial crop grown extensively in India as a narcotic crop. It plays a significant role in the Indian economy by contributing about Rs. 14000 crores as excise revenue and Rs. 4,402 crores towards foreign exchange. India is the second largest producer in the world after China. Flue cured Virginia (FCV) tobacco alone accounts for 200 million Kgs of leaf production in India. Karnataka is the third largest tobacco growing state and stands second in FCV tobacco production in the country. The productivity of tobacco is low because of several biotic and abiotic stresses affecting the crop. Among the biotic factors, bud worm, *Helicoverpa armigera* (Hubner) (Lepidoptera:Noctuidae) is the key pest. The *Helicoverpa* causes significant losses to tobacco during growth and reproductive stage of the crop, by feeding on growing buds in early stage and developing capsules at later stage. This pest is highly polyphagous and has been reported to damage more than 182 species of alternative host plants. Availability of many alternative hosts and also extensive cultivation of this crop in various agro-climatic zones is one of the key reasons for its incidence on the crop. Sole dependence on insecticides leads to development of resistance to the pest. Extensive use of synthetic pyrethroids against *Helicoverpa* has become resistant at several locations in the country (Dhingra *et al.,* 1988 and Armes *et al.,* 1992). Thus, in order to develop an effective management strategy the present study was planned.

MATERIALS AND METHODS

Laboratory and field experiments were carried out during *Kharif* 2010-2011 at Agricultural College, Shimoga.

I. Biology of bud worm, *H. armigera* (Hubner)

H. armigera infested tobacco plants were used as source for initiating the pure culture of bud worm under laboratory conditions. A pair of newly emerged male and female moths from this culture was released in a rearing cage and eggs were collected. After hatching, the larvae were reared in specimen boxes as pure culture till emergence of adults. A detailed study on biology of *H. armigera* was carried out by providing fresh food to the larvae in the laboratory. The larvae were reared separately in the clean plastic specimen boxes. Small pieces of fresh leaves of tobacco were provided daily as food for the larvae. Grown up larvae were transferred into the rearing boxes, one third of the box was filled with moist soil to provide the appropriate site for pupation to the grown up larvae. After pupation, the pupae were kept as such in boxes containing soil till the emergence of adults. A pair of newly emerged male and female moths confined in a

new box along with blotting paper and fresh leaf. The boxes were covered with perforated lid to prevent the escape of the adults. Five per cent honey solution was provided as food to the adults by dipping a piece of cotton in the honey solution. The cotton was changed daily. Fresh healthy leaves were provided in the boxes for egg laying. The leaves, muslin cloth, paper and boxes were observed every morning for egg laying. The eggs were kept in separate dishes and used to maintain a pure culture of the pest. Thus, the laboratory culture was raised and maintained for further investigation.

Egg

Twenty eggs were examined under microscope to study their colour, shape and other characters. To study the incubation period and hatching percentage of eggs, freshly laid eggs were observed under microscope daily in the morning and evening till hatching. The eggs were considered as hatched only when the tiny larva comes out from the eggs. Average incubation period was then calculated.

Larva

With a view to determine the number and duration of different larval instars and total larval period, the larvae were maintained in specimen boxes by providing tender and fresh leaves or buds as the food. The leaf in each box was changed daily in the morning. To determine the number of larval instars, the size of individual larva as well as exuvium were observed daily. The molting was confirmed by casted off exuvia and increased size of larvae of subsequent instars. The larvae in each instar were studied for their colour, shape and size. Observations on number of instars, duration of each instar and total larval period were recorded separately. The total larval duration was calculated from the date of hatching of egg to the end of final instar larvae.

Pupa

The length of pupa was measured by using millimeter scale. The pupal period was considered from the date of formation of pupa to the date of emergence of adult from the pupa. Sex of the adult emerged from the pupa was differentiated from the markings of genital and anal region.

Adult

The newly emerged male and female adults were used to study the colour, shape, size and appearance. The size of the adults with wing expansion was measured using millimeter scale.

Pre-oviposition, oviposition and post-oviposition periods

To study the pre-oviposition, oviposition and post-oviposition periods, the freshly emerged male and female adults from pupae were paired and confined in boxes separately for egg laying. They were provided with five per cent honey solution as food. Fresh leaves of tobacco were provided for egg laying. The sponge for honey solution and the leaves were changed daily. The eggs laid by each female on leaves, boxes, muslin cloth or lid and paper were removed daily with the help of fine camel hair brush and total number of eggs laid by each female were recorded separately.

A period between the time of emergence of the female from the pupae and beginning of egg laying was considered as the pre-oviposition period. Period between starting of egg laying and cessation of egg laying was noted as oviposition period, while, the period between cessation of egg laying to the death of female was considered as post-oviposition period.

Fecundity

Number of eggs laid by each female was recorded daily till the death of the female. Average fecundity of each female was worked out separately

Longevity

Longevity of male and female was calculated separately from the date of emergence to the date of death of the adults.

Total life cycle

Total life period of bud worm was calculated by recording the number of days taken by the insect to complete their different stages *i.e.,* from egg to adult. The total life cycle was recorded separately for male and female.

II Population dynamics of *H. armigera* by trap catches

During 2010-11, two pheromone traps were placed at a distance of 150 meter apart and the number of moths trapped was counted once in a week. To ensure better performance, lures were changed at 15 days interval. Later, moth counts from two pheromone traps were averaged.

Studies on relationship of trap catches with weather factors

The climatic factors *viz.,* maximum and minimum temperature, relative humidity and rainfall were collected from meteorological department, ZARS, Shimoga, for studying relationship of these factors with trap catches of adults. The weather data were also averaged as per standard week to correlate with the moth catches.

III. Efficacy of insecticides against tobacco bud worm

A field experiment was carried out during *Kharif* 2010-2011 at ZARS, Shimoga, to assess the efficacy of different insecticides against tobacco bud worm. The field experiment was laid out in randomized block design (RCBD) using KST-19 variety of FCV tobacco with three replications and eight treatments including control. The plot size was 5.4 X 5.4 m. The transplanting was done on 19th July 2010 with a spacing of 90 X 60 cm between the row and plants, respectively. Ten plants were selected from each plot for recording observations. The treatments were randomized completely and plants were tagged with wax labels. All agronomic practices were followed as per the package of practices except pest management, recommended by the UAS, Bangalore (Anon., 2010).

Seven different insecticides were evaluated against bud worm. The insecticides were sprayed whenever the population of pest reached economic threshold level. Spray applications were made with hand operated knapsack sprayer.

Observations were made on the larval population of bud worm on buds and leaves from selected plants from each plot. Population of larvae was recorded at one day before, third and seventh day after application of chemicals. The mean larval population of bud worm was worked out and data were subjected to statistical analysis. To study the relationship of trap catches with different weather parameters, the simple correlation and regression analysis were performed (Rothschild *et al.,* 1982; Hendricks *et al.,*

1980). Similarly to assess the efficacy of insecticides against tobacco bud worm, the mean larval population of bud worm was worked out and data were subjected to statistical analysis.

RESULTS AND DISCUSSION

TABLE1. Duration of different stages of *H. armigera* on tobacco under laboratory condition

Sl. No.	Stage of insect		No. Observed	Length (mm)		
				Minimum	Maximum	Average ± SD
1	Larva	I Instar	8	1.43	1.53	1.47 ± 0.03
		II Instar	8	3.31	3.42	3.36 ± 0.04
		III Instar	8	9.36	9.74	9.60 ± 0.03
		IV Instar	8	20.22	25.79	23.09 ± 1.32
		V Instar	8	30.71	37.34	33.40 ± 1.15
		VI Instar	8	40.12	45.25	41.88 ± 2.11
2	Pupa	Male	8	17.85	20.91	19.22 ± 1.16
		Female	8	19.21	28.93	21.76 ± 2.18

TABLE 2. Measurement of different stages of *H. armigera* reared on tobacco

Sl. No.	Stage of insect		No. Observed	Period (days)		
				Minimum	Maximum	Average ± SD
1	Egg		16	3.00	5.00	4.02 ± 0.64
	Larva	I Instar	16	2.00	3.00	2.15 ± 0.37
		II Instar	16	2.00	3.00	2.76 ± 0.40
		III Instar	16	3.00	4.00	3.58 ± 0.48
		IV Instar	16	4.00	5.00	4.82 ± 0.68
		V Instar	16	4.00	6.00	5.10 ± 0.76
		VI Instar	16	5.00	7.00	6.11 ± 0.58
2		Total	16	22.00	26.00	23.94 ± 1.21
3	Pre- Pupa		10	2.00	3.00	2.32 ± 0.47
4	Pupa		10	9.00	11.00	10.70 ± 1.26
5	Adult	Male	10	4.00	6.00	4.93 ± 0.80
		Female	10	5.00	8.00	7.73 ± 1.30
6	Total life cycle	Male	10	46.00	48.00	47.40 ± 0.80
		Female	10	46.00	51.00	50.13 ± 1.23

TABLE 3. Length and breadth of adult *H. armigera* reared on tobacco

Details	No. observed	Length (mm)			Breadth (mm)		
		Minimum	Maximum	Average ± SD	Minimum	Maximum	Average ± SD
Male	5	15.50	17.61	16.45 ± 0.78	32.40	37.12	34.61 ± 1.47
Female	5	18.15	20.89	19.30 ± 0.79	34.52	39.04	37.01 ± 1.64

TABLE 4. Pre- oviposition, Oviposition, Post- oviposition period and longevity of *H. armigera* on tobacco

Sl. No.	Details		Period (days)		
			Minimum	Maximum	Average ± SD
1	Pre-mating period*		24.00	32.00	24.00 ± 0.16
2	Mating period*		6.00	8.00	6.00 ± 0.13
3	Pre-oviposition period		1.00	2.00	1.00 ± 0.64
4	Oviposition period		3.00	6.00	5.40 ± 1.00
5	Post-oviposition period		1.00	2.00	1.38 ± 0.59
6	Adult longevity	Male	4.00	6.00	4.93 ± 0.80
		Female	5.00	8.00	7.73 ± 1.16

(* Period in hours)

No. of insects observed -6 (n=6)

TABLE 5. Average weekly catches of bud worm moths and average weekly weather parameters of ZARS, Navile, Shimoga during 2010-11

Standard week	No. of moths / trap / week	Mean Rainfall (mm)	Mean Temperature (°C)		Mean Relative Humidity (%)	
			Maximum	Minimum	Morning (RH1) 07.30 hr	Afternoon (RH2) 13.30hr
2010 July 29	0	7.60	34.54	19.03	91.00	39.14
30	0	13.57	32.93	18.97	90.14	45.43
31	0	8.46	35.14	19.66	91.00	41.00
32	0.50	1.20	36.66	20.11	92.14	39.00
33	1.00	3.43	34.74	19.77	91.71	46.00
34	1.00	27.69	33.26	19.50	92.71	46.17
35	1.50	14.14	32.87	20.06	91.00	45.57
36	2.50	3.57	32.29	19.83	91.86	42.86
37	1.50	0.31	34.00	20.77	91.29	44.14
38	2.50	4.74	34.89	21.23	92.43	55.14
39	3.50	29.2	31.83	19.74	91.43	42.29
40	4.00	30.83	32.11	19.54	89.86	55.29
41	2.00	0	34.97	20.94	92.00	57.00
42	1.00	4.34	34.89	20.49	91.86	56.71
43	1.50	0.80	33.03	19.37	92.29	53.29
44	1.00	1.46	30.60	19.17	89.00	48.86
45	1.00	7.17	30.20	19.00	91.71	51.71
46	1.50	10.83	31.66	19.60	90.71	52.00
47	1.00	0.31	31.77	20.11	89.86	53.86
48	0	0	30.86	20.06	92.29	53.29
49	0	0	30.74	19.57	93.00	54.43
50	0	0	30.34	18.94	92.14	54.00
51	0.50	0	30.86	19.80	90.43	52.86
52	0	0	30.30	19.49	92.13	53.00
2011 Jan 1	0	0	31.60	18.80	92.29	53.29
2	0.50	0	30.00	18.23	92.14	52.57
3	1.00	0	30.26	14.00	91.86	54.57
4	0	0	31.77	13.89	91.71	54.14
5	0	0	33.76	14.70	91.43	63.00
6	0	0	33.29	13.51	92.29	64.57
7	0	0	32.74	13.83	89.14	62.00
8	0	0	33.89	15.91	92.57	60.57
9	0	0	35.29	18.71	91.86	55.29
10	0	0	35.94	17.51	90.86	52.57
11	0	0	35.24	17.86	91.14	52.36
12	0	0	36.29	18.01	90.97	51.68

TABLE 6. Correlation coefficient (r) between number of moths trapped with field larval incidence

Correlated week	Trap catch and larval population
Four week before trap catch	-0.570
Three weeks before trap catch	-0.420
Two weeks before trap catch	-0.470
One week before trap catch	-0.290
During same week of trap catch	0.870*
One week after trap catch	0.140
Two week after trap catch	-0.790*
Three weeks after trap catch	-0.190

Table r value @ 5% 0.67, * Significant @ 5%

TABLE 7. Correlation coefficient (r) of *H. armigera* trap catches with weather parameters

Weather factor	Rainfall (mm)	Temperature (°C)		Relative Humidity (%)	
		Maximum	Minimum	RH_1	RH_2
Trap	0.624*	-0.076	0.425*	-0.110	-0.203

Table r value at 5% = 0.28
N=36
* Significant @ 5%

TABLE 8. Comparative efficacy of new molecules and botanicals against bud worm

Treatment		No. of Larvae/plant			Larval reduction (%)	
		PTC	3 DAT	7 DAT	3 DAT	7 DAT
T_1	Novoluron 10EC	2.00 (1.56)[a]	1.00 (1.27)[ab]	0 (1.00)[a]	50.00	100.00
T_2	Indoxacarb 14.5SC	2.66 (1.74)[a]	0.66 (1.15)[a]	0.33 (1.07)[a]	75.18	87.59
T_3	*Nomuraea rileyi*	2.33 (1.64)[a]	1.33 (1.34)[ab]	0.66 (1.15)[a]	42.91	71.67
T_4	Azadirachtin 0.03%	2.33 (1.68)[a]	2.00 (1.56)[ab]	0.66 (1.15)[a]	14.16	71.67
T_5	HaNPV	1.66 (1.46)[a]	1.66 (1.44)[ab]	0.33 (1.07)[a]	0.0	80.12
T_6	NSKE 2%	4.00 (2.09)[a]	2.00 (1.56)[ab]	0.66 (1.15)[a]	50.00	83.50
T_7	Chlorpyriphos 20EC	3.30 (1.94)[a]	1.33 (1.34)[ab]	0.33 (1.07)[a]	59.69	90.00
T_8	Control	2.66 (1.77)[a]	2.66 (1.77)[b]	2.33 (1.68)[b]	–	–
SEm±		0.202	0.16	0.09		
CD (P≤0.05)		NS	0.48	0.29		

Figures in the parenthesis are √X+0.5 transformed values
Means in the same column showing similar alphabets are on par
NS- non significant
PTC - Pre-treatment count
DAT – Date after treatment

I. **Biology of tobacco bud worm under laboratory condition**

Freshly laid bud worm eggs were spherical in shape with flattened base, cream coloured and later turned dark. The egg was doom shaped and surface was sculptured. These results are in line with the findings of Barber (1981) on maize, Pearson (1985) on cotton and Patil (1987) on sorghum.

In the present investigation the average egg period was 4.02 ± 0.64 days with a range of 3 to 5 days (table 1). In contrast to this Sloan (1980) reported the egg period as 6 days on sorghum at Queensland. Rajgopal (1970) observed egg period as 2.15 to 5.15 days in Karnataka on maize. Patel and Talati (1987) from Gujarath recorded egg period as 4 days on sunflower which is in conformity with the present study.

The newly hatched larva was tiny, active and light brown body with dark brown head, along with number of short hairs arising from the dark tubercles. The colour of the larva varied very much and ranged from greenish brown, yellowish-brown, light black brown to brown with longitudinal stripes. Similar variations in colour pattern have been observed by Nagarajrao and Abraham (1986) on jowar in Madras in which the colour variations ranged from relatively black to yellow green during the larval period. Rajgopal (1970) also reported colour variation in the larva on maize.

There were six larval instars on tobacco. In the present investigation fully grown larva measured an average of 41.88± 2.11mm (table 2). Reports of Pearson (1985) on cotton regarding the length of fully grown larva (40mm) are in close association with the present findings. In contrast Patil (1987) observed 31.16mm length of full grown larvae on sorghum.The total larval period occupied 22 to 26 days (average of 23.94±1.21 days) with average duration of six larval instars as 2.15, 2.76, 3.58, 4.82, 5.10 and 6.11 days (table1), respectively. Cherian (1999) noted the larval period as 26 to 30 days. According to Sloan

(1980) the larval period occupied 12 to 21 days but Stoeva (1989) reported the larval developmental period as 12 to 54 days. According to Rajgopal (1970) in Karnataka, the larval period occupied 15 to 20 days. In the present investigation the duration of later three instars are in agreement with Patel and Talati (1987). Margal (1990) observed the larval period as 22.8 days on sunflower, which is in line with present study.Freshly formed pupa was obtect type with anterior end broad, tapering posteriorly to a pointed tip. Freshly formed pupa was greenish in colour which later turned to dark brown and these findings are in agreement with Pearson (1985) and Patil (1987).

In the present investigation the average length of male and female pupa was 19.22 mm and 21.76 mm (table 2), which is in line with the findings of Lewin *et al.* (1983). During the course of investigation the pupal period ranged from 9 to 11 days with an average of 10.70±1.26 days (table 1). But Cherian (1999) observed 12 to 14 days as pupal period on Ganja in Madras. Sloan (1980) reported that the pupal period lasted for 10 to 11 days on sorghum which is in line with present study. According to Stoeva (1989), pupal period ranged from 8 to 12 days on maize, which is in agreement with present study. In Karnataka Rajgopal (1970) reported the pupal period as 9 to 22 days. The variation in the pupal period may be due to variation in the season, locality and host.

The adult moth was medium sized, stoutly built with light brown forewing with a deep brown speck in the centre. These findings are in line with the observations of Pearson (1985). The adult emergence occurred during late evening and mating took place during the early hours of night which are in line with Rajgopal (1970). In the present study, the average wing span of male and female was 34.61±1.47 mm and 37.01±1.64 mm (table 3), respectively. These observations are in agreement with Pearson (1985) and Lewin *et al.* (1983). The average longevity of the adult male and female during the present study was 4.93±0.80 and 7.73 ±1.16 days (table 4), respectively. Which is in line with the findings of Patel and Talati (1987), Patil (1987) and Margal (1990). The total life cycle of male and female varied from 46 to 48 days (average of 47.40±0.80 days) and 46 to 51 days (average of 50.13±1.23 days), respectively. These findings are in line with the earlier report of Sloan (1980), Stoeva (1989), Rajgopal (1970), Patil (1987) and Margal (1990).

II Population dynamics of tobacco bud worm

Population fluctuation

In the present study scattered activity of bud worm was observed throughout the period. The peak catches were observed from 36th to 41st standard week (table 5 & Fig. 1). These results are in accordance with the findings of Srinivas (1984) who reported varied activity of bud worm throughout the year and also peak collection during September onwards up to November. Further the findings are also in line with the reports of Balasubramanian *et al.* (1993), Patil *et al.* (1992) and Naik (1988).

The varied moth activity might be due to the weather factors, availability of other hosts and the preferred crop stage around the experimental area.

Relationship between moth catches and larval field incidence

The male moth catches and the larval field incidence showed highly significant positive association during the same week and had significant negative correlation with two weeks after peak catches (table 6 & fig.2).

Present findings are in line with findings of Narendra (1995) who reported that the moth catches and the larval population on cotton indicated significant positive correlation during same week (r=0.787*), two week (r=0.529*) and three (r=0.550*) weeks before the observation.

Relationship between weather parameters and bud worm population

Present investigations revealed that the rainfall and minimum temperature were found highly significant and positively correlated with moth catches. Whereas non significant negative correlation was observed with maximum temperature, morning and afternoon relative humidity (table 7) These results are in agreement with the findings of Pimbert and Srivastava (1991) who reported that prolonged rainfall promote the growth of *H. armigera*. The present outcome in relation to minimum temperature is in line with the report of Guptha (1988) who reported significant positive correlation between minimum temperature and moth catches and also negative non significant correlation with relative humidity. Similarly the findings of Patil *et al.* (1992), Venkataiah and Subbaratnam (1992) and Tadas *et al.* (1994) are in close agreement with present findings.

Comparative efficacy of new molecules and botanicals against bud worm

The mean number of larvae present per plant before chemical application ranged from 1.66 to 3.30 (Table 8) and there was no significant difference in the larval population. Three days after application of chemicals the average larval population ranged from 0.66 to 2.66. Indoxacarb recorded lowest larval population (0.66 larva/ plant) followed by novaluron, chlorpyriphos, *Nomuraea rileyi* and HaNPV with 1.00, 1.33, 1.33 and 1.66 larvae per plant, respectively. Whereas, azadirachtin and NSKE recorded slightly higher larval population (2.00 larvae/plant), and were significantly superior than the untreated control (2.66 larvae/plant).

Three days after application, reduction in larval population had a range of zero to 75.18 per cent. Application of indoxacarb registered maximum larval reduction (75.18%) followed by chlorpyriphos (59.59%). Whereas, HaNPV showed no effect on mortality of larvae.

Seven days after application, the larval population ranged from zero to 2.33. All treatments were statistically superior over control (2.33 larvae/plant). The novaluron was significantly superior to all other treatments by recording zero larva per plant. Indoxacarb (0.33 larva/plant), HaNPV (0.33 larva/plant) and chlorpyriphos (0.33 larva/plant) were on par in recording lower larval population as compared to *Nomuraea rileyi* (0.66 larva/plant), azadirachtin (0.66 larva/plant) and NSKE (0.66 larva/plant).

Cent per cent larval reduction of *Helicoverpa* was observed in plots with novoluron treatment after seven days. Maximum per cent larval reduction was observed in chlorpyriphos (90%). The other treatments succeeding the

former were indoxacarb (87.59%), NSKE (83.50%) and HaNPV (80.12%). The minimum larval reduction was recorded in *N. rileyi* and azadirachtin (71.67%).

From the results it is evident that all the treatments were significantly superior than check in reducing the larval population. Present findings are in line with report of Wavare *et al.* (2008) who reported that the different concentration of novaluron suppressed all developing stages of the pest. Similarly the report of Sohail *et al.* (2004), Siddegowda *et al.* (2006) and Patil *et al.* (2004) on indoxacarb and chlorpyriphos; Gohokar *et al.* (1987) and Harsolia *et al.* (2007) on NSKE; Mistray *et al.* (1984) and Rabindra *et al.* (1985) on NPV are in close agreement with present findings.

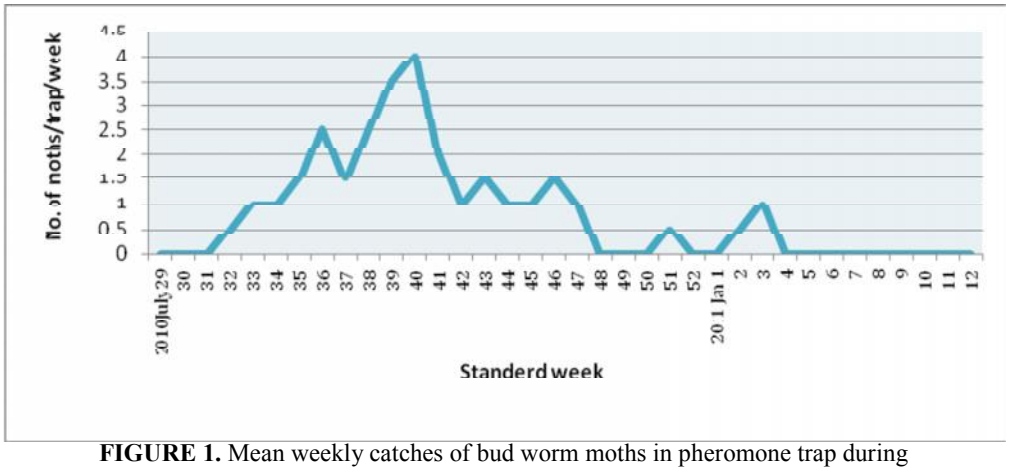

FIGURE 1. Mean weekly catches of bud worm moths in pheromone trap during

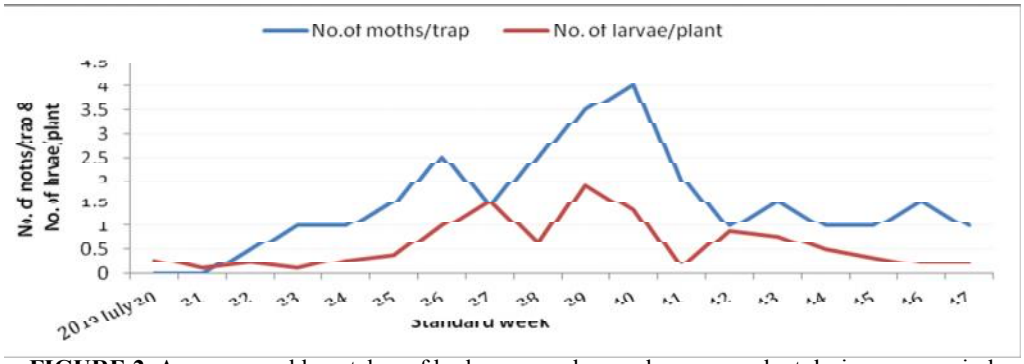

FIGURE 2. Average weekly catches of bud worm and mean larvae per plant during crop period

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