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Life cycle study of jute Semilooper (*Anomis sabulifera* L.) and generation of pest calendar in Uttar Dinajpur district

Abdul Sadat and Kaushik Chakraborty

Abstract
Jute is an economically important fibber crop of India which is known for its agriculture based economy. Though India holds first position in raw jute cultivation but never achieved its goal of per capita production to fulfill national and international market demand. Destructive action of *Anomis sabulifera* is one major cause of jute production loss though farmers are using increasing dose of chemical pesticides. Present study focused on to understand life history of the pest to generate pest calendar which will impart effective control measures against the pest. Investigation showed that life cycle of *a. sabulifeara* varies from 28-34 days in field while it was quite regular in laboratory conditions. Four generation of the pest was observed during study period with different degree of incidence. 3rd generation pest population was noticed as most devastating to host crop with highest infestation (1.65 larvae/leaf). Pest dynamics was significantly influenced by the agro-climatic conditions (99.10%). Based on those data pest calendar was provided which could offer a clearly commanding informative outline for pest control measure.

Keywords: *Anomis sabulifera,* incidence, jute ecosystem, pest forecasting

Introduction
Jute fiber is a biodegradable agricultural product cultivated throughout jute growing belt of India. Production of jute has a commercial importance for Indian economy [1]. It is a major economic crop in the eastern part of India covering the Gangetic plains of West Bengal [2]. West Bengal holds first position in raw jute cultivation with 80% of the national production [3]. Out of the all of the jute growing districts of West Bengal, Uttar Dinajpur produces 51554 metric tons jute [4]. Implementation of jute-IPM etiquette for sustainable agriculture knowledge of insect pest is essential as bench mark [5].
Jute semilooper (*Anomis sabulifera* L.) is one of the major threat to the crop. This phytophagous pest feed on both jute pods and unripe seeds that lead to 30.50 - 37.50 % fibre loss [6, 7]. From West Bengal, Rahman and Khan [8, 9] had reported that semilooper was still a major pest and responsible for 31–34% fibre yield loos every year though chemical pesticide use increased drastically year after year. Therefore, embracing management practice must be depends on the insect pest dynamics [9]. Regional agro-climatic conditions had an observable effect on the dynamics of *A. sabulifea* [10, 11, 12]. Sense on generating pest calendar is thus found indispensable and obligatory to forecast insect pest incidence and accordingly to predict the extent of damage [13].
Jute has covered an ample agricultural land in the District Uttar Dinajpur [4]. The dynamics of jute semilooper through different genera in Uttar Dinajpur, in jute ecosystem was not investigated so far. Therefore, present study was designed (i) to examine life cycle of *A. sabulifera* both in lab and field condition (ii) to understand pest dynamics durinf jute growing season and (iii) to pertain the generated information relating to *A. sabulifera* population dynamics for construction of pest calendar which will be helpful in integrated pest management decision-making.

Materials and Methods
The experimental study was conducted at Raiganj [26º35´15´´ (N) – 87º48´37´´ (W)] of the District Uttar Dinajpur, West Bengal throughout jute cultivation period (April to August) for 2015-17. The jute seeds were sown in a row spacing of 25 cm in small plots of 4 m ×4 m with a gap of 1 m between each plot. At completely grown condition, plant to plant distance was maintained at 6–8 cm apart after thinning.

Fertilizer treatment and the necessary field management were done following national protocol with suitable modifications. The soil of the experimental field was sandy loam with pH value 6.8 and EC value 0.28mmhs/cm. N, P_2O_5 and K_2O contents were 280, 26 and 265 kg/ha, respectively. Meteorological data were collected from Meteorological Department, Northern Region, West Bengal.
Insect pests were identified by following Lefroy [14] and Shukla and Upadhyay [15].Pest ppopulation was counted through random sampling of 10 different jute crops. Life cycle was studied both in laboratory and field conditions. 1 meter x 1 meter x 1 meters Nylon net fitted with wooden frame was used for study of life cycle in laboratory condition. The polled data were analyzed by KyPlot version 2.0 beta 15 (32 bit) [12].

Results

Life history and dynamics of the pest population

Present study revealed that jute semilooper, *A. sabulifera* was a holo-metabolic insect belongs to the order Lepidoptera and family Noctoidae. It was completed its life cycle (Fig 1) within 28-34 days through four metamorphic stages, which included egg (2-3 days); 5- larval stages (15-17 days); pupa (7-8 days) and adult (5-7 days). Healthy gravid mother moth was found to be laid 150-165 eggs on the back of jute leaves. After hatching they were gone through complete metamorphosis with distinct characteristics (Table 1). In field condition four generations of *A. sabulifera* was observed during study period (18-36 SMW, standard meteorological weeks). Egg of first generation were noticed on 5th May (18 SMW) and adults were persisted upto 2nd June (22 SMW). 2nd, 3rd and 4th generation pests were observed during 31st May-5th July (22-27 SMW), 3rd July-3rd August (27-31 SMW) and 2nd August-1st September (31-36 SMW) respectively (Fig 2). It was interestingly noticed that life cycle duration in the laboratory condition was more or less stable were as in field condition four generations of the pest were showed life history of 29, 36, 32 and 31 days respectively. Phytophagous larvae were first appeared at 22 SMW with an incidence of (0.11 larvae/leaf). After that pest population increases in jute field and reached the highest peak at 30 SMW with the presence of 1.65 larvae/leaf (Fig 3). Then pest incidences were diminished slowly but remain active until crop harvesting. Out of the four generation the 3rd one was the most devastating for the jute crop which causes more than 30 percent crop loss.

Table 1: Morphological feathers and duration variation of *A. sabulifera*

Stages	Size (mm) Length X Breath	Duration (Days)	Morphological feathers
Egg	4 x 3	2.75	Oval, pale crème coloured
L_1	8 x 7	2.50	Minute, pale crème yellow coloured translucent appearance with apical black spot
L_2	20 x 1.5	3.12	Pale greenish yellow coloured translucent appearance with black head
L_3	28 x 2	3.70	Greenish coloured without any black spot or stripe
L_4	35 x 3	4.20	Dark green in colour
L_5	47 x 3	4.50	Dark green in colour
Pupa	34 x 8	7.50	Shiny, dark brown in colour with conical abdomen
Adult	48 (ws)	6.50	Deep grey in colour with pale margin on the forewing. Female with conical blunt tip while male possess pointed abdominal tip

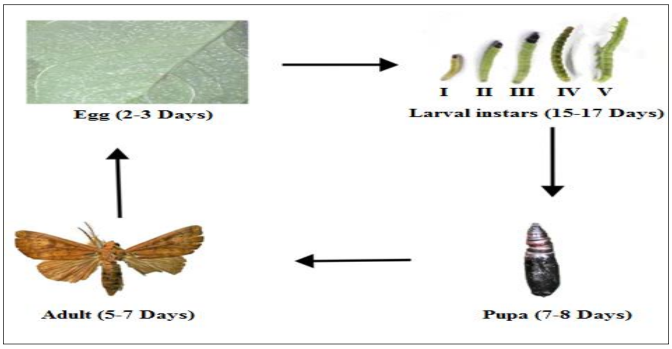

Fig 1: Life cycle of *A. sabulifera* in jute ecosystem of Uttar Dinapur

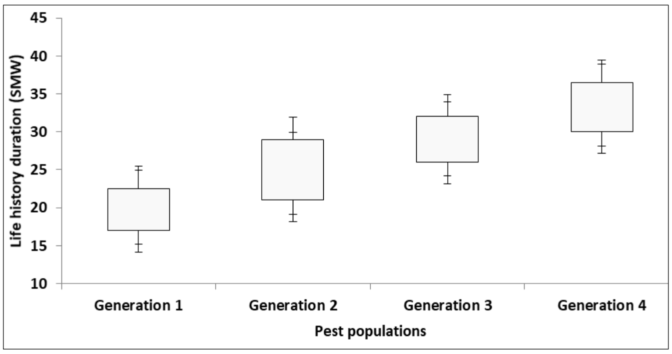

Fig 2: Variation in duration of life history of *A. sabulifera* in jute field condition

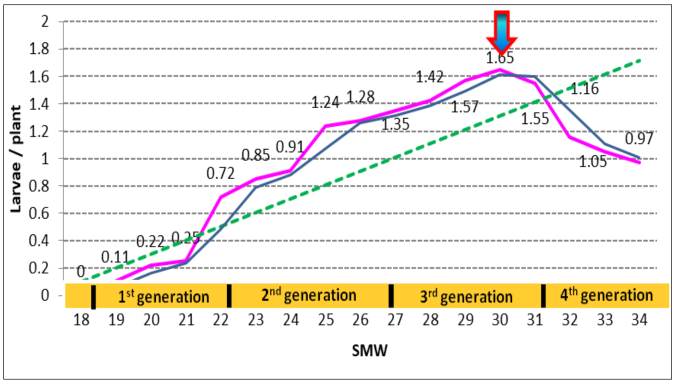

Fig 3: Population dynamics of *A. sabulifera* in jute ecosystem of Uttar Dinjpur

Agro-climatic condition of the jute ecosystem

Meteorological data for temperature, sunshine hour, relative moisture and rain fall were collected for Raiganj (Table 3). Data showed that during jute cultivation period maximum temperature was ranges from 39.90 to 31.20 ^{0}C. Other parameter regarding air temperature were noticed as minimum temperature (29.50-22.50 ^{0}C), temperature gradient (15.50-12.20 ^{0}C) and average temperature (32.25-28.20 ^{0}C). Relative humidity (RH) recorded as maximum RH (98-83 %), minimum RH (82-55 %), RH gradient (41-16 %) and average RH (90-63 %). While maximum rainfall (162 mm) was noticed on 28 SMW with 7 rainy days per week.

Generation of pest forecasting equation and Pest calendar formation

Multiple regressions were done (Table 2) to understand the effect of meteorological parameters on the incidence of *A. sabulifera*. The overall impact of all of the meteorological factors (Tmax, Tmin, Tgr, Tavr, Rhmax, RHmin, RHgr, Rhavr, Shr, Rfall, Rday) on *A. sabulifera* population were recorded the extent of 99.10 per cent. But it was notable that maximum temperature (x_1) alone imparted negative effect on the pests' incidence with 69.19% regression coefficient and maximum temperature (x_1) with minimum temperature (x_2) influenced pest with 92.59% value of regression coefficient. The equation Y=78.035-1.753X_1-2.961X_2+0.294X_3-0.083X_4+12.764X_5-11.853X_6-11.627X_7-0.016X_8-0.529X_9-0.096X_{10}+ 0.163X_{11} (Y= infestation of *A. sabulifera*, x_1= maximum temperature, x_2= minimum temperature, x_3= temperature gradient, x_4= average temperature, x_5= maximum relative humidity, x_6= minimum relative humidity, x_7= relative humidity gradient, x_8= average relative humidity, x_9= sunshine hour, x_{10}= rain fall and x_{11}= rainy day) provided a helpful pest forecasting tools.

Table 2: Multiple regression equation between weather parameters and infestation *of A. sabulifera*

Pest infestation vs weather parameter	Regression coefficient	Level of significance
$Y= 185.340-4.512X_1$	(R^2=69.19%)	$P< 0.0001$
$Y= 164.440-0.4574X_1-5.104X_2$	(R^2= 92.59%)	$P< 0.0001$
$Y= 168.460-0.515X_1-5.150X_2-0.0414X_3$	(R^2=93.69%)	$P< 0.0001$
$Y= 168.980-0.545X_1-5.095X_2-0.0413X_3-0.027X_4$	(R^2= 93.70%)	$P< 0.0001$
$Y= -79.282+1.131X_1-3.345X_2-0.040X_3+0.063X_4+1.563X_5$	(R^2= 95.99%)	$P< 0.0001$
$Y= 69.422+0.854X_1-3.315X_2-0.042X_3+0.001X_4+1.663X_5-0.139X_6$	(R^2= 96.20%)	$P< 0.0001$
$Y= -104.930+0.2680X_1-2.332X_2+0.512X_3-0.008X_4+20.732X_5 - 18.983X_6-18.622X_7$	(R^2= 97.14%)	$P< 0.0001$
$Y= -166.54-0.251X_1-1.421X_2+0.481X_3+0.337X_4-0.124X_5-19.204X_6-17.891X_7 +1.292X_8$	(R^2= 98.39%)	$P< 0.0001$
$Y= -155.510-0.456X_1-1.271X_2+0.430X_3+0.297X_4+18.521X_5-17.624X_6-16.313X_7+1.267X_8-0.309X_9$	(R^2= 98.63%)	$P< 0.0001$
$Y= 74.512-1.797X_1-2.873X_2+0.309X_3-0.823X_4+13.363X_5-12.452X_6-12.198X_7+0.013X_8-0.526X_9-0.089X_{10}$	(R^2= 99.09%)	$P< 0.0001$
$Y=78.035-1.753X_1-2.961X_2+0.294X_3-0.083X_4+12.764X_5-11.853X_6-11.627X_7-0.016X_8-0.529X_9-0.096X_{10}+ 0.163X_{11}$	(R^2= 99.10%)	$P< 0.0002$

Where, Y - Infestation of *A. sabulifera*, X_1-Tmax, X_2 –Tmin, X_3 –Tgr, X_4 –Tavr, X_5 –Rhmax, X_6 –Rhmin, X_7 –RHgr, X_8 –Rhavr, X_9 – Shr, X_{10} – Rfall, X_{11} - Rday

Based on the all information pest calendar was generated to understand actual dynamics of *A. sabulifera* in the jute field of the District Uttar Dinajpur (Table 3). This pest calendar showed the time of growth and developmental stages of jute crop along with different stages of life cycle of *A. sabulifera* and its' different generation that affect crop. Pest calendar depicted that during jute cultivation period larvae of *A. sabuliera* first appeared on 19th SMW (on the month of May) but their population under economic threshold. But at third generation of pest during mid of July cross the economic injury level. This pest calendar guide the not infected level of pest to moderate level of injury, high warning level of injury to severe level of injury. The warning system was established on the basis of database and pest prediction models. From this simplified workbook related to pest we can suggest the different pest warning methodologies (physical and chemical).

Table 3: Pest calendar for *A. sabulifera* in jute ecosystem

Climatic parameters	Tmax (^{0}C)	38.5	38.2	37.5	36.8	39.9	39.7	37.5	37.2	33.7	32.5	31.5	31.2	31.5	33.2	33.8	33.7	35.2
	Tmin (^{0}C)	29.5	28.7	28.5	28.2	25.5	24.2	24.5	23.7	22.5	22.4	22.5	22.3	22.6	22.5	22.8	23	23.5
	Tgr (^{0}C)	15.1	15.5	15.5	14.9	15.4	15.4	15.5	14.5	15.5	12.8	12.2	13.2	14.8	14.1	13.8	14	14.5
	Tavg (^{0}C)	32.25	31.85	32.25	32.75	31.5	30.8	31	29.75	29.75	28.2	28.4	29.6	29.4	30.55	30.3	29.5	29.95
	RHmax (%)	83	85	87	92	85	87	92	95	96	98	98	97	96	97	95	96	92
	RHmin (%)	56	58	60	58	55	57	70	72	75	80	82	78	79	80	62	65	72
	RHgr (%)	27	27	27	34	30	30	22	23	21	18	16	19	17	17	33	41	20
	RHavr (%)	66.5	75	71	63	72.2	67	85.5	78	80.5	90	82	80	89	81	77	79	81.5
	SSH (hr/day)	5.78	5.78	5.74	5.78	1.84	5.17	8.47	2.29	2.02	3.48	6.47	6.94	8.69	7.35	8.51	5.61	8.53
	Rfall (mm)	20.5	45.7	44	73.5	32	35	52.5	87	98.5	75	162	148	102	82.5	70.5	38	44.5
	Rdays	3	4	3	2	1	3	3	4	4	3	7	7	6	4	3	2	1
Jute growth stages	(EV):Early vegetative stage	EV	EV	EV	MV	MV	MV	MV	LV	LV	LV	LV	LV	LV	LV	LV	M	M
	(MV):Mid vegetative stage																	
	(LV):Late vegetative stage																	

	(M):Mature stage	EV	EV	EV	MV	MV	MV	MV	LV	LV	LV	LV	LV	LV	LV	LV	M	M
Stages of life cycle of *A. sabulifera*	(E):Egg		E+L	L	L+P	A	E+L	L	L+P	A	E+L	L	L+P	A	E+L	L	L+P	A
	(L):Larva (P):Pupa																	
	(A):Adult		E+L	L	L+P	A	E+L	L	L+P	A	E+L	L	L+P	A	E+L	L	L+P	A
Generation of *A. sabulifera*			**1st generation**				**2nd generation**				**3rd generation**				**4th generation**			
Pest warning options																		
Suggested management practice	Field scouting																	
	Cultural/Biological control																	
	Insecticide application																	
Standard meteorological week (SMW)		18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
Calendar months		May				June				July				August				

Pest warning options	No injury (0 %)	Low injury (1-15 %)	Moderate injury (16-25 %)
	Warning (26-35 %)	Most destructive (>35 %)	

Discussion

Present study showed that life cycle of *A. sabulifera* completed within 28-30 days in laboratory condition but the pest showed different incidence pattern in jute ecosystem. In field condition life cycle of the pest was varies from 28 to 34 days. The variation in life history in field condition was due to effects of meteorological factors. This finding was akin with the findings of Tripthi and Ram [16], Rahman and Khan [11] and Sheikh [17]. Development of larval stages was largely influenced by the phonological and morphological characters of jute leaves [11, 18, 19]. Morphological attributes of jute leaf were the main nutrition providing elements, where as leaf biochemistry was the curtail element for pests' fecundity, metamorphosis and servivility. First generation larvae appeared in 19 SMW when crop plant was in early vegetative stage and highest pest population was recorded in the mid vegetative stage when it provide high nutritional value to the pest and agro-climatic condition was favorable with moderate temperature and high relative humidity. As time goes on leaves of the host crop became matured with high content of secondary metabolites and agro-climatic condition was unfavorable (high temperature and low humidity) to the pest, its' population decreased. Multiple regration analysis revealed that temperature had a negative effect on the pests' incidence while relative humidity was imparted significant positive effect on the pest. Zaman [20] from Pakistan reported that the population density of jute pests was positively correlated with RH as pest population increased noticeably with the elevation of humidity. Study by Bangladesh Jute Research Institute [21] also documented that temperature, humidity, rainfall and sunshine hour were the major meteorological factors that determined the incidence of *A. sabulifera*. Ahir *et al.* [22] from Gujrat during the study of seasonal incidence of lepidopteran pests concluded that environmental temperature, humidity and rainfall were interdependent meteorological factors in which humidity and rainfall showed significant positive effect on each other and temperature imparted negative correlation with these two weather parameters.

Pest calendar provided a summarized scenario of crop development and pests' life history throughout the jute cultivation period with influences of climate. Pest calendar revealed that each season had a specific pest activity and for control pest we had created a weekly pest calendar that would beneficial to farmers to see what the coming weeks may bring in more detail. It will help easily to determine the particular type of pest they are deal with. Pest calendar highlights the peak for seasonal pest infestations. Many authors advocated that the use of less-persistent insecticides, together with pressure from consumers and retailers to reduce the number of insecticide treatments applied to crops, means that growers need to target insecticide treatments more accurately [23, 24, 25, 26, 27]. The next logical step, after determining the timing of pest activity, is to develop treatment thresholds to determine which of the various treatments are actually necessary. However, a considerable amount of further basic research will be required if we are ever to produce robust systems that will allow final crop damage to be forecast accurately from the numbers of insects monitored during the early stages of crop infestation.

Conclusion

Pest forecasting is the foundation for the issue of early warnings, development and validation of pest control models and decision support systems, which are crucial for the design and implementation of successful IPM programmes. Pest calendars are potential tools for interpreting the available data on population dynamics of pests in agro-ecosystems and natural habitats. Finally, the calendar could offer a clearly commanding informative outline pest control measure.

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