# Spatial Pattern Detection Modeling of Aphid (*Aphis gossypii* Glover) of Brinjal (*Solanum melongena* L.) in Chhattisgarh

Shabnam Reetu Tirkey[#1] and Ravi R. Saxena[*2]

[#]*Department of Agril. Statistics, Indira Gandhi Krishi Vishwavidyalaya, Krishak Nagar, Raipur (C.G.) – 492012, India*

***Abstract-*** *A field study was made during 2014 at Chhattisgarh region to study the spatial distribution of aphids (Aphis gossypii* Glover*) in brinjal (Solanum melongena* Linn.*). The various indices of dispersion, viz., variance mean ratio, exponent k, patchiness index, Lloyd's mean crowding, David and Moore's index, Cole's index, Taylor's power law and Morisita's index revealed that the brinjal of aphid exhibited aggregated or contagious pattern of distribution in the field. In study of Taylor's power law, slope parameter (b=1.166) was > 1 indicating contagious (aggregated) or regular nature of distribution. The aphid population infestation followed negative binomial distribution pattern as an alternative of poisson or random distribution. Spatial distribution parameters are useful in the field as well as to estimate the population density of aphid.*

**Keywords-** *Brinjal, aphid, spatial distribution.*

## I. INTRODUCTION

Brinjal, *Solanum melongena* Linn. (Family: Solanceae) is an important vegetable crop grown throughout the world. India is the major producer of brinjal in the world. The area under brinjal cultivation in India is 711.3 thousand hectares with estimated annual production of 13557.8 thousand metric tonnes with a productivity of 19.1 metric tonnes per hectare [1]. In Chhattisgarh, brinjal is grown in an area of 33069 hectare, with an annual production of 585978 metric tonnes and productivity of 17.63 metric tonnes per hectare which is less than the national average [2]. The losses caused by brinjal pests vary from season to season depending upon environmental factors. The most extensive pest of this important vegetable is brinjal aphid (*Aphis gossypii* Glover), which reduces the crop yield up to 30-70 per cent and inflicts the colossal loss in production.

Spatial distribution is the most important ecological properties of a brinjal crop [8] and information on this aspect can serve as a basis for decision making to implement management strategies in the field [3]. A primary requisite in better understanding of an insect in the field of knowledge on this pattern. Distribution parameters are useful for the study as well as to estimate the population density of aphid. Insect population may follow the binomial (regular), random (Poisson) and negative binomial (aggregated) distribution pattern [13].

## II. MATERIALS AND METHODS

Field study was made at Chhattisgarh region to understand the spatial distribution of aphid occurring on brinjal. The brinjal crop was grown during 2014 at Chhattisgarh region in the farmer field. All the recommended cultural practices were followed to grow brinjal crop except insecticidal sprays. The various indices of dispersion to find out the analytical tool for distribution pattern of *Aphis gossypii* Glover: the variance mean ratio (VMR) [5] was calculated by following formula: VMR= $S^2/\bar{x}$,

$S^2/\bar{x}$ =1: random distribution

$S^2/\bar{x}$ <1: regular distribution

$S^2/\bar{x}$ >1: aggregate or contagious distribution.

The parameters of negative binomial distribution, i.e. common mean ($\bar{x}$) and exponent *k*, are also known as dispersion parameter. '*k*' is determined from the mean and variance of the data using formula:

$$k = \frac{\bar{x}^2}{s^2 - \bar{x}}$$

Mean crowding (x*) was proposed by Lloyd's to indicate the possible effect of mutual interference among individuals. Lloyed's index of mean crowding was suggested as follows:

$$X^* = \bar{x} + \frac{s^2}{\bar{x}} - 1$$

Patchiness index was calculated by followed formula: Patchiness index = $\frac{x^*}{\bar{x}}$, if the Patchiness less than one, the distribution will be dispersed. When equal to 1 or >1, the random distribution of population [9]. The index of clumping of David and Moore [4] was calculated by following:

$$I_{DM} = \frac{s^2}{\bar{x}} - 1$$

$I_{DM}$ = 0 value for random population.

$I_{DM}$ = Negative value shows regular distribution

$I_{DM}$ = Positive value for contagious distribution.

The relationship of mean crowding (x*) to mean density (x) is also known as Iwao's m*-m relationship. Iwao's [12] showed that in a regression of mean crowding on mean density, the regressions constant are characteristics to respective distribution pattern. It has a value of unity when the distribution is random and >1 for aggregated patterns. In graphical analysis of the one year data, it was found that contagiousness coefficient was >1 which indicated that aphid population followed negative binomial distribution, rather poisson or random distribution pattern.

Taylor's power law [7] hold in continuous series of distribution from regular through random to highly aggregate. When the b= 1: random distribution, <1: regular and >1: aggregated respectively. Taylor's power law is expressed by the relationship between variance and mean as:

$$S^2 = a\bar{x}^b$$

Where $S^2$ is the variance; sample mean; Taylor's scaling factor (a) and measures of aggregation (b) were estimated by regressing $\log_{10}$ variance against $\log_{10}$ mean. Based on regression analysis of $\log_{10}S^2$ and $\log_{10}\bar{x}$, the value of 'a' and 'b' was worked out as following equation:

$$S^2 = a + \bar{x}^b$$

Cole's [6] developed the formula, $I=\sum(\boldsymbol{x})^2/(\sum \boldsymbol{x})^2$ to study dispersion of the population. Cole's index value more than the value of maximum regularly and randomness, indicates aggregative of dispersion.

Morisita [10] reported a hypothesis for testing the uneven distribution coefficient of $I_\delta$ and Morisita's index ($I_\delta$) is calculation is done using:

$$I_\delta = n \sum x_i (x_i\text{-}1) / N (N\text{-}1)$$

Where n= the number of sample units, x= the number of individuals in each sample unit and N= total number of individuals in n samples. For a random distribution, a value of unity, but for uniform distribution Morisita's index will be < 1 and >1 for aggregated distribution.

## III. RESULTS AND DISCUSSION

The various indices of dispersion to find out the distribution pattern of aphid (*Aphis gossypii* G.) are presented in Table I. The aphid attacks mainly from 9th standard to 22th standard week. The aphid /leaf ranged from 3.92 to 15.74. The highest population was recorded in 17th standard week. The distribution pattern of the above pests of brinjal was further confirmed by studying various dispersion indices.

In this study the variance to mean ratio [15] was an insect, at all the stages of crop growth, suggesting clumped or aggregated. Gopaalan *et al.* [11] studied on the exponential diophantine equation. Exponent k (Table I) indicates that distribution of aphid population was aggregate that the population were approaching toward random distribution. This may be due to sample size where the value of k is often influenced by the size of the sampling unit as described by Cole [6], Waters and Henson [16]. The statistical properties of Kumaraswamy Quasi Lindley Distribution as studied by Elbatal and Elgarhy [14]. Lloyd's index of mean crowding ranged from 3.83 to 16.00 for aphid (Table I). The values of Lloyd's index of mean crowding at each date of observation were higher than their respective mean. This also showed that aphid population infested followed negative binomial distribution. The values of patchiness index were >1. It confirms that the distribution of aphid population was aggregate or clumped in nature, except 9th, 20th and 22nd standard weeks, in which it followed the regular distribution.

David and Moore's index value for each date of observation were greater than zero, except 9th, 20th and 22nd standard weeks. This indicated that the distribution approaching negative binomial distribution, except 9th, 20th and 22nd standard weeks, in which it approached regular distribution. Iwao's m*-m relationship in graphical analysis of one year data (Fig 1), it was found that contagiousness coefficient was less than one which indicated that aphid population followed poisson or random distribution pattern, rather negative binomial distribution.

Taylor's power law described the variance mean relation well (Fig 2). Based on regression analysis $\log_{10}s^2$ and $\log_{10}\bar{x}$, the value of 'a' and 'b' were worked out. The respective equation is as follow, $S^2 = -0.1333+\bar{x}^{1.166}$. The value of 'b' in equation is >1, these indicate that the entire aphid in brinjal is having contagious nature of distribution.

Cole's index values were greater than the values of maximum regularity and randomness suggesting aggregation. Distribution pattern of aphid using Morisita's index ($I_\delta$) in most sampling dates was aggregated.

## IV. Table I

**Dispersion parameters and indices of spatial distribution of aphid in brinajl crops**

| Standard week | 9th | 10th | 11th | 12th | 13th | 14th | 15th | 16th | 17th | 18th | 19th | 20th | 21st | 22nd |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Dispersion Parameter** | | | | | | | | | | | | | | |
| Mean | 4.55 | 5.14 | 5.78 | 8.31 | 9.92 | 11.70 | 12.33 | 13.19 | 15.74 | 14.04 | 15.25 | 8.10 | 4.57 | 3.92 |
| Variance | 4.32 | 6.39 | 8.47 | 10.32 | 12.55 | 13.90 | 15.60 | 17.98 | 19.84 | 16.08 | 19.44 | 1.56 | 5.04 | 3.56 |
| k-value | -88.91 | 20.98 | 12.44 | 34.28 | 37.40 | 62.43 | 46.52 | 36.24 | 60.33 | 96.50 | 55.52 | -10.03 | 44.57 | -42.09 |
| **Dispersion indices** | | | | | | | | | | | | | | |
| VMR | 0.95 | 1.24 | 1.46 | 1.24 | 1.27 | 1.19 | 1.27 | 1.36 | 1.26 | 1.15 | 1.27 | 0.19 | 1.10 | 0.91 |
| Lloyd's index of mean crowding | 4.50 | 5.38 | 6.24 | 8.55 | 10.18 | 11.89 | 12.60 | 13.55 | 16.00 | 14.19 | 15.52 | 7.29 | 4.68 | 3.83 |
| Patchiness index | 0.99 | 1.05 | 1.08 | 1.03 | 1.03 | 1.02 | 1.02 | 1.03 | 1.02 | 1.01 | 1.02 | 0.90 | 1.02 | 0.98 |
| IDM | -0.05 | 0.24 | 0.46 | 0.24 | 0.27 | 0.19 | 0.27 | 0.36 | 0.26 | 0.15 | 0.27 | -0.87 | 0.10 | -0.09 |
| Cole's index | 0.38 | 0.39 | 0.39 | 0.37 | 0.36 | 0.36 | 0.36 | 0.36 | 0.35 | 0.35 | 0.35 | 0.34 | 0.39 | 0.38 |
| Morisita's index | 1.09 | 1.43 | 1.84 | 3.62 | 5.12 | 7.05 | 7.83 | 8.97 | 12.65 | 9.95 | 11.90 | 3.14 | 1.05 | 0.75 |

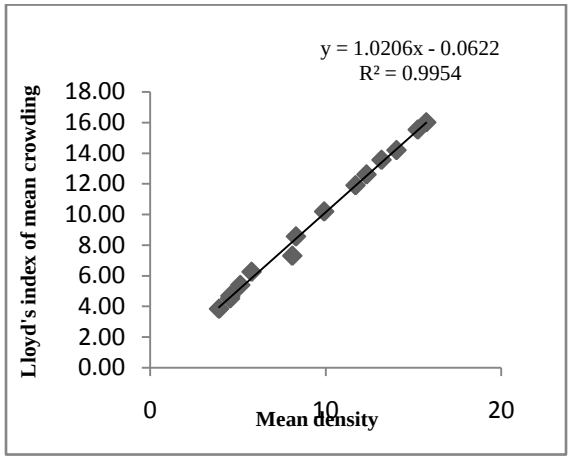


**Fig. 1 Relationship of mean density and Lloyd's index of mean crowding for aphid in brinjal crop**

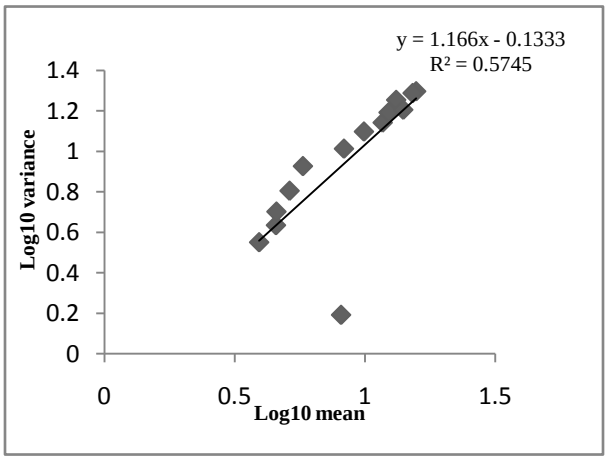


**Fig. 2 Taylor's Power plot for aphid in brinjal crop**

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