International Journal of Environment and Climate Change

Volume 13, Issue 10, Page 125-133, 2023; Article no.IJECC.103256
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Effect of Different Host Plants on Biology of Tobacco Caterpillar, *Spodoptera litura* (Fabricius)

Krishna Yadav [a], Deependra Kumar Saini [a*] and N. L. Dangi [a]

[a] Department of Entomology, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur, 313001, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJECC/2023/v13i102622

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/103256

Original Research Article

Received: 28/05/2023
Accepted: 01/08/2023
Published: 12/08/2023

ABSTRACT

The tobacco caterpillar, *Spodoptera litura* (Fabricius) is present as an economically important and regular polyphagous pests in India and other countries. The knowledge of biology and ecology of an insect pests is a prerequisite for its management. An experiment was conducted on biology of *Spodoptera litura* (Fabricius) on different host plants in laboratory of the Department of Entomology, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan. The results revealed that the minimum and maximum incubation period of *S. litura* was 2.98 and 3.30 days recorded on castor and cauliflower, respectively. The minimum larval and pre pupal period was 12.96 and 1.00 days recorded on castor. The minimum and maximum pupal period were recorded on cotton (8.27 days) and cauliflower (6.44 days), respectively. The adult male and female moth survival maximum larvae reared on cauliflower 5.00 and 6.90 days whereas minimum on castor 3.95 and 6.00 days, respectively. The maximum percent adult emergence was recorded larvae reared on castor (87.50%) followed by cauliflower (85.00%) whereas minimum on cotton (67.50%). The maximum fecundity was recorded on castor (886.25)

**Corresponding author: E-mail: sainideependra1998@gmail.com;*

followed by soybean (870.00). The entire minimum life cycle was recorded on castor (29.05 days) whereas maximum on cotton (36.50days) followed by soybean (34.24 days). It was concluded that castor is best host plant for *S. litura*.

Keywords: Biology; host plant; larval period; pupal period; adult emergence; fecundity.

1. INTRODUCTION

The tobacco caterpillar, *Spodoptera* (=*Prodenia*) *litura* (Fabricius) (Lepidoptera: Noctuidae) is one of the economically important and regular polyphagous pests on the field and horticultural crops [1]. It is widely distributed Asia including India, Pakistan, China, Korea and Japan [2]; Africa, Australasia and Pacific islands [3]. *S. litura* has wide host range, feeding on approx. 389 species of plants belonging to 109 families worldwide [4] out of which 60 species of plants are known from India (Garad et al*.,* 1984) causing economic losses to different crop species ranging from 26-100% yield loss under field conditions [5]. Among the main host plant species attacked by *S. litura* in the tropics are *Colocasia esculenta*, cotton, flax, groundnuts, jute, lucerne, maize, rice, soybeans, tea, tobacco, vegetables such as: aubergines, Brassica, Capsicum, cucurbit vegetables, Phaseolus, potatoes, sweet potatoes and species of Vigna. Other hosts include ornamentals, wild plants, weeds and shade trees (for example, *Leucaena leucocephala*, and the shade tree of cocoa plantations in Indonesia) [6]. Although it had been a sporadic pest of many crops, gradually it is becoming a very important insect pest in recent years [7]. The outbreak of this pest generally occurs with a good rainfall after a long dry spell [8]. Although it had been a sporadic pest in India, an outbreak of this pest has been reported on soybean in Kota (Rajasthan) and Marathwada and Vidharba (Maharashtra) regions of India have been reported to cause monetary losses to the tune of USD 4.5 and 22.5 crores, respectively regions of India causing greater yield loss [9]. It has become a major pest and endemic to southern states of India causing yield losses up to 71% [10]. Recent outbreaks of *S. litura* caused 90% defoliation of sunflower cultivated germplasm growing in Central and Southern parts of India during 2005 [11]. Also the elevated CO_2 level, under present climatic changes, is supposed to increase the feeding by this pest on cotton by 30% [12].

The host plant quality is a key determinant of the fecundity of herbivorous insects, also affects insect reproductive strategies, egg size and quality, the allocation of resources to eggs and the choice of oviposition sites (Caroline et al., 2002). The newly hatched larvae feed gregariously from lower surface of the leaves and cause heavy damage to the leaves, shoots, stems and capsules. The larval stages are key elements in damaging the crops, grown up larvae consume almost whole plant leaf leaving behind midrib and hard veins only. The study of the influence of different host plants on the growth, development and fecundity of insects is very useful to understand host suitability of pests and larval survival and development can be reduced on poor quality hosts due to nutritional composite and secondary plant metabolites different host plants can also play an important role in population increase and outbreak of polyphagous insect pests [13]. The knowledge of the life parameters of *S. litura* and understanding the components of its fundamental life history on different host plant species may help to make progress in efficient strategies to control this economic pest [14,15].

2. MATERIALS AND METHODS

Insects Rearing: In order to study biology and morphometrics of *S. litura* on different hosts, initial culture as egg masses and first instar larvae of *S.litura* were collected from the agronomy/horticulture farm, Maharana Pratap University of Agriculture and Technology, District Udaipur, Rajasthan and transferred to a clean jar by providing fresh and soft castor leaves with long petiole. The leaf was kept in the jar lined with moist filter peper and covered with muslin cloth. Castor leaves having a water soaked cotton swab wrapped to long petiole to keep it fresh. Larvae were allowed to grow in jars. Rearing jars were cleaned with 2% formaldehyde (excreta and filter peper was changed) and fresh food was supplied daily to maintained good hygienic conditions to growing larvae. When larvae were about to pre-pupate stage, they were transferred to the another glass jars with bottom lining of moistened filter paper and a 5-6 cm thick layer of soil underneath at bottom to facilitate pupation. The pupae will be collected after 3

days of pupation and transfer to egg laying chambers for adult emergence and egg lying.

Mating Period and Fecundity*:* Immediately after adult moth emergence, one pair of male and female moths were released into a separate egg laying glass jar. The inner surface of egg laying glass jar was lined with white paper for providing space for egg laying. A piece of cotton soaked in 10% sucrose solution in a perti dish (dia. = 3 cm), was kept inside the jar as a food source for the emerging adults, which were covered with muslin cloth. For this purpose, ten small glass jars were maintained for observing oviposition period, fecundity, and viability of eggs, adult male and female longevity.

Developmental Stages: For describing different developmental stages of *S. litura i.e.,* egg, larva, pupa, adult and changes in their body size and colour, each stage was observed and data recorded regularly. Observations were recorded on the biology of *S .litura* on five different host plants *viz.,* castor (as standard host), cabbage, soybean, cotton and cauliflower. The experiments were started with newly laid egg masses of *S. litura* females. On each host, four replications (10 larvae in each) were maintained.

Egg: Count the number of eggs laid by female in each treatment. Incubation period was recorded from the day of egg laying to emergence of first instar larvae (in days) on different hosts.

Larva: Immediately after hatching, first instar larvae were allowed to feed on fresh soft leaves of different hosts in rearing glass jars up to third instar because of their gregarious nature. However, during their successive development, the larvae of *S. litura* was reduced to 20 - 40 in each rearing glass jars. Rearing jars were cleaned with 2% formaldehyde (excreta and filter paper was changed) and fresh food was supplied daily to maintained good hygienic conditions to growing larvae. During fourth and fifth instar stages, 15 – 25 larvae were kept in glass jars and provided with sufficient food and space. Rearing jars were covered with sterlized muslin cloth and secured with a rubber band.

Pre-pupal Period: Pre-pupal stage was characterized by the larva becoming sluggish, decreased in size and further feeding ceased, soon the body contracted longitudinally and insect become motionless. The observation of the pre-pupal stage will be recorded based on the above symptoms of the larvae. Period taken from the formation of pre-pupa to pupa will be considered as pre-pupal period.

Pupae: The pupal period was recorded from the day of pupation to the day of adult emergence by taking a sample of 10 pupae in each replications.

Adult:

1. Percentage adult emergence: The number of adults emerged from the pupae were converted in percent to obtain the data on percentage adult emergence.
2. Adult longevity: Adult longevity was recorded by keeping the female and male moths in separate glass jars numbering 10 pupae in each jar. A piece of cotton soaked in 10% sucrose solution in a perti dish (dia. = 3 cm), was kept inside the jar as a food source for the emerging adults. Number of days for which adult survived was recorded as adult longevity period. The interval (in days) between the emergence of the adults and its death was recorded as adult longevity period.

Site of Oviposition: Site of oviposition was observed under laboratory and field conditions. Under field conditions, the egg mass was observed on underside of different host leaf, covered with yellowish brown hairs. However in laboratory, egg laying was observed on muslin cloth and filter paper, and most of the egg masses were not covered with yellowish brown hairs.

Statistical Analysis: The life history parameters of *S. litura* was analyzed using one-way ANOVA (SPSS version 22) for calculating critical difference (C.D.), Standard error of mean, mean and standard deviation.

3. RESULTS AND DISCUSSION

The findings of the experiment have been presented below under the respective heads as detailed in materials and methods.

Biology of Tobacco Caterpillar, *Spodoptera litura* (Fabricius) on Different Hosts: The host preference was investigated on the basis of observations recorded on different developmental stages of *S. litura*. The comparative effects of five host plants *viz.,* castor, cabbage, soybean, cotton and cauliflower. The development of this insect was studied in order to determine the most preferred

host. It was assessed on the basis of incubation period, larval period, pre pupal period, pupal period, adult emergence, adult longevity, fecundity, incubation period, total life span from the larvae reared on different hosts.

Incubation Period: It is evident from Table 1 that the maximum incubation period was reported on castor (2.98 days) and it was found statistically at par with soybean (3.00 days), cabbage (3.15 days), cotton (3.25days) and cauliflower (3.30 days). Incubation period recorded on all hosts showed no significant difference. The observations on the incubation period are in confirming with the finding of Ramaiah and Maheswari [16], reported that incubation period on castor as 3.00 days, Gupta et al. (2015) 5.5 days on mango, Azidah and Azirum [17] 3.00 days on different hosts, Shakya et al. [18] 4.2 days on tomato, Rajasekar and Sridevi [19] 3.875 days on castor and Soni et al. (2001) reported shortest incubation period on castor than the cauliflower.

3.1 Larval Period

First Instar Larvae: The newly hatched first instars larvae were pale green in colour with dark black head having distinctly visible black hairs on the body and small tiny blackish spot visible on first abdominal segment and which later became yellowish green in colour. It is presented Table 2 larvae reared on castor had minimum first instar larval period (2.31 days) and it was found statistically at par with cabbage (2.50 days) and cauliflower (2.50 days). On cotton and soybean relatively longer first instar larval period was recorded as 3.51 and 3.43 days, respectively.

Second Instar Larvae: The second instar larvae were smooth-skinned hairless with pale greenish in colour. It is evident Table 2 larvae reared on castor had minimum first instar larval period (2.35 days) which was significantly different with other hosts. It was 2.64 days on cabbage which was significantly at par with cauliflower (2.85 days) and soybean (3.13 days). On cotton relatively higher second instar larval period was recorded as 3.40 days.

Third Instar Larvae: The third instar larvae grew bigger and changed their body colour to dark green with two dorsal black spots on the first abdominal segment and dark crescent shaped black spots on the sides of the subsequent abdominal segment. Third instar larval period lasted for about 3.3 - 4.15 days on different hosts which were statistically at par with each other host and did not show any significant difference (Table 2).

Fourth Instar Larvae: The fourth instar larvae changed their colour from green to brown with three thin lines of dorsal bands changed the colour, with the central band becoming shiny orange and the two lateral bands becoming yellowish in colour. It is presented in Table 2 that larvae reared on castor had minimum fourth instar larval period (3.00 days) which was significantly different with other hosts. It was recorded as 3.31 days on cabbage (2.35 days) which was significantly at par with cauliflower (3.40) days. On cotton relatively longer fourth instar larval period was recorded as 3.99 days which was statistically at par with soybean (3.86 days).

Fifth Instar Larvae: After fourth moult, the larvae gets bigger in size and secretes green coloured fluid when its disturbed. The fifth instar larvae were brown in colour with three thin yellowish lines or bands as mentioned above. A row of black intermittent dots clearly run along it side. The maximum fifth instar larval period were recorded on cotton (3.28 days) and castor (2.00 days) respectively, which were significantly different with other treatments. Cabbage (2.51days), cauliflower (2.56 days) and soybean (2.91 days) found were statistically at par with each other (Table 2).

Thus entire larval period of *S. litura* was completed in ranged between 12.96 to 18.33 days on different hosts under laboratory conditions. The observations revealed that longest larval period was recorded on cotton (18.33 days) which was significantly different from other host followed by soybean (17.31 days). It was 14.54 days on cabbage and cauliflower (14.94 days) which was statistically at par with each other. However significantly shortest larval period was recorded were on castor (12.96 days).

Similarly, Ramaiah and Maheswari [16] reported the larval period of 13.50 days on castor. Gupta et al. (2015) observed the larval period of 15.45 days on mango, Shakya et al. [18] 25.00 days on tomato Rajasekar and Sridevi [19] 12.67 days on castor. Dwivedi et al. [20] also reported castor as the most suitable host for the larval development of *S. litura*, from the present findings it was revealed that cotton and soybean were the least preferred host as they had a

retarding effect on the larval development, these findings corroborate with the findings of Rani et al. [21] reported cotton as the least preferred host and had a retarding effect on larval development. The present findings are in agreement with Mishra and Srivastava [22], Mandal et al. [23], Ramaiah and Maheswari [16], Soni et al. (2001) and Azidah and Azirum [17] who reported the shorter larval durations on the most preferred host.

Pre-Pupal Period: Prior to pupation, the mature larvae curled into C-shape and the pre pupal period lasted for about 1.00-1.74 days. It is evident Table 1 larvae reared on castor had minimum pre pupal period (1.00 days) and it was found statistically at par with soybean (1.11 days) host. On cotton and cabbage relatively longest pre-pupal period were recorded as 1.28 and 1.39 days, respectively, which were statistically at par with each other. However, on cauliflower, significantly longest pre-pupal period (1.66 days) was observed.

Pupal Period: Minimum pupal period (6.44 days) was recorded on the pupae formed from the larvae reared of cauliflower followed by castor (7.13 days) and found statistically at par with each other, whereas the maximum pupal period of 8.27 days was recorded of the pupae formed from the larvae reared on cotton followed by cabbage (7.96 days) and soybean (7.66 days) those were found statistically at par with each other (Table 1). Similarly, Ramaiah and Maheswari [16] reported the pupal period of 7.50 days on castor. Shabout et al. [24] reported the pupal period of 7.54 days on castor followed by cotton (8.00 days) and soybean (8.43 days). Rajasekar and Sridevi [19] observed pupal period on castor as 7.66 days.

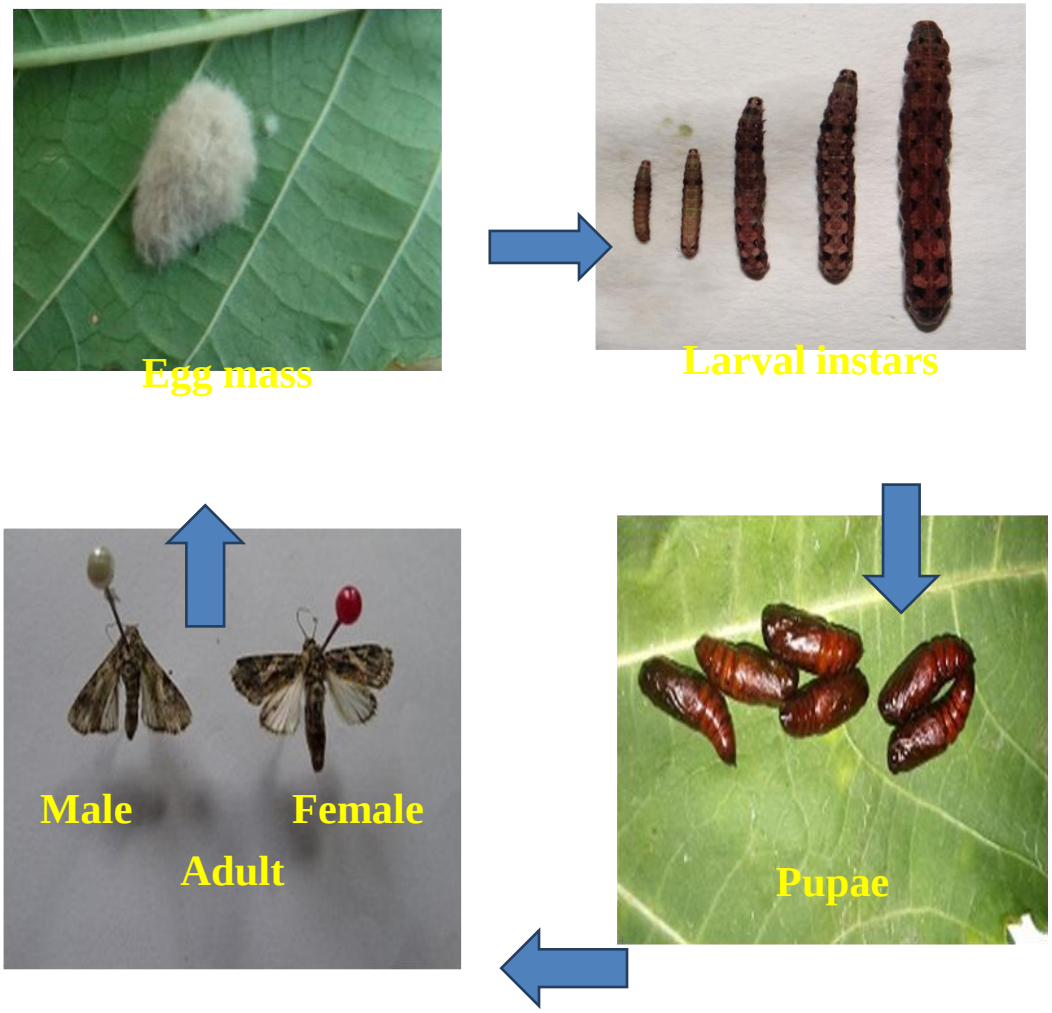

Plate 1. Developmental stages of tobacco caterpillar, *Spodoptera litura* (Fabricius)

Table 1. Biology of tobacco caterpillar, *Spodoptera litura* on different hosts

S. No.	Host plants	Incubation Period (Days±SD)*	Larval Period (Days)	Pre- Pupal Period (Days)	Pupal period (Days)	Percent adult emergence (%)	Adult longevity		Fecundity(No.)	Life Span (Days)
							Male (Days)	Female (Days)		
1	Castor	2.98±0.29	12.96±2.35	1.00±0.08	7.13±0.34	87.50±5.00	3.95±0.34	6.00±0.68	886.25±16.52	29.05±4.60
2	Cabbage	3.15±0.15	14.57±2.73	1.39±0.07	7.96±0.42	77.50±6.45	4.90±0.51	6.85±0.59	790.00±21.21	32.94±5.12
3	Soybean	3.00±0.22	17.31±1.63	1.11±0.11	7.66±0.53	80.00±8.16	4.10±0.18	6.22±0.50	870.00±16.83	34.24±6.34
4	Cotton	3.25±0.15	18.33±1.41	1.28±0.13	8.27±0.69	67.50±9.57	4.25±0.39	6.50±0.49	803.75±19.31	36.50±6.69
5	Cauliflower	3.30±0.16	14.94±2.94	1.66±0.08	6.44±0.43	85.00±7.07	5.00±0.34	6.90±0.55	765.00±21.60	32.28±5.13
6	S.E±	0.101	0.708	0.484	0.249	0 .494	0.184	0.282	3.708	1.031
7	CD (5%)	0.304	2.135	0.1461	0.751	1.480	0.555	0.852	11.176	3.093

Table 2. Larval period of tobacco caterpillar, *Spodoptera litura* on different hosts

S. No.	Host Plants	Larval period (Days)				
	Instars	Ist (Mean±SD)*	IInd	IIIrd	IVth	Vth
i.	Castor	2.31±0.24	2.35±0.45	3.3±0.68	3.00±0.41	2.00±0.58
ii.	Cabbage	2.50±0.46	2.64±0.46	3.6±0.71	3.31±0.59	2.52±0.52
iii.	Soybean	3.43±0.22	3.13±0.32	3.99±0.23	3.86±0.52	2.91±0.35
iv.	Cotton	3.51±0.25	3.40±0.29	4.15±0.31	3.99±0.23	3.28±0.33
v.	Cauliflower	2.50±0.46	2.85±0.58	3.63±0.75	3.40±0.68	2.56±0.47
vi.	S.E±	0.171	0.215	0 .288	0.254	0.230
vii.	CD (5%)	0.517	0.650	0.870	0.768	0.693

Adult: The adult moth was hairy and brown in colour with a complex pattern of creamy coloured crisscrossing markings on the forewings and hind wings were silvery whitish in colour. The male is generally shorter than the female and males had a prominent white band on forewings unlike female. The male adult is darker and female is pale brown in colour.

Thus entire life cycle of *S. litura* was completed in ranged between 29.05 to 36.50 days on different host under laboratory conditions. It is evident from Table 1 that maximum life span was recorded on cotton (36.50 days) which was significantly different with other host. It was 34.24 days on soybean, cabbage (32.94 days) and cauliflower (32.28 days) those were statistically at par with each other. However significantly shortest life span was recorded on castor (29.05 days).

Adult Emergence: The data presented in Table 1 showed maximum per cent adult emergence from castor reared larvae (87.50%), which was statistically at par with cauliflower (85.00%) and soybean (80.00 days). However significantly lowest per cent adult emergence was recorded from cotton (67.50%) next to cabbage (77.50%) and both were statistically at par with each other. Soni et al. (2001) recorded that maximum adult emergence from the larvae reared on cauliflower *viz.,* 90.63 per cent and 92.50 per cent, respectively.

3.2 Adult Longevity

Male: The longevity of male moths obtained from the larvae reared on different host, was recorded after keeping them on 10% sucrose solution (Table 1). Adult male moths emerged from cauliflower survived significantly maximum (5.00 days), which was statistically at par with cabbage (4.90 days) whereas the moths obtained from castor, soybean, and cotton survived for 3.95, 4.10 and 4.25 days, respectively with non significant difference.

Female: It is evident from Table 1 that maximum longevity of female moths of *S. litura* was recorded on cauliflower (6.90 days) followed by cabbage (6.85 days), cotton (6.50 days), soybean (6.22 days) and castor (6.00 days) did not show any significant difference.

The present findings with slight difference were in agreement with the finding of Ramaiah and Maheswari [16] who recorded longevity of moths male (6.50 days) and female (8.00 days) of *S. litura* on castor. Rajasekar and Sridevi [19] reported longevity of moths male (3.16 days) and female (5.50 days) of *S. litura* on castor. Shabout et al. (2011) reported the female longevity of 6.33 days on castor followed by (6.07 days) and cotton (6.22 days).

Fecundity: The female adult moths obtained from the larvae reared on different hosts were kept on 10% sucrose solution for egg laying. As evident from Table 1 that female moth obtained from castor, laid maximum (886.25) number of eggs which was statistically at par with soybean (870.00). Moths obtained from the larvae reared on cotton, cabbage and cauliflower laid 803.75, 790.00 and 765.00 eggs, respectively with non-significant difference. Similarly, Ramaiah and Maheswari [16], recorded the fecundity of female on castor (890.50). Soni et al. (2001), who recorded the highest fecundity of female on cabbage (557.06) than on cauliflower (397.63) and Rajasekar and Sridevi [19] reported 262.5 on castor.

4. CONCLUSION

Thus, by taking all the .criteria into consideration for comparing the relative effect of different host plants on biology of *S. litura*, it can be concluded that castor was the most preferred host followed by cauliflower and cotton least preferred host plant against *S. litura.*

ACKNOWLEDGEMENTS

The authors thank the Dean College of Agriculture for providing necessary facilities.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Shankara Murthy M, Thippaiah M, Kitturmmath MS. Effect of neem formulations on larvae of tobacco cutworm, *Spodoptera litura* (Fab.). Insect Environment. 2006;12:84-85.
2. Cheng T, Wu J, Wu Y, Chilukuri RV, Huang L, Yamamoto K, Liu J. Genomic adaptation to polyphagy and insecticides in a major East Asian noctuid pest. Nature Ecology and Evolution. 2017;1(11):1747.

3. Armes NJ, Wighthfaii JA, Jadhav DR, Rao RGV. Status of insecticide Resistance in *Spodoptera litura* in Andhra Pradesh, India. Pesticide Sciences. 1997;50(3):240-248.
4. Lin T, Chen X, Li B, Chen P, Guo M, Zhou X, Zhong S, Cheng X. Geographical origin identification of *Spodoptera litura* (Lepidoptera: Noctuidae) based on trace element profiles using tobacco as intermedium planted on soils from five different regions. Microchemical Journal. 2019;146:49-55.
5. Dhir BC, Mohapatra HK, Senapati B. Assessment of crop loss in groundnut due to tobacco caterpillar, *Spodoptera litura* (Fab.). Indian Journal of Plant Protection. 1992;20(2):215-217.
6. CABI. Invasive Species Compendium: Datasheets, maps, images, abstracts and full text on invasive species of the world; 2019.
   Available:http: // www. cabi. Org /isc /datasheet/ 44520
   Accessed 18 November 2019.
7. Gao CX, Bei YW, Chen TH, Gu XH. On factors causing outbreak of *Spodoptera litura* (Fabricius). ActaAgriculturae Zhejiangensis. 2004;16:332-335.
8. Chari MS, Patel NG. Cotton leaf worm Spodoptera litura (Fab.) its biology and integrated control measures. Cotton Development. 1983;13:7-8.
9. Dhaliwal GS, Koul O. Quest for Pest Management: From Green Revolution to Gene Revolution. Kalyani Publishers, New Delhi; 2010.
10. Amin PW. Major Field insect pests of groundnut in India and associated crop losses. In: BH Krishnamurthy Rao and KSRK Murthy (eds.), Proceedings of the National Seminar on Crop Losses due to Insect Pests. Hyderabad, Andhra Pradesh, India. 7–9 January, 1983;337-344.
11. Sujatha M, Lakshminaraana M. Resistance to *Spodoptera litura* (Fab.) in Helianthus species and backcross derived inbred lines from crosses involving diploid species. Euphytica. 2007;155:205–213.
12. Kranthi KR, Kranthi S, Gopalakrishnan N, Asokan R, Mayee CD. Bt resistance-Its management and prospects in the current context of climate change. In: IPM Strategies to Combat Emerging Pests in the Current Scenario of Climate Change (VV Ramamurthy, GP Gupta and SN Puri, eds.). Proceedings of National Symposium, Pasighat, Arunachal Pradesh. 200;237-261.
13. Shahout HA, Xu JX, Yao XM, Ji QD. Influence and Mechanism of Different Host Plants on the Growth, Development and, Fecundity of Reproductive System of Common Cutworm *Spodoptera litura* (Fabricius). Asian Journal of Agricultural Science. 2011;3:291-300.
14. Greenberg SM, Sappington TW, Legaspi BC, Liu TX, Setamou M. Feeding and life history of *Spodoptera exigua* (Lepidoptera: Noctuidae) on different host plants. Annals Entomological Social Am. 2001;94:566-575.
15. Tisdale RA, Sappington TW. Realized and potential fecundity, egg fertility, and longevity of laboratory-reared female beet army worm (Lepidoptera: Noctuidae) under different adult diet regimes. Annals of the Entomological Society of America. 2001; 94:415-419.
16. Ramaiah M, Maheswari TU. Biology studies of tobacco caterpillar, *Spodoptera litura* Fabricius. Journal of Entomology and Zoology Studies. 2018;6:2284-2289.
17. Azidah AA, Sofian-Azirun M. Life history of *Spodoptera exigua* (Lepidoptera: Noctuidae) on various host plants. Bulletin of Entomological Research. 2006;96:613-618.
18. Shakya PK, Haseeb M, Manzoor U. Biology of tobacco cutworm, Spodoptera litura. Biotic Environment, formerly Insect Environment. 2015;21(2&3):30-32.
19. Rajasekar B, Sridevi G. Biology and efficacy of insecticides against tobacco caterpillar, *Spodoptera litura* (Fabricius) on Castor leaves. Bulletin of Environment Pharmacology and Life Sciences. 2017; 6:24-27.
20. Dwivedi SC, Mathur B, Mathur B. Evaluation of food preference of fourth instar larvae of *Spodoptera litura*. Insect Environment. 1997;2(4):138-139.
21. Rani S, Goel BB, Gupta GP, Rani S. Growth and development of *Spodoptera litura* (Fab.) on different host plants. Annals Plant Protection Sciences. 2002;10(2):216-219.
22. Mishra SK, Srivastava RP. Comparative studies on growth and development of tobacco caterpillar *Spodoptera litura* (Fab.) on mulberry and castor. Journal of Insect Science. 1998;11(1):69-70.
23. Mandal S, Mandal RK, Mandal S. Effect of different food plant and temperature on

growth and life cycle of tobacco caterpillar *Spodoptera litura* (Fab.). Environment Ecology. 2000;18(1):177-180.

24. Southwood TRE, Henderson PA. Ecological Methods. 3rd Edn., Blackwell Science, Oxford; 2000.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/103256