EGYPTIAN ACADEMIC JOURNAL OF
BIOLOGICAL SCIENCES
ENTOMOLOGY

A

ISSN
1687-8809

WWW.EAJBS.EG.NET

Vol. 15 No. 4 (2022)

Citation: *Egypt. Acad. J. Biolog. Sci. (A. Entomology) Vol. 15(4) pp.47-55 (2022)*
DOI: 10.21608/eajbsa.2022.267900

Egypt. Acad. J. Biolog. Sci., 15(4):47-55 (2022)

Egyptian Academic Journal of Biological Sciences
A. Entomology

ISSN 1687- 8809
http://eajbsa.journals.ekb.eg/

Spatial Distribution of *Thrips tabaci* Lindeman (Thysanoptera: Thripidae) on Onion Plants at Different Irrigation Intervals

M. Z. Embarak*
Plant Protection Res. Institute, Agricultural Research Center, Giza, Egypt.
E-mail: magedzahe@yahoo.com

ARTICLE INFO
Article History
Received:27/8/2022
Accepted:24/10/2022
Available:28/10/2022

Keywords:
Thrips tabaci, irrigation intervals, dispersion, spatial distribution

ABSTRACT

Onion thrips, *Thrips tabaci* Lindeman, is one of the most serious pests of onion throughout the world. Knowledge of spatial distribution is important for developing an effective sampling plan and ultimately for IPM strategies for a given pest. In the present **s**tudy spatial distribution of *T. tabaci* was studied on onion, *Allium cepa* L. under three irrigation regimes of Egypt during 2021. Dispersion index like a variance to mean ratio (σ^2/X) revealed a negative binomial distribution, whereas the other dispersion indices like David Moore index (IDM = $\sigma^2/X-1$), mean crowding (X*), Lloyd's mean crowding index (X*/X) and 'k' of negative binomial verified the aggregated nature of the spatial distribution of onion thrips at 10, 20 and 30-days irrigation intervals throughout the cropping season. Moreover, Taylor's power equation was $\sigma^2= 1.549X^{1.581}$, $\sigma^2= 1.636X^{1.623}$ and $\sigma^2= 1.872X^{1.504}$, while Iwao's patchiness regression equation was $X^*= 2.973+1.432X$, $X^*= 9.251+1.457X$ and $X^*= 9.161+1.352X$ for the three above-mention irrigation intervals, respectively. An optimum number of required samples varied with the mean density of the thrips.

INTRODUCTION

Onion, *Allium cepa* L., is considered one of the most important field crops in many parts of the world. In Egypt, it is a field crop of outstanding importance on account of its great value for local consumption and exportation to different countries.

The onion thrip, T. tabaci, is considered among the main injurious insect pest to onion crop (El-Serwiy *et al.*, 1985; El-Saadany and Salman, 2000; Sallam and Hosseny, 2003; Kaplan and Bayhan, 2017).

Water uses in Egypt are under increasing pressure, because of limited water resources, the unstoppable population growth, our future aspirations to increase the cultivated area and expand the agricultural land as well as the significant expansion of water use in industry, agriculture and household consumption. Moreover, Egypt to face the adverse effects of climate change resorted to the rationalization of water consumption by devising new varieties consuming lower quantities of water and switching to modern irrigation systems to raise the efficiency of the waterway network and maximize water returns. In relation to the use of water in agriculture, Climatic factors are closely related to

Citation: *Egypt. Acad. J. Biolog. Sci. (A. Entomology) Vol. 15(4) pp.47-55 (2022)*
DOI: 10.21608/eajbsa.2022.267900

the individual's development and growth, and the population dynamics of insect pests. Environmental moisture (including atmospheric relative humidity and soil moisture content) can directly affect their individual development and population occurrence (Chang *et al.*, 2008).

Estimating the pest densities is the principal tool for any research programme in relation to insect ecology and/or pest management. The accurate estimate of the population density depends upon the reliable sampling programme. The sampling programme includes proper sampling time, sampling unit, and optimum number, as well as the knowledge of the spatial distribution of the species, is crucial (Pedigo and Buntin, 1994; Boeve and Weiss, 1998; Southwood and Henderson, 2000). Organisms are all discrete entities that interact mainly with the neighboring individuals of their own or other species (Tilman *et al.*, 1997). Therefore, the knowledge of spatial distribution is also important to understand the bioecology of the pest and to determine the sampling protocol for that species.

The most commonly used methods to describe the pattern of dispersion of arthropod populations have been summarized by Southwood and Henderson (2000). Several estimates based on the dispersion coefficient, *K*, of the negative binomial distribution and based on the variance-mean relationships of Taylor (1961) and Iwao (1968) are used as indices of aggregation (Krebs, 1999; Southwood and Henderson, 2000; Sedaration *et al.*, 2010). Sampling plans based on these indices optimize the sampling effort as well as the sampling precision (Kuno, 1991). Although the objectives of sampling a finite population can differ, the development of a sampling procedure requires knowledge of the spatial distribution of the population (Liu *et al.,* 2002).

There are several studies that have described the effects of different irrigation intervals on the population density of Thysanoptera species (Fournier *et al.*, 1995; Kannan and Mohamed, 2001; Burnstone, 2009; Patel *et al.*, 2010; Yadav *et al.*, 2018) but published reports on the spatial distribution of *T. tabaci* in onion fields in relation of different irrigation regimes are lacking. The importance of the current study originates from its attempt to develop a reliable sampling programme and explain the spatial distribution of *T. tabaci* (Thysanoptera: Thripidae) as a tool for effective management strategy against this pest on onion.

MATERIALS AND METHODS

The present investigation was conducted at Abnoub district located 25 km northeast of Assiut city, Assiut governorate of Egypt, during the growing season of 2021 to study the seasonal population activity of *T. tabaci* on the onion variety (Giza 6 Mohassan) cultivated on Nov., 1st., under different three irrigation schemes. An area of about a quarter feddan was chosen and divided into 12 plots. The three irrigation schemes were distributed in complete randomized blocks with four replicates each. Normal agriculture practices were performed and no chemical pest control was done during the study period.

Sampling Program:

After 40 days of transplanting, in order to permit normal rooting, weekly samples of 9 plants/plots were taken from the two diagonals of each plot to represent random collection in the early morning. In order to determine the sample size, primary sampling took place in an equal number of different three irrigation schemes on 2nd December 2021. Samples were separately kept in polyethylene bags and transferred to the laboratory for more careful investigation with the aid of a stereomicroscope. The number of thrips individuals (nymph/adult) on the whole plant, was counted and recorded.

Relative Variation (RV) was calculated according to (Hillhouse and Pitre, 1974) to evaluate the efficiency of the data. RV for the sampling data was calculated as in Equation (1):

$$\mathbf{RV = (SE/X)\ 100}$$

Where SE is the standard error of the mean and X is the mean of primary sampling data. The reliable sample size was determined by employing the following equation (2):

$$\mathbf{N = (ts/dx)^2}$$

Where N= Sample size, t= t-student, s=Standard deviation, d= Desired fixed proportion of the mean and x= the mean of primary data (Pedigo and Buntin, 1994).

Indices of Spatial Distribution or Dispersion:

The spatial distribution of *T. tabaci* was determined by the following six methods: the index of dispersion, the index clumping or David-Moore index (IDM), the ‘K’ value of negative binomial distribution, Lloyd’s mean crowding, and regression techniques of Taylor’s Power Law and Iwao’s Patchiness.

The ratio between variance and mean density (σ^2/X) was the simplest approach to measure the dispersion of a population. This ratio is one for poison or random distribution, less than one for uniform distribution and more than one for an aggregated or negative binomial distribution. A null hypothesis that the onion thrips follows random distribution was considered and the departure of the distribution from random to uniform or aggregated was tested by calculating the index of distribution (ID), as in Eq.3:

$$\mathbf{ID = (\sigma^2/X)\ (n-1)}$$

Where *n* is the number of samples. In order to test the goodness of fit, *Z* coefficient should be calculated according to Eq.4 shown below:

$$\mathbf{Z = \sqrt{}2ID - \sqrt{}2v\text{-}1}$$

Where *v* is degrees of freedom (*n-1*). Z-value between -1.96 and +1.96 confirms the random distribution, whereas z-values less than -1.96 and more than +1.96 verify uniform and aggregated distribution respectively (Patil and Stiteler, 1974).

The index clumping or David-Moore index (IDM) was calculated as per David and Moore (David and Moore, 1954) in Eq.5:

$$\mathbf{IDM = \sigma^2/X\text{-}1,\ \sigma^2 = variance\ and\ X = mean.}$$

The value of IDM is zero for random distribution, less than zero for uniform and more than one for aggregated distribution.

Mean crowding (X*) which explains the possible effect of competition and mutual interference among individuals was calculated as in Eq.6:

$$\mathbf{X^* = X + IDM.}$$

Lloyd’s mean crowding index (X*/X) was worked to verify the type of distribution (Lloyd, 1967) as in Eq.7 shown below:

$$\mathbf{X^*/X = 1+\sigma^2\ /\ X^2\text{-}1/\ X}$$

The value of (X*/X) is 1, <1 and >1 for random, uniform and aggregated distribution, respectively.

The ‘K’ of negative binomial, often referred to as the parameter of dispersion was calculated as under (Southwood and Henderson, 2000) in Eq.8:

$$\mathbf{K= X^2/\ (\sigma^2\text{-}X)}$$

The spatial distribution pattern is aggregative, uniform and approximation of random when K>0, K<0 and K>8, respectively.

The relationship between variance and mean was worked out by fitting Taylor’s power equation (Taylor, 1961) as in Eq.9:

$$\mathbf{\sigma^2 = \mathit{a}X^{\mathit{b}}}$$

Where σ^2 is the variance; X the sample mean; *a* is a scaling factor related to sample size and *b* measures the species aggregation. When *b*= 1, < 1 and > 1, the distribution is random, regular and aggregated, respectively.

Through the use of a log transformation, one can estimate the coefficients with linear regression as in Eq.10:

$$\sigma^2 = \log a + b \log X$$

Where *a* and *b* are the parameters of the model, estimated by linearizing the equation by a log-log transformation (Taylor, 1961).

Iwao's patchiness regression (Iwao, 1972) between mean crowding (X^*) and mean density (X) was calculated as in Eq.11:

$$X^* = \alpha + \beta X$$

Where α indicates the tendency to crowding (positive) or repulsion (negative) and β reflects the distribution of population in space and is interpreted in the same manner as *b* of Taylor's power law (Iwao and Kuno, 1968).

RESULTS AND DISCUSSION

Sampling Program:

The results from primary sampling showed that the optimum number of the sample with a precision level (expressed as the standard error of the mean) of 20% was 36.31, 39.86 and 33.65 for 10-, 20- and 30-days irrigation intervals, respectively. The relative variation (RV) of the primary sampling date was 9.89, 10.37 and 9.53 for the above-mentioned irrigation interval, respectively, which was deemed as very appropriate for a sampling program (Table 1).

Table 1: Estimated parameters by primary sampling of *T. tabaci* on onion at different irrigation intervals during 2021.

Irrigation interval[a]	n[b]	SE[c]	SD[d]	RV[e]	m[f]	d[g]	N[h]
10	36	0.294	1.765	9.894	2.972	0.20	36.309
20	36	0.320	1.918	10.367	3.083	0.20	39.863
30	36	0.204	1.222	9.526	2.139	0.20	33.654

[a] Irrigation interval; [b] Number of samples; [c] Standard error of the mean; [d] Standard deviation; [e] Relative variation; [f] Mean of primary data, [g] Desired fixed proportion of the mean, [h] Sample size.

Indices of the Spatial Distribution of *T. tabaci* on Onion Plants:

The different indices of aggregation for *T. tabaci*, are shown in (Table 2). The mean density was lower than the variance for all the sampling dates indicating an aggregated or negative binomial distribution for the onion thrips throughout the crop-growing season. The variance to mean ratio (σ^2/X) varied from (6.27 to 103.87; 3.74 to 124.74; 4.68 to 117.49) during different sampling dates at 10-, 20- and 30-days irrigation intervals, respectively. In each case, the variance to mean ratio (σ^2/X) was more than one, representing a negative binomial distribution of the onion thrips. The index of dispersion ID and Z-values were calculated to determine the departure of the distribution from randomness to poison. Z-values varied from (12.64 to 311.73; 11.21 to 344.85; 9.79 to 333.69) for different sampling dates and were significantly greater than 1.96, which means that the onion thrips exhibited aggregation behavior in their habitat at all above-mentioned irrigation intervals. All of the IDM values calculated were more than one suggesting an aggregated pattern of dispersion for the onion thrips. The 'K' of the negative binomial distribution was more than 0.00 and less than 8.0 at the three irrigation intervals, indicating an aggregated distribution. Also, the mean crowding X^* differs from (7.88 to 277.26; 6.56 to 324.49; 5.99 to 277.77) for different sampling dates at the three above-mentioned irrigation intervals, respectively, revealing an aggregated distribution. Moreover, Lloyd's mean crowding index (X^*/X) was more than one for all sampling dates verifying the aggregated nature of the spatial distribution of onion thrips at the above-mentioned irrigation intervals. The patchiness regression fitted to describe the relationship between mean crowding X^* and the mean density X during different irrigation intervals (Figs. 1, 2 and 3), further illustrates the distribution type of *T. tabaci* population. The regression equations of straight line at 10-, 20- and 30-days irrigation intervals are $X^*=2.973+1.432X$ ($R^2=0.987$), $X^*=9.251+1.457X$ ($R^2=0.968$) and $X^*=9.161+1.352X$ (($R^2=0.966$), respectively. The values of α in the three equations are all more than 0.000, while all of the β is more than 1.000. These data imply that the individuals are mutually exclusive in an aggregated general negative binomial distribution. Meanwhile, Taylor's model at the three aforementioned irrigation intervals (Figs. 4, 5 and 6) was used to analyze the relationship between log variance (σ^2) and log mean density (X). The equations of variance (σ^2) and mean density (X) at 10-, 20- and 30-days intervals were $\sigma^2=1.549X^{1.581}$ ($R^2=0.956$), $\sigma^2=1.636X^{1.623}$ ($R^2=0.956$) and $\sigma^2=1.872X^{1.504}$ ($R^2=0.963$), respectively. The values of *b* in the three equations are all more than 1.000 indicating an aggregation distribution, but the level of aggregation does rely on density.

Table 2: Spatial distribution of *T. tabaci* on onion during 2021.

Sampling date	population density and indices of dispersion																										
	10-day irrigation period									20-day irrigation period									30-day irrigation period								
	X	σ²	σ²/X	Id	Z	IDM	K	X*	X*/X	X	σ²	σ²/X	Id	Z	IDM	K	X*	X*/X	X	σ²	σ²/X	Id	Z	IDM	K	X*	X*/X
Dec. 2nd, 2020	2.61	16.36	6.27	219.28	12.64	5.27	0.50	7.88	3.02	2.75	31.45	11.44	400.27	19.99	10.44	0.26	13.19	4.80	2.31	10.79	4.68	163.80	9.79	3.68	0.63	5.99	2.60
Dec. 9th, 2020	2.97	24.48	8.24	584.89	22.33	7.24	0.41	10.21	3.44	3.81	14.28	3.75	266.34	11.21	2.75	1.38	6.56	1.72	4.64	82.75	17.84	1266.55	38.46	16.84	0.28	21.48	4.63
Dec.16th, 2020	6.00	135.26	22.54	2412.09	54.86	21.54	0.28	27.54	4.59	3.50	35.11	10.03	1073.49	31.74	9.03	0.39	12.53	3.58	6.64	117.89	17.76	1900.12	47.05	16.76	0.40	23.40	3.52
Dec. 23nd, 2020	5.44	34.43	6.32	904.19	25.64	5.32	1.02	10.77	1.98	7.17	107.00	14.93	2135.02	48.46	13.93	0.51	21.10	2.94	12.56	184.83	14.72	2105.05	48.00	13.72	0.92	26.28	2.09
Dec. 30th, 2020	8.08	66.59	8.24	1474.65	35.41	7.24	1.12	15.32	1.90	9.19	154.16	16.77	3001.25	58.58	15.77	0.58	24.96	2.71	12.53	221.11	17.65	3159.32	60.60	16.65	0.75	29.18	2.33
Jan. 6th, 2021	8.78	64.12	7.30	1570.55	35.33	6.30	1.39	15.08	1.72	8.53	31.86	3.74	803.15	19.37	2.74	3.12	11.26	1.32	16.92	274.76	16.24	3492.08	62.86	15.24	1.11	32.16	1.90
Jan. 13th, 2021	12.36	126.35	10.22	2565.65	49.25	9.22	1.34	21.58	1.75	15.33	215.49	14.05	3527.41	61.61	13.05	1.17	28.39	1.85	17.56	186.08	10.60	2660.51	50.56	9.60	1.83	27.16	1.55
Jan. 20th, 2021	15.78	130.18	8.25	2367.95	44.88	7.25	2.18	23.03	1.46	23.03	539.40	23.42	6722.64	92.02	22.42	1.03	45.45	1.97	24.14	321.78	13.33	3825.81	63.54	12.33	1.96	36.47	1.51
Jan. 27th, 2021	22.75	236.71	10.40	3360.72	56.59	9.40	2.42	32.15	1.41	33.14	1415.72	42.72	13798.85	140.73	41.72	0.79	74.86	2.26	32.61	568.19	17.42	5627.67	80.69	16.42	1.99	49.03	1.50
Feb. 3rd, 2021	26.36	213.84	8.11	2912.15	49.54	7.11	3.71	33.47	1.27	39.94	623.71	15.61	5605.59	79.11	14.61	2.73	54.56	1.37	63.61	2013.16	31.65	11361.60	123.97	30.65	2.08	94.26	1.48
Feb. 10th, 2021	45.42	589.22	12.97	5124.60	73.15	11.97	3.79	57.39	1.26	82.08	3362.59	40.97	16181.41	151.81	39.97	2.05	122.05	1.49	103.44	4450.03	43.02	16992.31	156.26	42.02	2.46	145.46	1.41
Feb. 17th, 2021	107.22	3774.63	35.20	15172.86	144.86	34.20	3.13	141.43	1.32	111.58	4804.54	43.06	18557.92	163.31	42.06	2.65	153.64	1.38	118.14	4393.44	37.19	16028.35	149.70	36.19	3.26	154.33	1.31
Feb. 24th, 2021	120.06	7548.68	62.88	29363.36	211.79	61.88	1.94	181.93	1.52	155.17	7240.31	46.66	21790.94	178.22	45.66	3.40	200.83	1.29	124.00	3528.57	28.46	13289.06	132.48	27.46	4.52	151.46	1.22
March 3rd, 2021	180.69	11233.48	62.17	31270.68	218.38	61.17	2.95	241.86	1.34	219.69	23242.50	105.79	53214.73	294.53	104.79	2.10	324.49	1.48	201.92	15518.14	76.85	38657.64	246.35	75.85	2.66	277.77	1.38
March 10th, 2021	152.83	11420.89	74.73	40278.24	251.01	73.73	2.07	226.56	1.48	173.92	16492.19	94.83	51112.36	286.91	93.83	1.85	267.74	1.54	195.78	13698.12	69.97	37712.59	241.82	68.97	2.84	264.75	1.35
March 17th, 2021	174.39	18114.59	103.87	59727.93	311.73	102.87	1.70	277.26	1.59	137.75	17182.88	124.74	71725.26	344.85	123.74	1.11	261.49	1.90	136.69	16060.79	117.49	67559.10	333.69	116.49	1.17	253.19	1.85
March 24th, 2021	68.56	2435.40	35.52	21705.42	173.41	34.52	1.99	103.08	1.50	51.08	2776.59	54.35	33210.41	222.78	53.35	0.96	104.44	2.04	35.11	1007.47	28.69	17531.94	152.31	27.69	1.27	62.80	1.79

X mean density, σ^2 variance, ID index of distribution, Z -z value, IDM David-Moore index, k parameter of dispersion, X^* mean crowding, X*/X Lloyd's mean crowding index.

For developing a sampling program for research or management purposes of an arthropod population, the two characteristic features needed are its population density and its dispersion pattern (Pedigo & Buntin 1994). Generally, a precision level (expressed as the standard error of the mean) of about 25 percent to achieve a higher precision level for research applications and IPM programs is desired, however, if the estimate is required to construct the life table a higher level of precision (10%) is desirable (Southwood and Henderson, 2000 and Vajargah *et al.*, 2011). Therefore, the optimum sample size calculated at the beginning of the work was suitable for this species.

The results of variance to mean ratio, Z-values, IDM values, 'K' values and Lloyd's mean crowding indicated that *T. tabaci* had an aggregated distribution on an onion at all three irrigation intervals may be resulting from the most number of nymphs of onion thrips find its habitat in onion neck regardless the irrigation intervals thus the difference in irrigation intervals doesn't affect in the distribution pattern of *T. tabaci*. Similar to the present finding has described the aggregated distribution of Thysanoptera species on different plants (Steiner 1990; Cho *et al.*, 2001; Deligeorgidis *et al.*, 2002; Seal *et al.*, 2006). Other authors, such as Sedaration *et al.*, 2010, attributed the distribution of *T. tabaci* in aggregates to the parthenogenetic reproduction of the species. Sardana *et al.* (2016) indicated that the aggregate distribution of *Thrips palmi* Karny on cucurbits could be explained, in part, by oviposition behavior since females preferred to lay eggs in some sections of the plant tissue.

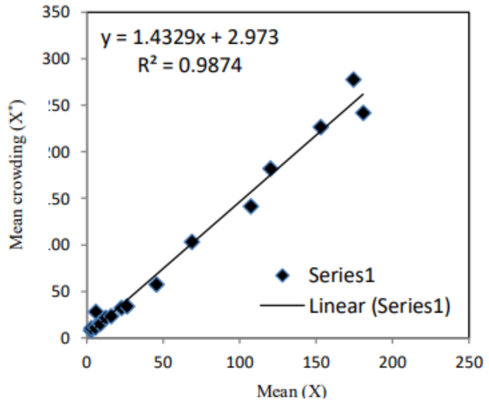

Fig. 1. Iwao's patchiness regression between mean crowding and mean for *T. tabaci* at 10-day irrigation interval during 2021.

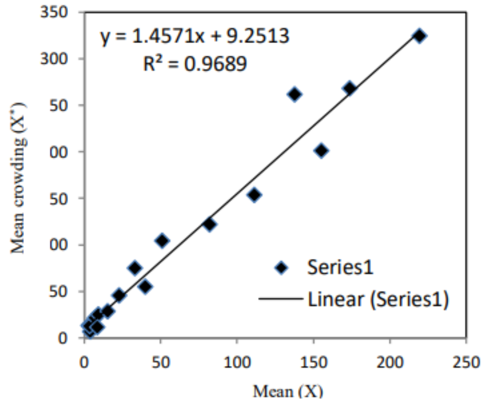

Fig. 2. Iwao's patchiness regression between mean crowding and mean for *T. tabaci* at 20-day irrigation interval during 2021.

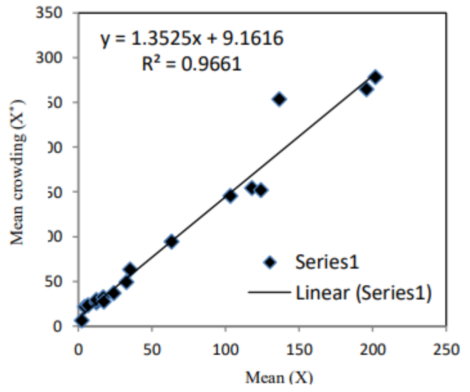

Fig.3. Iwao's patchiness regression between mean crowding and mean for *T. tabaci* at 30-day irrigation interval during 2021

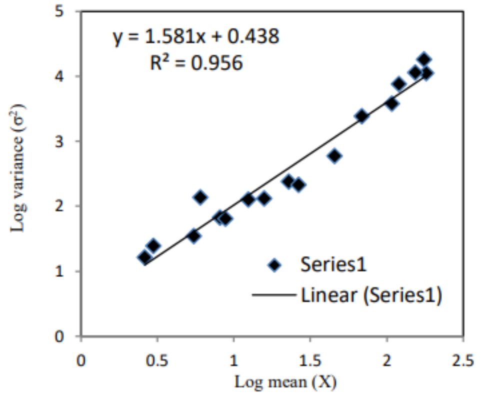

Fig.4. Taylor power equation between log variance and log mean for *T. tabaci* at 10-day irrigation interval during 2021.

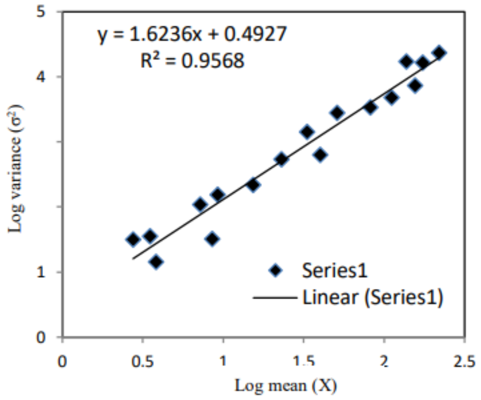

Fig.5. Taylor power equation between log variance and log mean for *T. tabaci* at 20-day irrigation interval during 2021.

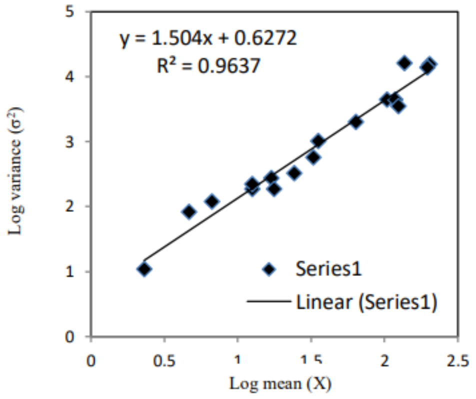

Fig.6. Taylor power equation between log variance and log mean for *T. tabaci* at 30-day irrigation interval during 2021.

Since in regression methods the mean and variance of each sampling time were used separately, therefore the Taylor's power law and Iwao's patchiness were more accurate than the variance-to-mean ratio method. The two regression techniques (Taylor's Power Law and Iwao's patchiness regression) have been widely used to evaluate dispersal, data normalizing for statistical analysis, and developing sampling protocols for many insects (Davis, 1994; Deligeorgidis *et al.*, 2002). In the present study, Taylor's model revealed an aggregation distribution, but the level of aggregation does rely on density, in harmony with (Li *et al.*, 2017) mentioned that the aggregation level relies on density whereas a higher density may lead to intraspecific competition and the limited resources available may be the cause of aggregation present finding In conformity, Sedaration *et al.* (2010) reported that Taylor's *b* and Iwao's *β* were both more than one, indicating that *T. tabaci* on some soybean varieties had aggregated spatial distribution. Pandey *et al.* (2008) indicated similar results that Iwao's patchiness index and Taylor's law revealed that the onion thrips exhibited an aggregated pattern of distribution in the field.

REFERENCES

Boeve, P. J. and Weiss, M. (1998): Spatial Distribution and Sampling Plans with Fixed Levels of Precision for Cereal Aphids (Homoptera: Aphididae) Infesting Spring Wheat. *The Canadian Entomologist*, 130(1): 67-77.

Burnstone, J. A. (2009): Investigations into the biology and behaviour of *Thrips tabaci* L. Ph. D. Thesis, University of Warwick, 178pp.

Chang, X. N.; Gao, H. J.; Chen, F. J.; Zhai, B. P. (2008): Effects of environmental moisture and precipitation on insects: A review. *Chinese Journal of Ecology,* 27(4):619-625.

Cho, K.; Lee, J. J.; Park, J. J.; Kim, J. K. and Uhm, K. B. (2001): Analysis of Spatial Pattern of *Frankliniella occidentalis* (Thysanoptera: Thripidae) on Greenhouse Cucumbers Using Dispersion Index and Spatial Autocorrelation. *Applied Entomology and Zoology,* 36: 25-32.

David F. N. and Moore G. P. (1954): Notes on contagious distributions in plants population. *Annals of Botany, 18(1):*47-53. https://doi.org/10.1093/ oxfordjournals.aob. a083381

Davis, P. M. (1994): Statistics for describing populations. In: Pedigo, L. P. & Buntin, D. G. (Eds.), Handbook of Sampling Methods for Arthropods in Agriculture. CRC Press, Boca Raton, Florida, pp. 35−54.

Deligeorgidis, P. N.; Athanassiou, C. G. and Kavallieratos, N. G. (2002): Seasonal Abundance, Spatial Distribution and Sampling Indices for thrips Populations on Cotton; A Four-Year Survey from Central Greece. *Journal of applied Entomology,* 126(7-8): 343-348.

El-Saadany, G. B. and Salman, A. M. A. (2000): Separate and combined effect of nitrogenous fertilization and plant spacing as density dependent factors governing the population activities of onion thrips, *Thrips tabaci* and onion maggot, *Delia alliaria*. *Zagazig Journal of Agricultural Researches,* 27(3): 715-722.

El-Serwiy, S. A.; El-Haidari, H. S.; Rozoki, I. A. and Rajeb, A. S. (1985): Comparative susceptibility of different onion varieties to infestation by onion *Thrips tabaci* (Lind), (Thysanoptera: Thripidae). *Journal of Agricultural and Water Resources researches,* 4(4): 117-125.

Fournier, F.; Guy, B. and Robin, S. (1995): Effect of *Thrips tabaci* (Thysanopters: Thripidae) on yellow onion yields and economic thresholds for its management. *Entomological Society of America,* 88(5):1401-1407.

Hillhouse, T. L. and Pitre, H. N. (1974): Comparison of Sampling Techniques to Obtain Measurements of Insect Populations on Soybeans. *Journal of Economic Entomology,* 67: 411-414.

Iwao, S. (1972): Application of the m-m method to the analysis of spatial patterns by changing the quadrat size. Res Popul Ecol. 14: 97-128.https://doi.org/10.1007/BF02511188

Iwao, S. and Kuno, E. (1968): Use of the Regression of Mean Crowding on Mean Density for Estimating Sample Size and the Transformation of Data for the Analysis of Variance. *Researches on Population Ecology,* 10: 210.

Kannan, H. O. and Mohamed, M. B. (2001): The impact of irrigation frequency on population density of thrips, *Thrips tabaci* Rom (Thripidae, Thysanoptera) and yield of onion in E1 Rahad, Sudan. *Annals of Applied Biology,* 138 (2): 129-132.

Kaplan, M. and Bayhan, E. (2017): Determination of damage rates of thysanoptera species in some vineyards areas in Mardin province. Journal of Tekirdag Agricultural Faculty, 14(1):1-8.

Krebs, C. J. (1999): Ecological Methodology. 2nd Ed., Addison Wesley Longman Inc., New York, 620 PP.

Kuno, E. (1991): Sampling and Analysis of Insect Populations. *Annual Review of Entomology,* 36: 285-304.

Li, N.; Chen, Q.; Zhu, J.; Wang, X.; Huang, J.B.; Huang, G.H. (2017): Seasonal dynamics and spatial distributionpattern of *Parapoynxcrisonalis*(Lepidoptera:Crambidae) on water chestnuts. *PLoS One,* 12(9): e0184149. ttps://doi.org/10.1371/journal.pone.0184149 PMID: 28863164.

Liu, C.; Wang, G.; Wang, W. and Zhou, S. (2002): Spatial Pattern of *Tetranychusurticae* Population Apple Tree Garden. *Journal of Applied Ecology,* 13: 993-996.

Lloyd, M. (1967): Mean Crowding. *Journal of Animal Ecology,* 36: 1-30.

Pandey, A. K.; Dwivedi, S. K.; Ahmed, S. B. and Ahmed, Z. (2008): Spatial distribution of thrips (*Thrips tabaci*) in onion (*Allium cepa*) under cold arid region of Jammu and Kashmir. *Indian Journal of Agricultural Sciences,* 78(1):65-69.

Patel, B. H.; Koshiya,D. J.; Korat, D. M. and Vaishnav, P. R. (2010): Effect of irrigation intervals and nitrogen levels on the incidence of thrips, *Scirtothrips dorsalis* Hood in chilli. *Karnataka Journal of Agricultural Sciences,* 23(2): 243-245.

Patil, G. P. and Stiteler, W. M. (1974): Concepts of Aggregation and their Quantification: A Critical Review with Some New Results and Applications. *Research in Population Ecology,* 15: 238-254.

Pedigo, L. P. and Buntin, G. D. (1994): Handbook of Sampling Methods for Arthropods in Agriculture. CRC Press, Florida, 714 PP.

Sallam, A. A. A. and Hosseny,M. H. (2003): Effect of some insecticides against *Thrips tabaci* Lind. and relation with yield of onion crop. *Assuit Journal of Agricultural Sciences,* 34: 99-110.

Sardana, H. R.; M. N. Bhat; Chaudhary, H; Sureja, A. K.; Sharma, K. and Ahmad, M. (2016): Spatial Distribution Behaviour of Thrips in Important Cucurbitaceous Vegetable Crops.*Vegetos,* 29:3.

Seal, D. R.; Ciomperlik, M. A.; Richards, M. L. and Klaseen, W. (2006): Distribution of Chilli Thrips, *Scirtothrips dorsalis* (Thysanoptera: Thripidae), in Pepper Fields and Pepper Plants on St. Vincent. *Florida Entomologist,* 89(3): 311-320.

Sedaratian, A.; Fathipour, Y.; Talebi, A. A. and Farahani, S. (2010): Population density and spatial distribution pattern of *Thrips tabaci* (Thysanoptera: Thripidae) on different soybean varieties. *Journal of Agricultural Sciences and Technology,* 12: 275-288.

Southwood, T. R. E. and Henderson, P. A. (2000): Ecological Methods, 3rd edition. Blackwell Sciences, Oxford, 592 PP.

Steiner, M. Y. (1990): Determining Population Characteristic and Sampling Procedure for the Western Flower Thrips (Thysanoptera: Thripidae) and Predatory Mite *Amblyseiuscucumeris* (Acari: Phytoseiidae) on Greenhouse Cucumber. *Environmental Entomology,* 19(5): 1605-1613.

Taylor, L. R. (1961): Aggregation, Variance to the Mean. *Nature*, 189: 732-735.

Tilman, D.; Lehman, C. L. and Kareiva, P. (1997): Population Dynamics in Spatial Habitat. In: "Spatial Ecology", Tilman, D. and P. Kareiva (Eds.). Princeton University Press, Princeton, PP. 3-45.

Vajargah, M. M.; Golizadeh, A.; Rafieedastjerdi, H.; Zalucki, M. P.; Hassanpour, M. and Naseri, B. (2011): Population density and spatial distribution pattern of Hyperapostica (Coleoptera: Curculionidae) in Ardabil, Iran. *NotulaeBotanicae Horti Agrobotanici,* 39: 42-48. https://doi.org/10.15835/nbha3926381

Yadav, M.; Rabindra, P.; Pradeep, K.; Chitrangda, P.; Praveen, K. and Uday, K. (2018): A review on onion thrips and their management of bulb crops. *Journal of Pharmacognosy and Phytochemistry,* SP1: 891-896.