Biology and management of *Spodoptera litura* on cabbage in laboratory conditions

Abstract

Spodoptera litura, commonly known as the tobacco cutworm, is a significant polyphagous pest of cabbage and other cruciferous crops. This study investigated the biology and evaluated the efficacy of different management strategies against *Spodoptera litura* on cabbage under laboratory conditions. Observations on the life cycle parameters, including incubation period, larval duration, pupal duration, and adult longevity, were recorded. Different management strategies, such as neem kernel extract, *Beauveria bassiana*, and newer insecticides (Novaluron and Spinosad), were evaluated for their efficacy in controlling larval populations. The results revealed the life cycle parameters of *Spodoptera litura* on cabbage and identified the most effective management strategies for its control. This information can be utilized to develop sustainable and eco-friendly pest management programs for *Spodoptera litura*on cabbage in field conditions.

Introduction

Cabbage is an important cole crop. It is used as salad, boiled vegetables and dehydrated vegetables as well as in cooked curries and pickles. It possesses both antioxidant and anticarcinogenic properties (Cohen *et al*., 2000). It is now grown almost throughout the year. West Bengal, Orissa, Assam, Bihar, Gujarat, Jharkhand, Madhya Pradesh, Chhattisgarh, Haryana, Uttar Pradesh are major cabbage growing states. Although cabbage is attacked by a number of insect pests of which tobacco caterpillar (*Spodoptera litura*, Fab.) is a serious pest of cabbage. Pest infestation normally leads to reduction in market value and may result in total crop failure in case of heavy infestation. It has also been reported as pest of cabbage, cauliflower, castor, cotton, groundnut, tobacco, maize, green gram, potatoes, soybean, rice, sunflower, tomato etc. more than 60 plant cultivated species reported in India (Garad *et al*., 1984).

Although the biology of this pest has been worked out by several researchers, in the era of climate change it is pertinent to study the biology of the insect pests concerningthe phenology of the host plants as the pest's biology is affected by biotic and abiotic factors. Temperature is the most important factor affecting the biology of insects in various ways. Information on biotic

aspects of biology is essentially required to find out the changes brought about if any due to climate change to get ready to cope with the situation of pest status and to devise the management practices and formulate the IPM program accordingly for sustainable agricultural production.

*Spodoptera litur*a was the first lepidopteran to develop insecticide resistance in India (Srivastava and Joshi, 1965). By 1965, resistance to Benzene Hexa Chloride (BHC) was reported in field populations from Rajasthan (Srivastava and Joshi, 1965) and West Bengal (Mukherjee and Srivastava, 1970). High level of resistance to different groups of synthetic pyrethroids has also been detected in the field strains of *Spodoptera litura* (Mayuravalli*et al.*, 1985). *Spodoptera litura* has been reported to develop resistance to insecticides belonging to organophosphates and pyrethroid groups (Armes *et al.*, 1997; Kranthi *et al.*, 2002).

As a result, managing *Spodoptera litura* has grown more challenging globally, and the most widely used insecticides are not working to control it. The development of resistance is a result of the selection pressure exerted on sprayed populations, increasing the frequency of resistant individuals (Torres-Vila *et al.*, 2002).Hence in this study, we have used a biopesticide (*Beauveria bassiana*), botanical insecticide (Neem seed kernel extract) and some newer insecticides like Spinosad and Novaluron for the management of *S. litura*.

Materials and Methods

3.1 Biology of *Spodoptera litura*on cabbage under laboratory conditions

The details of the materials used and techniques adapted are as follows:

Cultivation of Cabbage

Cabbage (var. Cabbage Savitri) was grown in Rabi season on 21 September 2017 in the horticulture field of the Faculty of Agricultural Sciences, Aligarh, Uttat Pradesh, India. All the recommended agronomic practices were followed to raise the crop, except plant protection measures.

Preparation of field

The land was prepared by giving two ploughings. Two cartloads of farmyard manure were incorporated during land preparation.

Sowing of seeds

For raising nursery, seeds @ 500 g/ha were sown in nursery beds one month prior to transplanting.

Transplanting

Seedlings (4-week-old) were transplanted to main field. A day before uprooting, seed beds were irrigated for easy uprooting and to minimize the root damage. Transplanting of seedlings was done in the afternoon for better establishment. The planting was done at a distance of 60 × 45 cm.

Irrigation and intercultural operations

The crop was irrigated at every 10-15 days to fulfill the water requirement and to maintain enough moisture in the field. Shallow frequent cultivation was given in the cabbage field by hoe to kill young weeds.

Maintenance of the culture of test insect

Laboratory culture of the pest was started with the larvae collected from cabbage fields of *Jawan*, Aligarh, (U.P). Moths thus reared were caged in glass jars (20cm×15cm), covered on top with muslin cloth and provided with stripes of folded crepe paper for oviposition. The adults were fed on 10 per cent honey solution soaked in cotton wool. The eggs were collected every day and kept separately in a petri plate for hatching. The first stage larva of *S. litura* was transferred to fresh tender leaves of cabbage in a plastic vial. Later instars were kept separately. The full-grown larvae were released in a glass jar provided with a layer of about 10 cm sterilized moist soil at the bottom for pupation. The adults emerging from the pupae were reared through a second generation to ensure the continuous supply of larvae of different stages. Culture was maintained at 27±1 °C temperature and 70±5 relative humidity in Biological Oxygen Demand incubator.

Biology of *Spodoptera litura*

Twenty eggs from egg mass were examined under microscope to study their color and shape. Freshly laid eggs were observed and counted daily. Hatching percentage was calculated from the number of eggs hatched out of total number of eggs kept under observation.

To determine the number and duration of different larval instars and total larval period, the newly emerged larvae (1^{st} instars) were placed individually in plastic vials ($4.5\times12cm^2$) with the help of fine camel hair brush. Tender and fresh cabbage leaves were kept inside the vials as the food and replaced daily with fresh leaves. The number of larval instars, duration of larval

instars was observed daily. The numbers of larval instars were determined on the basis of moults observed at each moulting.

Pupal period was considered from the date of pupa formation to the date of adult emergence. The newly emerged male and female adults were used to study the longevity of adults separately. To study the pre-oviposition, oviposition and post-oviposition periods, the freshly emerged male and female adults were paired and confined in jars separately for egg laying. The eggs laid by each female on paper stripes, and muslin cloth were removed daily with the help of a fine camel hair brush and total number of eggs laid by each female was recorded separately. A time gap between mating and the commencement of egg laying was considered as the pre-oviposition period. The period between the starting and cessation of egg laying was recorded as the oviposition period, while, the period between the cessation of egg laying to the death of female was considered as post oviposition period.

The number of eggs laid by each female was recorded daily till the death of the female. The average fecundity of each female was worked out separately. The longevity of the female and male was calculated separately from the date of emergence to the survival of the adults. The total life period of *Spodoptera litura* was calculated by recording the number of days taken by the insect to complete different stages, *i.e*., from egg to adult.

Bioefficacy of some insecticides on different stages of *Spodoptera litura* in laboratory conditions

Laboratory trials were conducted to test and compare the efficacy of *Beauveria bassiana*, neem based insecticide, spinosad and novaluron against *Spodoptera litura*. For evaluation of bioefficacy, solution of spinosad (2.5% SC) @ 0.025 per cent, novaluron (10% EC) @ 0.01 per cent, Neem Kernel Extract (containing 0.15% azadirachtin) @ 0.2 per cent was prepared and commercial formulations of *Beauveria bassiana* viz., Multiplex Baba and Green Beauveria, were taken. Conidial suspensions of these formulations @ 1×10^8 CFU / ml, 2×10^8 spores / ml, 2×10^8 CFU / g respectively at 2 different concentrations, 2 and 4% were prepared in distilled water containing 0.01% Cween 80. This concentration was more or less near the minimum recommended concentration for use on cabbage crops. The five sets of boxes were maintained for each insecticide. The young cabbage leaves were dipped in insecticides for 30 seconds and after air-drying the food was transferred to the sterilized Petri plates lined with filter paper. Three 1^{st}, 2^{nd}, 3^{rd} and 4^{th} instar larvae were introduced in separate sterilized Petri plates. A control set

was also run simultaneously which contained the larvae and food sprayed with only 0.01% aqueous Cween 80. Five such replications with 10 larvae were maintained for each treatment including that of control.

Aseptic conditions were maintained throughout the experiment. Petri plates with treated and control sets were incubated at 27±1 °C in BOD incubator and observations were recorded daily on mortality.

Results And Discussion

Biology of *Spodoptera litura* on cabbage:

Eggs

The eggs were spherical in shape. The colour in the beginning was pale green, which become dark before hatching and covered with brown coloured tuft of hairs. The average number of eggs observed per egg mass was 420 eggs which were arranged in 3-4 layers.

Incubation period

The incubation period of the eggs under laboratory conditions was 3 days with an average of 3±0.

Larval period

The larva moulted five times and passed through six instars before becoming pupa. The duration of first, second, third, fourth, fifth and sixth instar ranged from 2 to 3, 2 to 4, 2 to 5, 4 to 5, 1 to 4, 1 to 3 and 1 to 3 with an average of 2.10, 3.0, 3.90, 4.70,1.30, 2 days respectively. The total larval period was completed in 27 to 35 days with an average of 29.60 days. Neonates were translucent green with prominently big black head. The body had a number of black short hairs arising from dark coloured tubercles. The second and third instar larvae are morphologically similar but third instar larvae is longer than second.

Pre- pupal and pupal Period

Pre-pupal stage was characterized by shortening of larva in length, suspended feeding and movement to periphery. Larva becomes blackish with less prominent stripes. Pre-pupal period ranges from 1 to 3 days with an average of 1.50 days. Pupation occurred in soil. Newly formed

pupa was light greenish in colour and later changed to reddish brown in colour. Pupa was obtect type with the anterior end broad, round and tapering posterior to pointed tip. Pupal period lasts about 8 to 11 days with an average of 8.80±1.48.

Adult

Generally, adult emergence occurred during night time. The adult males and females were hairy, greyish brown in colour. Sexes can easily be identified on the basis of markings on wings. In males, forewings were pale brown with variegated brownish stripes and greyish spots on posterior portion of wings. In females, markings on forewings are same as male except for greyish spots. The adult female longevity was in the range 7 to 10 days with an average of 8.20 days and male longevity was 5 to 8 days with an average of 5.90 days. Details are mentioned in the Table-1 and 2.

Table 1. Biological parameters (days) of *Spodoptera litura* on cabbage leaves

Observation (No. of insects)	Incubation period	Duration of larval instars						Pre pupal period	Pupal period	Total immature period	Longevity	
		I	II	III	IV	V	VI				Male	Female
10	3	3	2	3	5	4	2	3	10	35	8	10
10	3	2	2	4	5	2	2	1	10	31	5	9
10	3	2	2	3	5	2	1	2	9	29	6	7
10	3	2	2	3	5	1	2	2	11	31	7	9
10	3	2	3	2	5	1	3	1	10	30	5	8
10	3	2	9	5	4	1	1	1	6	32	5	7
10	3	2	2	3	4	1	3	1	8	27	6	8
10	3	2	3	5	5	2	1	1	8	30	7	8
10	3	2	3	7	5	1	3	2	5	31	5	8
10	3	2	2	4	4	1	2	1	8	27	5	8
Mean ± SD	3.0 ±0.0	2.10 ±0.32	3.0 ±2.16	3.90 ±1.45	4.70 ±0.48	1.30 ±0.97	2 ±0.82	1.50 ±0.71	8.50 ±1.90	30.30 ±2.36	5.90 ±1.10	8.20 ±0.92

Table 2. Life stages parameters (days) of *Spodoptera litura*

S.No.	Stage of insect	Min.	Max.	Average±S.I
1.	Incubation Period	3	3	3.0±0.0
2.	Larval instars			
	I instar	2	3	2.10±0.32
	II instar	2	4	3.00±2.16
	III instar	2	5	3.90±1.45
	IV instar	4	5	4.70±0.48
	V instar	1	4	1.30±0.97
	VI instar	1	3	2.00±0.82
	Pre-pupa	1	3	1.50±0.71
3.	Total pupal period	6	11	8.80±1.48
4.	Total immature period	27	35	30.30±2.36
5.	Longevity			
	Male	5	8	5.90±1.10
	Female	7	10	8.20±0.92

Comparison of the efficacy of *Beauveria bassiana* withneem based insecticide (Neem kernel extract) and new molecules on different stages of *Spodoptera litura* under laboratory conditions

Data presented in Table-3 shows that insecticides were highly effective than *Beauveria bassiana*. Spinosad (0.025 per cent) and Novaluron (0.01per cent) resulted in 100 per cent mortality of *Spodoptera litura* first instar larva at 3 DAT followed by Green Beauveria (2 per cent) with 43.33 per cent mortality and Neem kernel extract with 33.33 per cent mortality at 3 DAT. In second instar larvae 100 per cent mortality was observed when treated with spinosad and Novaluron at 3 DAT which was non-significant among themselves but significant with other treatments followed by 4 per cent Beauveria (73.33 per cent), 2 per cent Multiplex Baba (63.33 per cent) at 7 DAT and 2 per cent Green Beauveria (43.33 per cent) at 3 DAT. In third instar 100 per cent mortality was observed when treated with Spinosad and Novaluron followed by Neem kernel extract (11.11 per cent) and Multiplex Baba (10 per cent) at 3 DAT. *S.litura* when treated with *Beauveria bassiana* and insecticides, has proven 100 per cent mortality at 3 DAT which was significantly different with rest of the treatments of *Beauveria bassiana*.

Table 3. Comparision of the efficacy of *Beauveria bassiana* with insecticides on *Spodoptera litura*

Insecticides	**Concentration (%)**	**I instar**		**II instar**		**III instar**		**IV instar**	
		Mean % mortality of *S. litura* at indicated days							
		3	**7**	**3**	**7**	**3**	**7**	**3**	**7**
Neem kernel extract	0.20	33.33^{c}		0^{e}		11.11^{c}		0^{d}	
Spinosad	0.025	100^{a}		100^{a}		100^{a}		100^{a}	
Novaluron	0.01	100^{a}		100^{a}		100^{a}		100^{a}	
Green Beauveria	2.0	43.33^{b}	43.33^{b}						
Green Beauveria	4.0			43.33^{d}	73.33^{b}				
Multiplex Baba	4.0					10^{c}	20^{b}	16.67^{c}	23.33^{b}
Multiplex Baba	2.0				63.33^{c}				
P		0.003		0.021		0.106		0.24	
F		13.33		5.78		3.07		1.87	
DF		8,14		10,17		8,14		8,14	
LSD		2.31		2.17		2.20		2.57	

DF - degrees of freedom
LSD - Least significant difference at 5%

Conclusion

In conclusion, this study investigated the biology and management of *Spodoptera litura*, a significant pest of cabbage, under controlled laboratory conditions. The efficacy of Novaluron and Spinosad was better as compared to *Beauveria bassiana* as they killed the pest within a period of 3 days while *Beauveria bassiana* being a fungal biopesticide took time to develop and kill its host. These results provide valuable insights into the biology of *S. litura*in cabbage. The findings on management strategies can contribute to the development of more effective and sustainable pest control methods for this important crop. Further research should focus on field trials to validate laboratory findings exploring integrated pest management approaches.

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