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Estimation of optimum time of insecticidal spraying for controlling Gundhi bug infestation on Boro Rice in Terai region of West Bengal

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Abstract
Development of an appropriate forewarning system considerably helps to identify the point of time when growth rate of a pest is at its peak to ensure the most effective use of protection measures. Along with this, it also helps to reduce unnecessary application of insecticides as well as environmental pollution. Hence, in the current study, an attempt has been made to identify the optimum time point of insecticidal spraying. Based on different model selection criteria, cubic model is observed to be the best fit and optimum time of spraying insecticides against gundhi bug was found to be at 23 DAT.

Keywords: Cubic model, Distributional approach, ETL, Gundhi bug, Optimum spraying time, Rice-pest modelling.

Introduction
Rice (*Oryza sativa* L.) is considered as the major staple food crop across Asia and is becoming increasingly important in Africa and Latin America. In India, rice has been grown in various agro-climatic zones as high, medium and low land rice. Though India has already secured 2nd position in rice production in the world, globally rice yield has become nearly stagnant or even declining over time during last two decades (Duxbury *et al.*, 2003) [5]. Among the several factors causing yield reduction, increased pest infestation is one of the most significant ones (Mondal *et al.*, 2017) [6]. There are more than 100 insect pests that inflict damage to rice-crop. Among them, gundhi bug is of prime importance (Singh and Singh, 2014) [8]. In the hilly areas at Darjeeling district, 25 to 30 per cent damage are caused by bug (Banerjee and Chatterjee, 1982) [2].

Though usually the effect of insect pest incidence on crop yield has been determined through empirical approach by establishing regression models between pest severity at different crop stages and crop yield, this approach does not take into consideration the physiological basis of pest damage. So it is inevitable that crop losses determined using empirical yield-infestation relations are location specific and cannot be extrapolated without risk of error. Therefore, a comprehensive approach is much needed in order to identify different damage mechanisms of the pest. Under these circumstances, the use of economic thresholds of insect pests can greatly facilitate need-based application of insecticides, thereby avoiding unwanted pesticide use, which in turn, will reduce environmental pollution and the likelihood of development of resistant pests.

Materials and Methods
The present experiment was conducted on rice at the farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, West Bengal, India (26.52° N, 89.11° E) during boro season of 2015-16 in order to investigate the gundhi bug infestation. Dimension of the experimental field was 15×10 m. The crop was sown in the first week of February and transplanted in the first week of March. To observe natural pest population build up, no insecticides had been applied. 15 sample area of size 270×120 cm had been selected by using random number table, which covered 32.4 per cent of total experimental area. After that, 13 plants from each sample area were sampled by using ‘W’ pattern. Data on insect counts were noted from the sampled plants from 21 DAT (Days after transplanting) to 90 DAT (up to harvesting) at each interval of 3 days.

As the study was empirical in nature, different descriptive measures had been computed in order to get an initial idea about the data structure. Geometric distribution as well as exponential distribution had been employed in order to know when the pest population reached ETL (Economic Threshold Level) for the first time, considering the distribution of insect pest discrete and continuous, respectively. It provided an idea about optimum time of insecticidal spraying to control gundhi bug infestation. Probability distribution functions of these two distributions are presented in table 1.

Table 1: Different distributions with their corresponding probability distribution Function

Name of the distribution	Mathematical expression
Geometric distribution	P(X=x) = $q^x p$, x=0,1,2,… ; q=1-p = 0, Otherwise.
Exponential Distribution	f (x,θ) = $\theta e^{-\theta x}$, x≥ 0 = 0, Otherwise.

To relate the time of taking observations with DAT, a conversion formula was much needful, so that results obtained in time point could be readily converted into DAT for the practical purposes. Mean values of geometric and exponential distributions had been calculated in terms of time point(s), which further, by the above mentioned formula, had been converted for the purpose of appropriate interpretation.

Time point ‘t’ = 21 + (3*t) DAT

Kolmogorov-Smirnov test for goodness of fit had been used to make a comparison of observed sample distribution with the fitted theoretical distribution in order to obtain an idea about how good a theoretical distribution fitted to a field data. Test Statistics is given as:

$$D = \text{Maximum } |F_0(X) - S_N(X)|$$

Assuming that samples had been drawn from an infinite population, mean of the sample observations had been fitted to different growth models. Linear model needs the assumption of a linear relationship between the dependent and independent variable. It implies that per unit change in independent variable would bring same amount of change in dependent variable. But if the assumption of linear relationship between the dependent and independent variable can not be met and there exists one or two humps in the graphical representation of the data, quadratic and cubic model fit best, respectively. When data shows growth or decline of non-linear nature, non-linear growth models like Logistic, Monomolecular models are usually employed.

Mathematical expression of various linear and non-linear growth models are presented in table 2.

Table 2: Different linear and non-linear growth models with their corresponding mathematical expression

Name of the model	Mathematical expression
Linear	$Y = a + bt + \varepsilon$
Quadratic	$Y = a + bt + ct^2 + \varepsilon$
Cubic	$Y = a + bt + ct^2 + dt^3 + \varepsilon$
Monomolecular	$Y = a(1-be^{-ct}) + \varepsilon$
Logistic	$Y = \frac{a}{1+be^{-ct}} + \varepsilon$

The Akaike information criterion (AIC) was used to provide means for model selection (Akaike, 1978) [1]. It is a commonly used estimator of the relative quality of the statistical models for a given set of data. It deals with the trade-off between the goodness of fit and the simplicity of the model. In the sense of testing a null hypothesis, AIC does not provide a test of a model. It tells only about the relative quality of a model.

$$AIC = n \ln\left(\frac{RSS}{n}\right) + 2k$$

Like AIC, the Bayesian information criterion (BIC) or Schwarz criterion (SBC/SBIC) is another model selection criterion among a finite set of models; the model with the least BIC is preferred most. It is based, in part, on the likelihood function.

$$BIC = n \ln\left(\frac{RSS}{n}\right) + k \ln(n)$$

With a view to check randomness and normality of residuals of the best fitted growth model, run test and Kolmogorov-Smirnov test for normality had also been employed, respectively. Based on best fitted model satisfying the necessary assumptions, the point of time when growth rate of the gundhi bug is at its peak i.e. $t_{opt.}$ was calculated. $t_{opt.}$ is considered as the point of time when any protection measure against gundhi bug would be most effective. In other words, $t_{opt.}$ indicates optimum time of insecticidal spraying.

Results and Discussion

Descriptive Statistics for gundhi bug count data were computed and presented in table 3. Mean and variance values had been found to be 0.81 and 1.65, respectively. It had also been observed that data was skewed to the right (2.18) and leptokurtic (5.55) in nature. The maximum and minimum number of gundhi bug present in a day per sample during 2015 were 0 and 7, respectively.

Table 3: Descriptive statistics for gundhi bug count data during 2015

Name of the Insect Pest	Descriptive Statistics					
	Mean	Variance	Skewness	Kurtosis	Minimum	Maximum
Gundhi Bug	0.81	1.65	2.18	5.55	0	7

From table 4, it could be observed that mean values of geometric and exponential distribution were found to be 9 and 9.07 (on the basis of time point), respectively. But both the values were found to be significant even at 1 per cent level of significance (table 5), indicating lack of fit for both the distributions. In other words, there was a need to look for modeling approach in order to fit the data better.

Table 4: Parameter estimates and mean values of the fitted distributions for gundhi bug count data during 2015

Name of the Insect Pest	Parameter estimates and mean values of the fitted distributions			
	Geometric Distribution		Exponential Distribution	
	$\hat{p}$	Mean	θ	Mean
Gundhi Bug	0.10	9	0.11	9.07

Table 5: Kolmogorov-Smirnov Test Statistic value of the fitted distributions for gundhi bug count data during 2015

Name of the Insect Pest	Kolmogorov-Smirnov Test Statistic value of the fitted distributions	
	Geometric Distribution	Exponential Distribution
Gundhi Bug	0.3141**	0.2789**

**: Significant at 1 per cent level, *:Significant at 5 per cent level, NS:Non-significant

Implementing modeling approach, it could be seen that in case of gundhi bug count data, among the fitted linear and non-linear growth models, cubic model, graphically represented in fig.1, fitted best with lowest AIC (-2.11) and BIC (2.61) values, followed by quadratic model (table 6). Both the coefficients of linear (-0.158) and quadratic (0.004) terms were found to be significant at 1 per cent level. However, at 5 per cent level of significance, coefficient of cubic term (-0.002) was observed to be significant.

Table 6: Parameter estimates of fitted models for gundhi bug count data during 2015

Model Name	Parameter estimates				AIC	BIC
	a	b	c	d		
Linear Model	0.321*	0.041 NS	-	-	8.93	11.29
Quadratic Model	-0.892 NS	0.372**	-0.014**	-	2.09	5.63
Cubic Model	0.014**	-0.158**	0.004**	-0.002*	-2.11	2.61
Monomolecular Model	14.007*	0.926 NS	0.083 NS	-	51.01	53.36
Logistic Model	14.686*	8.798 NS	0.832 NS	-	53.71	55.29

** Significant at 1 per cent level, * Significant at 5 per cent level, NS: Non-significant

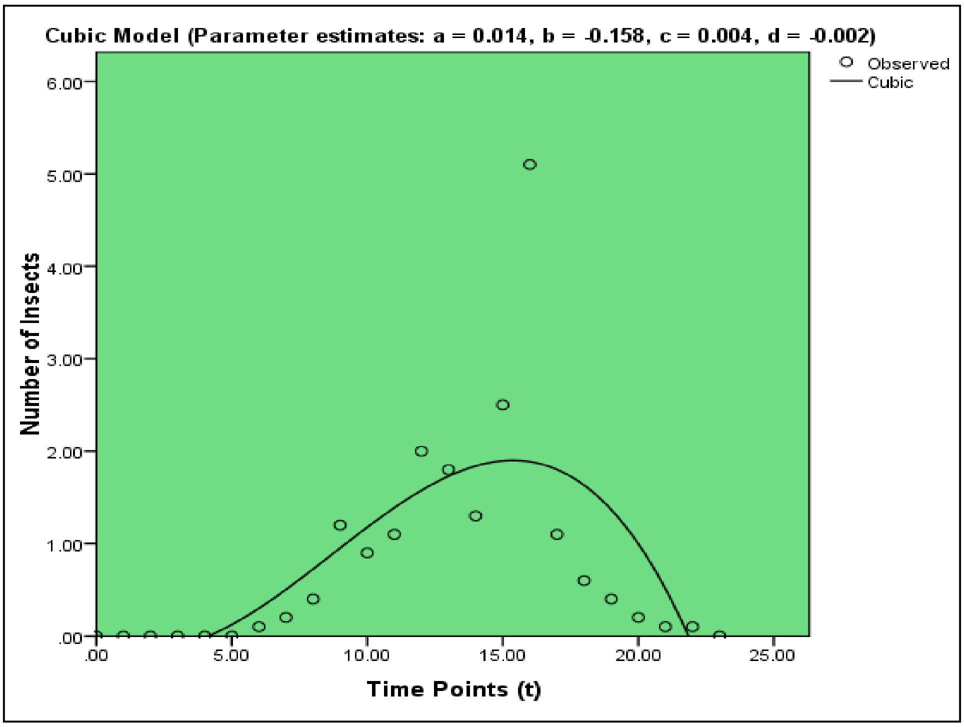

Fig 1: Best Fitted Model for gundhi bug Data during 2015

From table 7, it could be observed that in a sequence of 24 observations which consisted of 13 + signs (=N_1) and 11 − signs (= N_2), the critical values of runs were 7 and 19 at the 0.05 level of significance as shown in the table of run test statistic. The null hypothesis that residuals were distributed randomly, could not be rejected if the number of runs lied between 7 and 19. Here, as it was found that the number of runs (equal to 13) was greater than 7 and lesser than 19, we failed to reject the null hypothesis at the 0.05 level of significance. Further, we proceeded to check for the normality assumptions of the residuals.

Table 7: Runs test for Cubic model for gundhi bug data during 2015

Model	Test Value$_a$	Number of Cases < Test Value	Number of Cases >= Test Value	Total Number of Cases	Number of Runs	Z
Cubic	0.00	11	13	24	13	0.03

$_a$=median

KS Test had been performed and the calculated value of the test statistic was Dn(Cal.) = 0.279 and as the calculated value of Dn(Cal.) < Dn(Tab.),0.05 = 0.51926, the null hypothesis that the observed distribution was normal was accepted. Thus, it could be inferred that the residuals of cubic models were independent and normally distributed.

Now, based on cubic model, which was found to be the best fit and satisfied the necessary assumptions made on the residuals, the optimal spraying time of the insecticides i.e. when growth rate of the gundhi bug was at its peak,

$$t_{opt.} = -\frac{c}{3d} = 0.67 \text{ (On the basis of time point)}$$
$$= 23 \text{ DAT}$$

This finding is at par with the outcomes of Das *et al.* (2017) [4] in the study of rice leaf folder infestation in Pundibari region of West Bengal, where also cubic model was found to be fitted best. Similar kind of studies had also been carried out on modelling of pest population by Pal *et al.* (2013) [7] and Basak *et al.* (2017) [3].

The current study emphasises on the proper time of insectidal spray to control gundhi bug infestation in time in order to avoid adequate loss in terms of crop yield. Thus, the findings of the current experiment significantly helps as an in time alarm in the prevention against gundhi bug infestation in field conditions during bro seasons.

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References

1. Akaike H. A Bayesian analysis of the minimum AIC procedure. Annals of the Institute of Statistical Mathematics. 1978; 30(A):9-14.
2. Banerjee PK and Chatterjee PB. Pests of hill rice in West Bengal, India. International Rice Research Newsletter 1982; 7(4):12-14.
3. Basak S, Das SS, Pal S. Nonlinear modelling of rice leaf folder infestation on Boro rice in Pundibari (A part of Cooch Behar district). Journal of Entomology and Zoology Studies. 2017; 5(2):967-972.
4. Das SS, Debnath MK, Basak S, Ghosh J, Das A. Estimation of optimum time of spray for controlling rice leaf folder infestation on boro rice in terai region of West Bengal using best fitted linear and nonlinear growth model. International Journal of Current Microbiology and Applied Sciences. 2017; 6(6):2300-2309.
5. Duxbury JM, Mayer AB, Lauren JG, Hassan N. Food chain aspects of arsenic contamination in Bangladesh: effects on quality and productivity of rice. Journal of Environmental Science and Health, Part A: Toxic/Hazardous Substances and Environmental Engineering. 2003; 38(1):61-69.
6. Mondal D, Ghosh A, Roy D, Kumar A, Shamurailatpam D, Bera S *et al*. Yield loss assessment of rice (*Oryza sativa* L.) due to different biotic stresses under system of rice intensification (SRI). Journal of Entomology and Zoology Studies. 2017; 5(4):1974-1980.
7. Pal S, Ghosh A, Dhar T. On determination of ETL – a distributional approach. Biometrical Letters. 2013; 50(2):107-116.
8. Singh BB, Singh R. Major rice insect pests in NorthEastern UP. International Journal of Life science and Pharma Research. 2014; 3(1):124-143.