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Spatial distribution of thrips, *Thrips palmi* Karny on potato *(Solanum tuberosum)* under subtropical conditions of Madhya Pradesh

ANUJ BHATNAGAR
Central Potato Research Station, Gwalior, Madhya Pradesh, India
E mail: dr.anujbhatnagar_icar@yahoo.co.in

ABSTRACT: A field experiment was carried out during 2006-07 and 2007-08 at Central Potato Research Station (CPRS), Gwalior, India to study the spatial distribution of thrips (*Thrips palmi* Karny) in potato (*Solanum tuberosum)* crop. The various indices of dispersion, *viz.*, variance mean ratio, exponent k and common k (kc), Lloyd's indices of mean crowding (x*) and patchiness index (x * "x) and Taylor's power law revealed that the potato thrips exhibited aggregated or contagious pattern of distribution in the field. In study of Taylor's power law, slop parameter (b = 0.7617 and 0.702 for respective years) was < 1 indicating contagious distribution. This also indicates that thrips population followed negative binomial distribution pattern as an alternative of poisson or random distribution. The intercept also justified that the distribution of thrips was contagious in nature. Spatial distribution parameters are useful to out line the sampling programme as well as to estimate the population density of *T. palmi*.

Key words: Potato, spatial distribution, *Solanum tuberosum, Thrips palmi*

INTODUCTION

Potato (*Solanum tuberosum*) is a major staple food crop of Madhya Pradesh. One of the major limiting factors for cultivation of early potato is the high incidence of sap feeding insect which also act as vectors of virus diseases. Among them, thrips (*Thrips palmi* Karny) is an important vector of groundnut bud necrosis virus (GBNV) in potato crop. It is a cosmopolitan and an important insect which attacks weeds, flowers, trees and a large number of field and vegetable crops (Ananthakrishnan, 1980; Kawai, 1986). Thrips population moves from preceding potato crop to other cultivated host plants and weeds in the vicinity. The disease gives a dry blight appearance with dry leaves hanging on blighted (necrosed) stem. It has assumed significant status in parts of Madhya Pradesh, Rajasthan and Gujrat (Bhatnagar, 2009). The nymphs and adults remain active in the upper portion of potato plant. A primary requisite in better understanding of an organism in its ecosystem its knowledge of its spatial distribution patterns (Sevacherian and Stern, 1972). There is no such record on distribution pattern of potato thrips in subtropical region of Madhya Pradesh. Hence, the present study was undertaken to understand the distribution pattern of *T. palmi* on potato crop.

MATERIALS AND METHODS

Field studies were carried out at Central Potato Research Station, Gwalior, Madhya Pradesh, India to understand the spatial distribution *Thrips palmi* of predominant species of thrips occurring on potato. The variety 'Kufri Chandramukhi' was grown during September 2006-07 and 2007-08 both at CPRI experimental farm and in farmers' field in an area of 1000m^2 which was further divided into plots of 20 x 10m^2 size. All the recommended cultural practices were followed to grow potato crop except insecticidal sprays. The observations on population of thrips were started from the 15th September and continued till the 27th December during both the years from 40 randomly plants (each consists of average of three upper leaves) per plot. Mean weekly thrips counts on potato leaves were used to study the distribution pattern of thrips. Depending on infestation, mean and variance were determined for each date of observation to work out variance mean ratio (VMR).

The parameters of negative binomial distribution, i.e. arithmetic mean (x) and exponent k are also known as dispersion parameters. The value of 'k' was calculated by following formula.

$$k = \frac{\text{Mean } (x_i)}{x_i^{\,2} - x_i}$$ {for all i = 1 to 16. The value of i for all following formula remains same}.

Common k was estimated as per the procedure given by Bliss and Owen (1958) as below.

$$x_i' = \text{Mean } (x_i) - \frac{s_i^2}{n} \quad \text{where } n = 16$$

$$y_i' = s_i^{2} - \text{Mean}(x_i)$$

$$1/kc_i = \frac{\Sigma\, y_i'}{\Sigma\, x_i'}$$

Lloyd's indices of mean crowding was calculated as follows.

$$x_i^* = \text{Mean}(x_i) + \frac{\text{Mean}(x_i)}{k_i}$$

The ratio of mean crowding to mean called (x_i^*/ mean (x_i)) patchiness. Patchiness index was calculated by following formula.

$$\textit{Patchiness index} = \frac{x^*}{\text{Mean}(x_i)}$$

Mean colony size was calculated as

$$C_i^* = x_i^* + 1$$

The Index of clumping of David and Moore (1954) was also calculated bythe following formula;

$$I_{DMi} = \frac{s_i^2}{\text{Mean}(x_i)} - 1$$

If the mean and variance of a series of samples are plotted, they tend to increase together. This relationship has been shown by Taylor (1965; 1971) to obey a power law. It holds in a continuous series of distribution from regular through random to highly aggregated and is expressed by the empirical relationship between variance and mean was as.

$$s_i^2 = a + \text{mean}(x_i)^b$$

Where, 'a' is a sampling factor and 'b' is aggregation parameter. The regression of $\log_{10} s_i^2$ on $\log_{10} x_i$ was carried out to estimate the parameters of Taylor's power law.

RESULTS AND DISCUSSION

The various indices of dispersion to find out the distribution pattern of thrips, *T. palmi* are presented in Tables 1 and 2. There were 1.45 to 22.85 thrips/leaf during the year 2006-07 and during the year 2007-08 population ranged from 1.43 to 21.90 thrips/leaf. Highest number of thrips was recorded during the fourth week of September in both the years.

Variance-mean ratio (VMR)

Higher variance value than corresponding mean was observed on all the dates of observation. It ranged form 1.48 to 59.25 and 1.63 to 58.65 during the years 2006-07 and 2007-08 respectively. This showed the ominance of variance over respective mean at each date of observation. Higher variance value over mean indicated that there was contagious or aggregate distribution of thrips on potato crops. Variance mean ratio (VMR) is also an effective parameter which indicates nature and distribution pattern of insects in space and time. If the value of VMR is 1, there will be a poisson distribution while more than one and less than one indicates negative binomial distribution and regular respectively. The values of VMR for all the dates of observation during both the years of study were more than one which also proved that the thrips population was aggregated and followed the negative binomial distribution in potato crop.

Exponent k and common k (1/kc)

The parameter k is a valid measure of aggregation of population. The value of k can range from 0 (when aggregation is extreme) to infinity, which indicates a purely random distribution of counts of population. Any large value of k indicates an approach toward randomness and it also indicates the relative degree of aggregation for the condition involved. Data presented in Tables 1 and 2 indicate that the distribution of thrips was aggregate in nature with indication that populations were approaching toward random distribution. The value of k is often affected by the size of the sampling unit. However, sometimes the lower k values for low population reflect an initial aggregative tendency. The aggregative effect may be due to the initial non-random deposition of egg masses. Graphical test of the homogeneity of the samples is obtained by plotting $1/kc_i$ against mean (x_i) for each group of samples. If there is neither trend nor clustering, we may regard the fitting of common k as justified but if a trend of cluster occurs it is doubtful that common k is justified. Plotting k against mean (x_i) for each group of samples Fig. 1 (a & b) indicates that there was neither

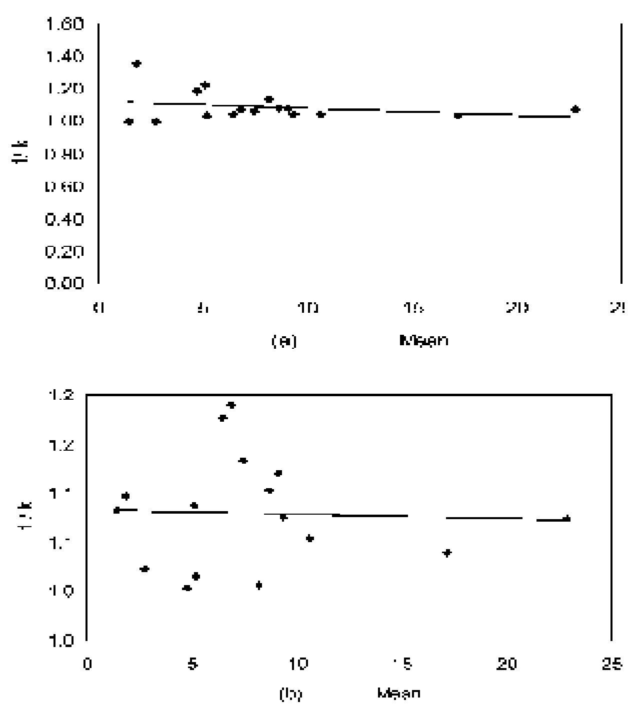

Fig. 1 : Relationship of 1/k to the mean of thrips population of the years 2006-07 (a) and 2007-08 (b)

Table 1. Different parameters of spatial distribution of thrips on potato crop during year 2006-07

Date of observation	Mean (thrips/ leaf)	Variance s^2	VMR	k-value	Mean crowding	Patch index	Mean colony size (C*)	CV	x^2	y^2	I_{DM}
15.09.2006	6.43	8.5071	1.3241	0.9567	13.1410	2.0453	14.1410	0.4540	39.4714	65.9449	0.3241
26.09.2006	22.85	59.2590	2.5934	0.9373	47.2286	2.0669	48.2286	0.3369	434.3318	3488.7760	1.5934
01.10.2006	17.18	26.0455	1.5165	0.9729	34.8286	2.0279	35.8286	0.2971	278.0214	661.1907	0.5165
04.10.2006	10.58	16.0455	1.5173	0.9566	21.6294	2.0453	22.6294	0.3788	105.3942	246.8835	0.5173
10.10.2006	9.08	15.7635	1.7370	0.9290	18.8436	2.0764	19.8436	0.4375	76.1435	239.4117	0.7370
15.10.2006	9.35	13.4128	1.4345	0.9591	19.0987	2.0426	20.0987	0.3917	82.9249	170.5538	0.4345
25.10.2006	7.40	10.8615	1.4678	0.9450	15.2311	2.0583	16.2311	0.4454	51.8107	110.5730	0.4678
02.11.2006	6.80	10.3092	1.5249	0.9332	14.0868	2.0716	15.0868	0.4735	43.5520	100.7209	0.5249
09.11.2006	5.15	6.1821	1.2004	0.9680	10.4704	2.0331	11.4704	0.4828	25.5671	33.0678	0.2004
17.11.2006	8.18	17.5327	2.1447	0.8823	17.4411	2.1335	18.4411	0.5122	59.1457	289.2203	1.1447
24.11.2006	8.65	14.8487	1.7186	0.9277	17.9737	2.0779	18.9737	0.4455	69.3104	211.8344	0.7186
30.11.2006	4.75	9.1667	1.9298	0.8435	10.3816	2.1856	11.3816	0.6374	20.4618	79.2778	0.9298
06.12.2006	2.75	2.8077	1.0210	1.0017	5.4955	1.9983	6.4955	0.6093	7.3654	5.1331	0.0210
13.12.2006	5.08	10.9942	2.1684	0.8202	11.2622	2.2192	12.2622	0.6534	22.7338	115.7981	1.1684
20.12.2006	1.83	2.0455	1.1208	0.7401	4.2908	2.3511	5.2908	0.7837	3.2260	2.3591	0.1208
27.12.2006	1.45	1.4846	1.0239	1.0012	2.8983	1.9988	3.8983	0.8403	2.0474	0.7541	0.0239
										Σy^2 5831.5023	
									Σx^2 1321.5074		
									1/Kc=	4.4128	

Table 2. Different parameters of spatial distribution of thrips on potato crop during year 2007-08

Date of observation	Mean (thrips/ leaf)	Variance s^2	VMR	k-value	Mean crowding	Patch index	Mean colony size (C*)	CV	x^2	y^2	I_{DM}
15.09.2007	8.10	20.1949	2.4932	0.8499	13 1410	2.1766	18.6309	0.5548	55.4142	399.7328	1.4932
26.09.2007	21.90	58.6564	2.6784	0.9315	47 2286	2.0736	46.4114	0.3497	393.5956	3418.6745	1.6784
01.10.2007	20.13	36.9840	1.8377	0.9621	34 8286	2.0393	42.0418	0.3022	370.8203	1347.6894	0.8377
04.10.2007	10.73	17.3840	1.6209	0.9487	21 6294	2.0541	23.0304	0.3888	107.4706	291.4776	0.6209
10.10.2007	7.08	13.4558	1.9019	0.8923	18 8436	2.1208	16.0043	0.5185	45.5292	173.9827	0.9019
15.10.2007	7.70	12.4718	1.6197	0.9300	19 0987	2.0752	16.9792	0.4586	55.4014	147.6457	0.6197
25.10.2007	5.63	10.6096	1.8214	0.8825	15 2311	2.1332	13.4259	0.5592	31.1165	106.7369	0.8214
02.11.2007	4.13	7.5481	1.8298	0.8403	14 0868	2.1901	10.0341	0.6660	15.5913	52.8485	0.8298
09.11.2007	3.20	3.4462	1.0769	0.9846	10 4704	2.0156	7.4500	0.580'	9.9431	8.6760	0.0769
17.11.2007	7.60	8.1436	1.0715	0.9941	17 4411	2.0059	16.2447	0.3755	56.1020	58.7181	0.0715
24.11.2007	8.60	16.6051	1.9308	0.9069	17 9737	2.1026	19.0826	0.4738	67.0667	257.1303	0.9308
30.11.2007	4.43	4.6096	1.0417	0.9965	10 3816	2.0035	9.8657	0.4852	19.0494	16.8236	0.0417
06.12.2007	2.93	3.1994	1.0938	0.9778	5 4955	2.0227	6.9165	0.6115	8.2997	7.3109	0.0938
13.12.2007	4.78	6.9481	1.4551	0.9194	11 2822	2.0877	10 9687	0.5520	21.5937	43.5008	0.4551
20.12.2007	2.53	2.7686	1.0965	0.9108	4 2908	2.0979	6.2973	0.6590	6.1840	5.1401	0.0965
27.12.2007	1.43	1.6353	1.1475	0.9230	2 8983	2.0834	3.9689	0.6974	1.9636	1.2491	0.1475
									• x^2=1265.1415	• y^2=6347.5387	
									1/kc=	5.0173	

trend nor clustering of common k value. Therefore, calculation of common k is justified and the value of common k (1/kc) of both the ropping seasons was less than 1.35 which indicates that population of potato thrips followed contagions nature of distribution as reported by Pandey *et al.* (2008).

David and Moore index

The clumping index of David and Moore gives a value of zero for random population, negative value for regular distribution and positive value for contagious pattern of distribution. David and Moore's index values for each date of observation were > 0 and positive in both the years. This indicates that the distribution was neither random nor regular and approaching negative binomial distribution.

Mean crowding

The mean crowding of thrips per leaf ranged form 2.85 to 47.22 during the year 2006-07 and 2.96 to 45.41 during the year 2007-08. The values of mean crowding on each date of observation were higher than their respective mean. This also showed that thrips population followed negative binomial distribution in space and time.

Patchiness index

If the patchiness value is less than 1, the distribution will be dispersed. When the value is equal to 1 or more than 1, the distribution of the population will be random or clumped, respectively. In this study, values of patchiness index were > 1 during both the years. It confirms that the distribution of thrips population was aggregated or clumped in nature.

Taylor's power law

In order to further confirm the aggregate pattern of thrips dispersion, Taylor's power analysis was done with 16 samples pertaining to cropping seasons during the years 2006-07 and 2007-08. In Taylor's power law, the regression coefficient is an index of concerned (Taylor, 1965). The law states that $s^2 = ax^{-b}$ where s^2 and x are sample variance and sample mean, respectively. The 'a' is scaling factor that is dependent on sampling method and habitat, and the exponent 'b' is a measure of aggregation. If 'b' equals to 1, then the population has a random distribution and when b > 1 or < 1 the population follow contagious (aggregated) or regular nature of distribution, respectively. Taylor's scaling factor (a) and measures of aggregation (b) parameters were estimated by regressing $\log_{10}$ variance against $\log_{10}$ mean. Taylor's power law described the variance mean relation well (Fig. 2 a and b). Based on regression analysis of $\log_{10} s^2$ and $\log_{10}$ mean x, the value of 'a' and 'b' were worked out. The respective equations are as follows.

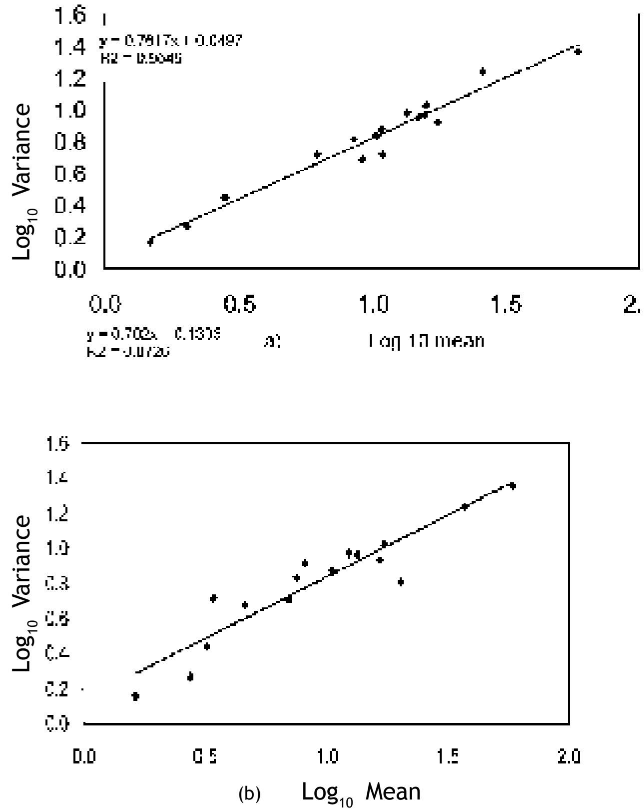

Fig. 2. Taylor's Power plot for *Thrips palmi* for year 2006-07 (a) and 2007-08 (b)

Crop year 2006-07: $s^2 = 0.0497x^{-0.7617}$
Crop year 2007-08: $s^2 = 0.1306x^{-0.702}$

The values of b were 0.7617 and 0.702 for 2006-07 and 2007-08 respectively. Coefficients of determination (R^2) were 0.95 and 0.87 repetitively during the years 2006-07 and 2007-08 were significant. The values of R^2 showed that 95.49 per cent and 87.26 per cent of the variation in the distribution could be explained by the fitted regression equation. The slope parameters of the fitted model were significantly less than unity, indicating a contagious distribution (b = 0.76 and 0.70) of thrips population in potato crop. The differences in 'b' value of two years study of *T. Palmi* probably ref1ects population density related changes in behaviour of species and/or due the change in weather conditions. In terms of the index of basic contagion, the insect has definite tendency of aggregation in both the years. Deligeorgidis *et al.* (2002) also reported that all species of thrips were aggregated in distribution among sampling units. The slope parameters were also stable during both the years. Based on different parameters it was found that potato thrips exhibited aggregated or clumped nature of the distribution on potato crop. Similar findings have been reported by Fournier (1955), Lu (1989) and Pandey *et al.* (2008). Spatial distribution parameters of this species can be employed to standardise the sampling programme as well as to estimate the population density of *T.palmi* which in turn help in devising effective management strategies.

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