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Seasonal incidence and damage potentiality of Litchi fruit Borer (*Conopomorpha sinensis* Bradley, 1986) in relation to major abiotic environmental factors

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ABSTRACT

Litchi (*Litchi chinensis* Sonn.) has been one of the major subtropical fruits, native of China. It belongs to the family Sapindaceae and was first introduced to India in the late 17th century. After its introduction, the fruit received considerable attention from the Indian farmers and agro based agencies and eventually became an important producer of Indian agriculture. Though India is the second largest producer of Litchi after China, net productivity still falls behind the optimum mark. Chiefly, the diseases associated with litchi and the related problems account for this low productivity. Pest complexes which damage fruits, flowers, stems, and leaves are one of the major issues faced by the litchi industry. Among insect pests, the litchi fruit borer *Conopomorpha sinensis* Bradley, 1986 (Lepidoptera: Gracillariidae) is one of the biggest threats to litchi farmers causing severe loss in fruit production. The fruit borer larva bores into the fruit by making tunnels inside the cotyledon and then feeds on the inner soft tissue. To determine the pattern and degree of infestation and its relationship to major environmental abiotic factors, a study was conducted on selected uniform plants (cv. Bombai) at a private orchard in Barasat, West Bengal, India. The study was conducted in three replications, with one tree served as one replication. 100 fruits were randomly selected from each replication to examine the degree of infestation by the fruit borers. Fruits having the symptom of infestation by the fruit borer were counted and transformed into percentage value. Various meteorological parameters were also recorded simultaneously to study the relationship of major abiotic environmental factors with fruit borer infestation. The association between these factors and fruit infestation was revealed through two methods: 1. descriptive and linear multiple regressions; 2. analysis of variance. As evident from the study, the infestation (3.3%) was first observed at 21days (26th March 2018), and attack by the borer gradually increased and reached its peak (42.66 %) after 60 days of fruit set (4th May 2018). After that, a considerable decrease was observed. According to our statistical analysis, it was found that rainfall has little influence on the activity of the pest species, while temperature has a significant impact on the pest, particularly on their larval activity.

Key words: *Abiotic, Bombai, Borer, Conopomorpha, Litchi, Sapindaceae.*

Introduction

Litchi (*Litchi chinensis*), belonging to the family Sapindaceae, originated in the mountain regions of central and western China and was introduced to India by the end of 17th century. India occupies second position in terms of cultivation area and production after China (Mehta, 2017). Besides India and China, litchi is extensively grown in Australia, South Africa, Hong Kong, Thailand, Mauritius, Malaysia, Indonesia, and Taiwan. In West Bengal state of India, at least 30 to 40 fruit crops are cultivated, of which litchi plays a significant role to the state's as well as country's agricultural sector. It has received more attention than other fruits from agrobased agencies and farmers. Litchi is becoming more popular because of its distinct flavour, good taste, better nutritive value, and juicy aril which gives cooling effect during hot summer (Chauhan *et al.,* 2008). It also offers a new route to earn foreign exchange in addition to its potential market in India. Litchi is primarily grown in the Muzaffar district of Bihar as well as in the sub mountain region of Uttar Pradesh, especially in the Dehradun valley, to some extent in Gurdaspur district of Punjab and a few parts of West Bengal, Assam, and Tripura. In West Bengal, mostly Bombai and Deshi varieties are cultivated. However, though India is one of the largest producers of litchi after China, productivity is not meeting the desired mark. One of the major issues being faced by the litchi industry is pest complexes which damage fruits, flowers, stems, and leaves of the fruit. Even though the considerable area under litchi cultivation in India is large enough, scientific reports on insect pest activities on litchi plants from the country are still poor. Insect pests of litchi are diverse and numerous, many of which characteristically show limited geographical distribution. The important pests of litchi trees as reported in India are leaf roller (*Statherotis discana*), the bark eating caterpillar (*Indarbela* sp.), and fruit borers (*Ephestia cautella*, *Carpophillus mutilates*, *Carpophillus obsoletus* and *Conopomorpha sinesis*). Usually, the litchi flowers in mid-February and fruits mature in the month of May (Yadav, 2011). Among insect pests, litchi fruit and shoot borer, *Conopomorpha sinensis* Bradley, 1986 is one of the significant threats to litchi growers, causing severe losses to fruit as well as young shoots, to the tune of 24-48% and 7-70%, respectively (Srivastava *et al*., 2016). The damage is primarily caused by the larva. The head of the larva is light brown, having a dark brown prothoracic shield. Generally, one fruit was found infested by one larva only. During the 1st phage of its infestation, it was observed that larva which did not get enough food for development, came out of that fruit and attacked another fresh uninfected fruit. The larva bore the fruit at any part by making tunnels inside the cotyledon and fed on the inner soft tissue. It is with this background, studies on the incidence of litchi fruit borer and its relation to major abiotic environmental factors were carried out by the present authors. The studies were carried out at a private litchi orchard located at Barasat, North 24 Parganas, West Bengal, India.

Materials and Methods

Field experiments were conducted during the fruiting season of litchi in 2018 throughout March to June at the litchi orchard. The orchard is located at 23° N latitude and 89° E longitude at an elevation of 9.75 meters from mean sea level. The soil of the experimental field was typically Gangetic alluvial having clay loam texture, neutral in reaction, and moderate in fertility with good water holding capacity. The number of litchi fruits (cv Bombai) infested by fruit borer was counted from each replication by visualizing the symptoms of infestation viz. a pinhead hole from which little yellowish brown excreta oozes out. The observation was taken at an interval of 3 days. The period of observation was 15 days (18^{th} March 2018) to 71 days (2^{nd} June 2018) after fruit set. For quantifying the degree of infestation by the fruit borer, 100 fruits were randomly selected from each replication, where one tree served as one replication. Fruits having the symptom of fruit borer infestation were counted and transformed to percentage value. To study the relationship of major abiotic factors with fruit borer infestation, different meteorological parameters were also recorded simultaneously. Data obtained from the study were analysed using IBM SPSS (version 22) software. Both descriptive and linear multiple regression and analysis of variance were used in showing the relationship between major abiotic environmental factors and fruit infestation. Because of their peculiarity in revealing the relation and variability between variables, these statistical techniques were used in the study of both average fruit infestation and mean climatic factors. The regression model used in this work is as follows-

$Y = f(X_1, X_2, X_3)$ …. (1)

$Y = a + \beta_1 X_1 + \beta_2 X_2 ++ \beta_3 X_3 + \varepsilon$ …… (2)

Where, Y=Average infestation (%), X_1=Average temperature, X_2=Average relative humidity, X_3 = Rainfall, β=Constant, β_1, β_2 and β_3 = coefficient of variation of X_1, X_2 and X_3, ε = unexplained variables.

Results

Data on the infestation of fruit borers was collected from the field and is presented in Table 1, 2 and Figure 1, 2. The fruits of Bombai variety which was set around 15th March 2018 were considered for taking observation. The infestations caused by fruit borer (3.33%) were found to appear on 26th March that is

Table 1. Period of Litchi fruit borer infestation on Litchi cv. Bombai.

Date	Days after fruit set	Infestation out of 100 fruits			Average % infestation
		Replication I	Replication II	Replication III	
18.03.2018	15	0	0	0	0
22.03.2018	18	0	0	0	0
26.03.2018	21	0	4	6	3.33
30.03.2018	24	4	6	7	5.66
03.04.2018	27	5	10	11	8.66
07.04.2018	30	10	12	9	10.33
11.04.2018	33	17	15	13	15
15.04.2018	36	30	27	20	25.66
19.04.2018	39	27	31	34	30.66
23.04.2018	42	44	37	23	34.66
27.04.2018	45	34	46	31	37
01.05.2018	48	36	27	53	38.66
05.05.2018	51	35	39	47	40.33
09.05.2018	54	40	32	41	37.66
13.05.2018	57	36	40	42	39.33
17.05.2018	60	45	56	27	42.66
21.05.2018	63	34	43	44	40.33
25.05.2018	66	21	37	33	30.33
29.05.2018	69	24	20	26	23.33
02.06.2018	71	15	9	7	10.33

Table 2. Incidence of litchi fruit borer in relation to major environmental abiotic factors.

Sl No	Date	Days after fruit set	Average infestation (%)	Average temperature (°C)	Average relative Humidity(%)	Rainfall (mm)
1	18.03.2018	15	0	28.5	54.2	0
2	22.03.2018	18	0	29.9	63.3	0
3	26.03.2018	21	3.33	29.2	65.6	0
4	30.03.2018	24	5.66	29.8	62.6	0
5	03.04.2018	27	8.66	28.5	61.5	0
6	07.04.2018	30	10.33	26.8	79.4	0
7	11.04.2018	33	15	28.9	67.8	0
8	15.04.2018	36	25.66	31.3	58.7	0
9	19.04.2018	39	30.66	31.3	72.3	4.6
10	23.04.2018	42	34.66	31	74.5	0
11	27.04.2018	45	37	28.7	62.8	0
12	01.05.2018	48	38.66	30.6	75.6	0
13	05.05.2018	51	40.33	32.5	81.6	0
14	09.05.2018	54	37.66	31.9	76.5	0
15	13.05.2018	57	39.33	29.6	82.4	3.2
16	17.05.2018	60	42.66	32.6	84.6	5.8
17	21.05.2018	63	40.33	31	80.4	2.4
18	25.05.2018	66	30.33	30.8	76.4	0
19	29.05.2018	69	23.33	30.8	72.6	0
20	02.06.2018	71	10.33	29.5	67.7	0

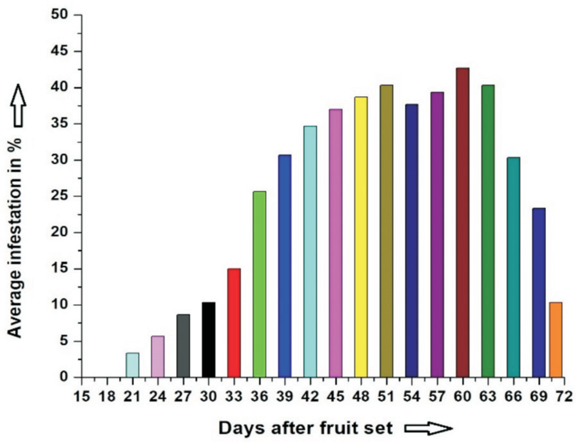

Fig. 1. Average infestation of litchi fruit borer with various days after fruit set.

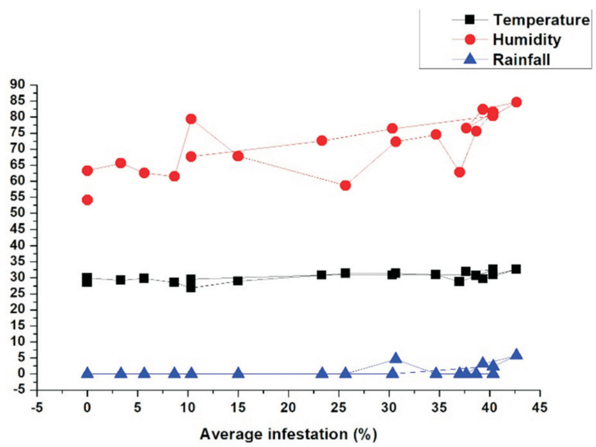

Fig. 2. Incidence of fruit borer in relation to abiotic factors of the environment.

21 days after fruit set, and was confirmed in the field (Table 3). The symptom of infestation was noted to be a pinhole injury on the skin of the fruit from which a little yellowish brown frass oozed out from the bored hole. A close examination of the fruit has revealed the presence of larva, which was found feeding within the cotyledon by forming a tunnel or gallery (Fig. 3). It was also observed that the newly emerged larvae were leaving the pinhole injuries on the skin of the fruit in two distinct stages of fruit growth. The primary or first phase of infestation appeared at 21 days after fruit set when the fruits were small, tender, young, and having no pulp formation. The second phase of the outbreak was found to start after 54 days of fruit set on 09.05.2018. The infestation caused by borer at this stage was 37.66%, when the fruits were developing reddish colorations leading to the stage of maturation. The second phase of infestation lasted up to harvesting of fruit which is 71 days after fruit set. In both the phases of infestation, the larvae bored at any portion of fruit and fed on the soft tissue inside it. The cause of the fruit dropping in both phases of infestation was due to undetermined factors, maybe due

Fig. 3. Larva inside the infected fruit.

Table 3. Multiple regression result on the effect of rainfall, mean temperature and relative humidity on litchi infestation.

Variables	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
Constant	-170.968	50.216	-	-3.405	0.004
Average temperature (X_1)	4.375	1.756	0.422	2.492	0.024
Average relative humidity (X_2)	0.879	0.314	0.500	2.797	0.013
Rainfall (X_3)	0.345	1.536	0.039	.224	0.042
R^2	0.651				
Adjusted R^2	0.585				
F value	9.935				
Regression equationY = -170.968 + 4.375 (X_1) + 0.879 (X_2) + 0.345 (X_3)					

to unhealing injury or hormonal imbalance in fruit growth. During the second phase of infestation the bored hole provided the entry path for fungus, resulting in rotting of fruits, leading to unfit for consumption and fruit falling.

Discussion

So far, the information on the incidence of different borer species, it was observed that only their larva was found to feed within a fruit. During the first phase of infestation, the larva, after feeding for a while, may come out from the fruit and infests another fresh fruit. This may be due to the unsuitability of the cotyledonary part to feed. At the same time, during the second phase of infestation, the larva usually remains within the same fruit and completes its larval growth. As evident from Table 1, the infestation was first observed on 26th March 2018 (21 Days after fruit set), and it was recorded to be 3.33%. The attack was increased gradually and reached its peak (42.66%) at 60 days after fruit set. After that it was found to decrease considerably. From 21 to 33 days after fruit set, the infestation was not remarkable. At this time, the pulp of fruit was highly acidic, and probably due to this reason, the insect did not prefer to infest fruit. Again, the infestation gradually increased from 36 days after fruit set and continued till fruit harvesting at 71 days, when the infestation was recorded to be 23.33%. The regression result for the effect of average temperature, average relative humidity, and rainfall on the average infestation of fruit by borers was shown in Table 3. The results from the analysis showed that the regression coefficient of determination R^2 was 0.651, which means about 65.1% of the variation in infestation was explained by means of rainfall, relative humidity, and temperature. The remaining 34.9% was mostly due to other variables external to the regression model. It is observed from table3 that the average percent infestation of fruit borer is positively correlated with average temperature, average relative humidity, and rainfall. The regression results also reveal that for every unit increase in temperature there is a 43.75% positive effect, for every unit increase in relative humidity there is an 8.79 % positive effect, and for every unit increase in rainfall there is a 3.45% positive effect on degree of infestation by litchi fruit borer.

Conclusion

It is evident from the present study that the activity of the pest species has a profound influence of average temperature (B = 4.375) and is positively correlated with the factors like temperature and relative humidity. Relative humidity was found to have less impact (B = 0.879) than average temperature on fruit infestation. Moreover, from the statistical analysis, it is also evident that rainfall has little influence on the activity of the pest species (B = 0.345) because of the fact that fruits were harvested before the rainy season. However, it was general observation that fruit infestation suddenly increased when there was a pre monsoon rainfall in May and June. The regression output shows that all the independent variables are statistically significant ($p< 0.05$). This significance indicates that changes in the independent variables correlate with shifts in the dependent variable. Therefore, the regression equation is $Y= -170.968 + 4.375 (X_1) + 0.879 (X_2) + 0.345 (X_3)$. The present findings are in close conformity with the reports of earlier workers like Lall and Sharma (1978) and Hameed *et al*. (1999). According to Hameed *et al*. (1999), the borer causes maximum damage to litchi during May-June, and its population was insignificant from October to March but reappeared in April. Lall and Sharma (1978) observed its maximum population density in September and lowest in December. Almost similar observation was made by Sharma (1985). According to Lall and Sharma, during the offseason, the borer survives on alternate hosts.

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