Assessment of Economic Threshold and Economic Injury Levels of *Thrips tabaci* on Onion Plants

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Abstract: These experiments were conducted in onion fields during 2016/2017 and 2017/2018 seasons for determining the economic damage threshold and economic injury levels of *T. tabaci* using marking plants technique as well as pesticide application technique. In regard to the results of marking plants, the values of economic damage threshold were ranged between 3-4 individuals/plant, during the 1st season and 3-5 during the 2nd season. The relatively low values were noticed during the vegetative and bulbs growth stages of onion plants. So, the Economic Injury Level (EIL) of *T. tabaci* on onion plants can be determined as the number of thrips follows the value of ET levels for the detected peaks ranged between 4-5 individuals/leaf during the two study seasons. As the results of pesticide application technique, the thrips mean numbers and mean yield of onion plants were correlated significantly during the two study seasons. Although, the mean yield of onion plants differed significantly according to the variation of thrips mean numbers resulted in relatively high effect (R2 = 67.367 and 67.094) for the two respective seasons. Results of chi-square analysis (rx2) indicated that the values of economic damage threshold of *T. tabaci* infested onion plants ranged between 6 - 8 thrips/plant, while the economic injury level ranged between 8-13 thrips/plant during the two respective seasons.

Keywords: *Thrips tabaci,* population dynamic, economic threshold, economic injury.

INTRODUCTION

Onion (*Allium cepa* L.) is the most important commercial bulb crop grown all over the world and consumed in various forms. It is generally used fresh, spices, as important elements of the Mediterranean diet and as medicines (Mishra *et al*., 2014). In Egypt, onions plants infested by many pests, the most important of which is onion thrips, *Thrips tabaci* Lindeman, (Thysanoptera: Thripidae). It has widely distribution, heavily attacking various bulb vegetable crops. The onion thrips *T. tabaci* feeds directly on leaves, causing silver blotches and premature senescence as well as distorted and undersized bulbs that reduced yield by 30-50% (Diaz *et al*., 2011; Shiberu and Mahammed, 2014; Nault *et al.,* 2012) and is considered as a limiting factor for the bulb yield as well as reducing its quality (Jenser and Szenasi, 2004; Eltez and Karasavuran, 2006; Mahmoud, 2008).

The action threshold is one of the most important decision making element in integrated pest management (Nault and Shelton, 2010). So, many authors tend to determine damage threshold level and concluded that the levels were varied as host plant and host growth stage (Bird *et al.*, 2004). The application of insecticides at economic threshold not only reduces the thrips infestation but also increases the bulb yield and quality of onion (Tripathy *et al.,* 2014). So, this study aimed to assessment of economic threshold and injury levels of onion thrips on onion plants.

MATERIALS AND METHODS

1. Marking plants technique:

Samples of 50 plants were randomly chosen just after onion seedling transplantation. These plant samples were labeled and left to natural infestation. The experimental areas were received recommended agricultural practices during the course of this study and no chemical control measurements were applied throughout growing seasons. Weekly actual investigated numbers of *T. tabaci* individuals on marked plants were recorded. The yield of each plant was assessed (g/plant) at the end of the growing seasons.

The obtained data was subjected to certain scheme of statistical analysis (Hosny*et al.*, 1972; Salem and Zaki, 1985; Ibrahim, 1994, 2001). The partial regression formula "C-multipliers" which has three independent variants (X1, X2 and X3) were used, where the average number of thrips/plant in the three peaks of population activity were (X1, X2 and X3) and the dependent variable (Y) represented the mean yield/plant. The partial regression was used to show the variability in the yield that could be influenced by thrips infestation during the three peaks through the whole seasons.

Standard error, "t" values, simple correlation (r) and simple regression (b) were calculated. The slop (b) of the straight regression line was performed to obtain the corrected values for the yield.

A regression line curve obtained by transforming the (Y) values into logarithmic values by using the following equation:

$$y = e^{-(a+bx)} \text{ (i.e. } \log y = a \pm bx).$$

2. Economic threshold level using insecticide application method:

The economic damage threshold and economic injury levels for onion thrips was estimated on onion (red variety). Experiments using Mospilan 20% sp (Acetamipride) were carried out during the two study seasons of 2016/2017 and 2017/2018. Experimental area of 30/100 Fedden planted by onion was divided equally into 30 experimental units (each 1/100 fed.). The treatment was replicated five times and arranged in completely randomized block design (CRBD).

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The insecticidal application treatments:

The first treatment (control) was sprayed by water only at the all times of spraying schedule, the second treatment was sprayed one time, the third treatment was sprayed two times, the fourth treatment was sprayed three times, the fifth treatment was sprayed four times at one week interval by Acetamipride (Mospilan 20% sp) insecticide at concentration of 25 g/100 litter water. The sixth treatment was sprayed five times with the same compound and interval periods, for keeping onion thrips at the lowest infestation level on onion and garlic plants.

Sample of 5 plants/replicate of each treatment were investigated actually in the field (using hand lens 10X) and the number of thrips individuals recorded weekly during the period extended from 19 March to 23 April during the 1st season (2016/2017) and from 19 February to 26 March during the 2nd season (2017/2018) on onion, whereas on garlic date were recorded from 1 January to 5 February during the 1st season and 22 January to 26 February during the 2nd season.

The simple correlation and regression coefficients were computed to clear the significance of relationship between the mean number of onion thrips and the obtained mean yield. The chi-square analysis "rχ2" was computed; to detect the point at which the onion or garlic yield at the upper part of the slope starts to show a significant reduction in plants yield could be taken as economic threshold level (Ibrahim, 1994, 2001; Ibrahim *et al.*, 2017).

RESULTS AND DISCUSSION

The economic damage threshold is the level of pest population at which integrated control measures must be taken to prevent the pest population from reaching the level that cause economic damage to the crop. *i.e*. the economic injury level (Stone *et al.*, 1959)

1. Determination of economic damage threshold level using marking plants technique:

The weekly counts of *T. tabaci* on 50 marked red onion variety plants are shown in Tables (1 and 2).The obtained results indicated that the thrips population was fluctuated on onion plants showing three annual peaks, observed at mid-March, end-April and the end-May during the 1st season of 2016/2017.During the 2nd season of 2017/2018, three distinct peaks were also recorded at early-January, end-February and early-April.

The results of statistical analysis (Table 3) showed negative highly significant correlation between the yield of the 50 marked onion plants and thrips mean numbers at tested peaks throughout the two study seasons, with correlation coefficient values of r = - 0.950, - 0.924 and - 0.945 for the 1st season; - 0.942, - 0.953 and - 0.935 for the 2nd season for the three peaks, respectively. Also, the results of multiple correlation indicated that the infestation through the three peaks of activity were responsible for combined effect, as explained variance percentage (EV%) of 92.476 and 93.703% on onion plants yield variation in 2016/2017 and 2017/2018 seasons, respectively.

During 2016/2017 season, the effect of the three peaks of *T. tabaci* was caused remarkable change of onion plant yield from one peak to another. The results of partial regression, which explain the effect of each peak with present of other peaks; revealed that, the explained variance percentage (EV%) for these three peaks were 45.53, 22.26 and 39.83% computed for peaks of mid-March (1st peak X1), the 2nd peak at the end of April and in the 3rd peak at the end of May, respectively. The values of regression coefficient (slop "b") for the three peaks with onion plants yield were -0.992**, -0.944*** and -1.137** for the three investigated peaks respectively (Table 3).

So, the results of partial regression (Table 3) of the second season of 2017/2018, further indicated that the three peaks of thrips infestation at the early of January (1st peak X1), at the end of February (2nd peak X2) and at early of April (3rd peak X3) had great influence on onion plants yield by E.V% = 34.89, 46.69 and 27.59% for the three peaks, respectively. Also, the values of slop "b" were -1.121***, -0.990***and -1.023***for the three peaks, respectively.

The chi square (r χ^2) analysis was computed to determine of the point at which the increase in insect number through each of infestation peaks (X1 & X2 & X3) cause significant reduction in the onion yield weight and the obtained results revealed that the three infestation peaks were varied as its effect on yield led to variation in the economic damage threshold values.

During 2016/2017 season, the thrips population during the 1st peak of infestation at mid-March increased from 5 to 9,13,17,20 individuals/plant causing onion yield insignificant decrease in 241-220 g/plant, while the increase of thrips mean from 5 to 25 individuals/plant and more, resulted insignificant reduction in the onion plant yield from (241 to 215 g/plant), (χ^2 value = 21.071; P < 0.01). Thus the increase in thrips numbers to an average of 25 individuals/plant, *i.e.* 4.16≈ 4 individual/leaf (depending on mean of leaves number/plant = 6 leaves) could be regarded as the economic threshold (ET) for the 1st peak during the beginning of bulbs growth period.

In the same trend, the results of the 2nd peak gave same ET value where the increasing in number of insects from 7 to 10, 14, 18 and 20 individuals/plant decreased the yield of onion plants insignificantly from 241 to 200 g/plant. Meanwhile the increase of thrips number to 25 individuals/plant onwards (χ^2 = 16.03**) caused significant decrease in the yield from 241 to 215 g/plant. Thus, the increase of thrips numbers to an average of 25 individuals/plant *i.e.* 4.16 ≈ 4 individual/leaf (depending on mean of leaves number/plant = 6 leaves) could be considered as the economic threshold for the 2nd peak during the same growth period. In case of the 3rd peak, the increasing of the thrips number from 3 to 7 and 14 individuals/plant decreased onion yield insignificantly from 241-235 g/plant, while the increase of thrips numbers to 17

individuals/plant (χ^2 = 13.12**) caused significant yield reduction from 241 to 229 g/plant. So, the raise of thrips numbers to an average of 17 individuals/plant *i.e.* 2.83 ≈ 3 individuals/leaf (depending on mean of leaves/plant = 6 leaves) could be considered as the economic damage threshold for the 3rd peak during the period of bulbs ripping.

Table (1): Yield-infestation relationship in 50 marked onion plants under natural infestation of *T. tabaci* during growing season of 2016/2017

Plant no.	Observed yield & thrips No./plant				First peak			Second peak			Their peak		
	Y	X1	X2	X3	X1	Y	ŷ	X2	Y	ŷ	X3	Y	ŷ
1	160	110	83	78	5	241	246.803	7	241	236.990	3	241	241.738
2	205	45	7	35	9	237	242.832	10	237	234.157	7	237	237.189
3	145	117	88	80	13	235	238.861	14	235	230.379	14	235	229.229
4	207	55	10	37	17	229	234.889	18	229	226.602	17	229	225.817
5	153	115	90	88	20	220	231.911	20	220	224.713	20	220	222.405
6	189	60	50	43	25	215	226.947	25	215	219.991	23	215	218.994
7	177	66	45	50	27	210	224.961	29	210	216.213	25	210	216.720
8	110	140	140	128	33	207	219.004	33	207	212.435	30	207	211.034
9	175	64	55	45	38	205	214.040	35	205	210.546	35	205	205.348
10	82	170	157	140	45	203	207.090	40	203	205.824	37	203	203.073
11	105	143	130	125	55	200	197.162	42	200	203.935	40	200	199.662
12	125	128	94	137	60	198	192.198	45	198	201.102	43	198	196.250
13	210	38	14	40	64	196	188.227	50	196	196.380	45	196	193.976
14	99	152	159	145	66	195	186.241	55	195	191.658	50	195	188.290
15	100	150	155	120	73	189	179.291	62	189	185.047	53	189	184.879
16	102	146	120	117	77	184	175.320	66	184	181.269	55	184	182.604
17	50	178	168	145	80	182	172.341	72	182	175.602	57	182	180.330
18	85	163	160	142	81	177	171.349	74	177	173.714	60	177	176.918
19	120	130	150	85	85	176	167.377	78	176	169.936	62	176	174.644
20	168	100	97	55	90	175	162.413	80	175	168.047	64	175	172.370
21	196	73	62	53	92	170	160.427	83	170	165.214	65	170	171.232
22	119	137	145	112	97	168	155.463	88	168	160.492	70	168	165.547
23	184	77	66	57	100	165	152.485	90	165	158.603	74	165	160.998
24	229	33	18	3	102	164	150.499	94	164	154.825	78	164	156.449
25	164	105	100	87	105	163	147.521	97	163	151.992	80	163	154.175
26	203	27	20	7	105	162	147.521	100	162	149.158	85	162	148.489
27	200	25	25	14	110	160	142.557	102	160	147.270	87	160	146.214
28	107	144	142	105	111	153	141.564	110	153	139.714	88	153	145.077
29	60	172	165	150	112	151	140.571	113	151	136.881	90	151	142.803
30	165	112	102	90	115	145	137.592	118	145	132.159	93	145	139.391
31	135	152	110	93	117	143	135.607	120	143	130.270	96	143	135.980
32	112	135	139	118	128	135	124.686	122	135	128.381	99	135	132.568
33	151	102	113	96	129	125	123.693	125	125	125.548	100	125	131.431
34	65	163	169	137	130	120	122.700	130	120	120.826	103	120	128.020
35	163	105	118	99	135	119	117.736	130	119	120.826	105	119	125.745
36	170	90	122	60	137	117	115.750	136	117	115.159	112	117	117.785
37	70	154	170	129	140	112	112.772	139	112	112.326	117	112	112.099
38	195	80	72	62	143	110	109.793	140	110	111.381	118	110	110.962
39	235	5	29	17	144	107	108.800	142	107	109.492	120	107	108.688
40	241	9	33	20	146	105	106.815	145	105	106.659	125	105	103.002
41	182	111	74	64	148	102	104.829	150	102	101.937	128	102	99.590
42	198	85	78	70	150	100	102.843	153	100	99.104	129	100	98.453
43	237	13	35	23	152	99	100.858	155	99	97.215	137	99	89.356
44	176	81	80	65	152	85	100.858	157	85	95.326	137	85	89.356
45	117	129	136	100	154	82	98.872	159	82	93.437	140	82	85.944
46	220	17	40	25	163	80	89.937	160	80	92.493	142	80	83.670
47	143	97	130	103	163	70	89.937	165	70	87.770	144	70	81.395
48	162	92	125	74	170	65	82.987	168	65	84.937	145	65	80.258
49	215	20	42	30	172	60	81.001	169	60	83.993	145	60	80.258
50	80	148	153	144	178	50	75.044	170	50	83.048	150	50	74.572

X1 = Thrips No. at 1st peak X2 = Thrips No. at 2nd peak X3 = Thrips No. at 3rd peak Y = yield
γ = Calculated values of yield (according to regression line equation)

Table (2): Yield-infestation relationship in 50 marked onion plants under natural infestation of *T. tabaci* during growing season of 2017/2018

Plant no.	Observed yield & thrips No./plant				First peak			Second peak			Third peak		
	Y	X1	X2	X3	X1	Y	y̆	X2	Y	y̆	X3	Y	y̆
1	197	37	42	70	4	225	230.863	7	225	231.230	5	225	234.934
2	95	122	133	153	8	223	226.377	10	223	228.259	9	223	230.842
3	90	125	155	149	10	219	224.134	14	219	224.296	13	219	226.749
4	195	40	45	65	13	215	220.770	18	215	220.334	15	215	224.702
5	129	82	112	120	15	211	218.528	20	211	218.353	20	211	219.586
6	225	4	10	5	18	210	215.163	22	210	216.372	23	210	216.517
7	100	115	119	123	20	208	212.921	27	208	211.419	28	208	211.401
8	85	120	158	153	25	207	207.314	30	207	208.447	32	207	207.308
9	194	42	48	63	29	205	202.828	35	205	203.494	36	205	203.215
10	169	80	71	117	30	202	201.707	37	202	201.513	38	202	201.169
11	105	107	162	130	35	200	196.100	40	200	198.542	40	200	199.123
12	117	118	122	117	37	197	193.857	42	197	196.560	45	197	194.007
13	164	87	75	75	40	195	190.493	45	195	193.589	47	195	191.960
14	80	134	132	154	42	194	188.25	48	194	190.617	50	194	188.891
15	193	45	52	60	45	193	184.886	52	193	186.655	54	193	184.798
16	110	130	126	116	47	190	182.643	55	190	183.683	56	190	182.752
17	157	78	77	110	50	188	179.279	60	188	178.730	60	188	178.659
18	223	8	7	9	52	186	177.036	63	186	175.759	63	186	175.589
19	152	90	80	105	55	183	173.672	65	183	173.777	65	183	173.543
20	190	60	55	56	58	180	170.308	68	180	170.806	70	180	168.427
21	70	145	160	150	60	170	168.065	71	170	167.834	75	170	163.311
22	188	47	60	54	65	169	162.458	75	169	163.872	79	169	159.218
23	120	94	130	104	67	164	160.216	77	164	161.891	83	164	155.125
24	219	10	14	13	70	160	156.851	80	160	158.919	87	160	151.032
25	75	135	125	127	75	157	151.244	85	157	153.966	90	157	147.963
26	65	75	156	145	78	152	147.880	88	152	150.994	94	152	143.870
27	143	97	88	132	80	150	145.638	93	150	146.042	98	150	139.777
28	211	13	18	40	82	148	143.395	96	148	143.070	100	148	137.731
29	68	138	140	144	87	143	137.788	100	143	139.108	104	143	133.638
30	55	140	155	142	90	140	134.424	105	140	134.155	105	140	132.615
31	186	50	63	50	94	137	129.938	112	137	127.221	110	137	127.499
32	215	15	20	38	97	130	126.574	119	130	120.287	116	130	121.360
33	130	100	135	100	100	129	123.210	122	129	117.315	117	129	120.337
34	148	70	85	98	104	124	118.724	125	124	114.343	117	124	120.337
35	183	52	65	47	107	120	115.360	126	120	113.353	120	120	117.267
36	210	18	22	36	107	117	115.360	130	117	109.391	123	117	114.198
37	137	104	142	94	110	112	111.996	132	112	107.409	127	112	110.105
38	208	20	27	32	115	110	106.389	133	110	106.419	130	110	107.035
39	180	55	68	45	115	105	106.389	135	105	104.438	132	105	104.989
40	207	25	30	28	118	100	103.025	140	100	99.485	135	100	101.919
41	124	107	140	135	120	95	100.782	140	95	99.485	137	95	99.873
42	170	58	93	79	122	90	98.539	142	90	97.504	140	90	96.803
43	205	29	35	23	125	85	95.175	147	85	92.551	142	85	94.757
44	72	142	150	140	130	80	89.568	150	80	89.579	144	80	92.710
45	160	65	96	83	134	75	85.083	155	75	84.626	145	75	91.687
46	202	30	37	20	135	72	83.961	155	72	84.626	149	72	87.594
47	112	115	147	137	138	70	80.597	156	70	83.636	150	70	86.571
48	140	110	105	90	140	68	78.355	158	68	81.655	153	68	83.502
49	150	67	100	87	142	65	76.112	160	65	79.674	153	65	83.502
50	200	35	40	15	145	55	72.748	162	55	77.692	154	55	82.478

X1 = Thrips No. at 1st peak X2 = Thrips No. at 2nd peak X3 = Thrips No. at 3rd peak Y = yield

γ = Calculated values of yield (according to regression line equation)

Table (3): Statistical analysis (partial regression, simple correlation and regression) for the relationship between the peaks of *T. tabaci* mean numbers and the onion yield of 50 marked plants during the two studied seasons of 2016/2017 and 2017/2018

Season	Variables		Peaks of *T. tabaci* population		
			x1	x2	x3
First season (2016/2017)	Partial regression	E.V %	45.53	22.26	39.83
		S.E	0.139	0.111	0.161
		t	-3.259	-2.004	-2.467
		P	**	ns	*
	Simple correlation	r	-0.950	-0.924	-0.945
		P	***	***	***
	Simple regression	b	-0.992	-0.944	-1.137
		p	***	***	**
	Combined effect	E.V %		92.476	
		F		201.750	
		P		***	
Second season (2017/2018)	Partial regression	E.V %	34.89	46.69	27.59
		S.E	0.129	0.111	0.112
		t	-2.697	-4.195	-2.459
		P	**	***	*
	Simple correlation	r	-0.942	-0.953	-0.935
		P	***	***	***
	Simple regression	b	-1.121	-0.990	-1.023
		p	***	***	***
	Combined effect	E.V %		93.703	
		F		244.070	
		P		***	

X1 = Thrips No. at 1st peak X2 = Thrips No. at 2nd peak X3 = Thrips No. at 3rd peak
* indicates only significant differences
** indicates high significant differences
*** indicates highly significant differences
ns indicates insignificant differences

Regarding to the second season of 2017/2018, the three peaks of *T. tabaci* was recorded at the early of January (1st peak X1), end of February (2nd peak X2) and early of April (3rd peak X3). The mean of thrips number during the 1st peak of infestation increased on inspected plants from 4 to 8,10,13,15 and 18 individuals/plant decreased onion yield of these plants insignificantly from 225-210 g/plant, while the increase of thrips numbers to 20 individuals/plant onwards, revealed highly significant reduction(χ^2 **) in the yield from 225 to 208 g/plant. So, the development of thrips numbers to an average of 20 individuals/plant, *i.e.* 3.33 ≈ 3 individuals/leaf (depending on mean of leaves number/plant = 6 leaves) could be recognized as the economic damage threshold for the 1st peak during the vegetative growth of onion plants.

For the second peak (2nd season) at the end of February of 2017/2018 season, the increasing of thrips number on investigated plants from 7 to 10,14,18,20 and 22individuals/plant decreased onion yield of these plants insignificantly from 225-210 g/plant, while the increase of thrips numbers to 27 individuals/plant caused significant reduction (χ^2 = 20.557**) in the onion plant yield from 225 to 208 g/plant (Table 4). So, the increase of thrips numbers to an average of 27 individuals/plant, *i.e.* 4.5 ≈ 5 individuals/leaf (depending on mean of leaves number/plant = 6 leaves) could be recorded as the economic damage threshold for the period of onion bulbs growth starting.

In case of the third peak (2nd season) at early of April, the growth of thrips number on inspected plants from 5 to 9,13,15 and 20 individuals/plant influenced onion yield insignificantly from 225-211 g/plant, while the increase of thrips numbers to 23 individual/plant (χ^2 = 18.197 **) caused significant decrease in the yield from 225 to 210 g/plant (Table 4). Therefore, the increase of thrips numbers to an average of 23 individuals/plant, *i.e.* 3.83 ≈ 4 individuals/leaf (depending on mean of leaves number/plant = 6 leaves) could be recorded as the economic damage threshold for the period of onion plants bulbs ripening.

The obtained results indicated that the values of economic damage threshold of *thrips tabaci* infested

onion plants ranged between 3 to 4 individuals/plant, during the 1st season and 3-5 during the 2nd season where the values were differed based on plants growth periods and seasons. So, the economic injury level (EIL) of *T. tabaci* on onion plants can be determined as the number of thrips follows the value of ET levels for the detected peaks ranged between 4-5 individuals/leaf during the two study seasons. That mean, the control measurements must be taken at the levels of ET determined for onion growth stages.

These results are in harmony with these of Bird et *al.* (2004) who concluded that the economic threshold level of *T. tabaci* was ranged from 4–10 and 10–15 thrips/plant is recommended for onion plant stages of 2–6 leaves and 6 leaves to maturity, respectively. Also, Mishra et *al.* (2014) found that the threshold of *T. tabaci* was 3 thrips/green leaves. On contrast, these results disagreed with those of Rueda et *al.* (2006) who noted that the action threshold of *T. tabaci* ranged between 0.5-1.6 thrips/leaf.%) of 92.476 and 93.703% on onion plants yield variation in 2016/2017 and 2017/2018 seasons, respectively.

During 2016/2017 season, the effect of the three peaks of *T. tabaci* was caused remarkable change of onion plant yield from one peak to another. The results of partial regression, which explain the effect of each peak with present of other peaks; revealed that, the explained variance percentage (EV%) for these three peaks were 45.53, 22.26 and 39.83%computed for peaks of mid-March (1st peak x1), the 2nd peak at the end of April and in the 3rd peak at the end of May, respectively. The values of regression coefficient (slop "b") for the three peaks with onion plants yield were o -0.992**, -0.944*** and -1.137** for the three investigated peaks respectively (Table 3).

So, the results of partial regression (Table 3) of the second season of 2017/2018, further indicated that the three peaks of thrips infestation at the early of January (1st peak x1), at the end of February (2nd peak x2) and at early of April (3rd peak x3) had great influence on onion plants yield by E.V% = 34.89, 46.69 and 27.59% for the three peaks, respectively. Also, the values of slop "b" were -1.121***, -0.990***and -1.023***for the three peaks, respectively.

The chi square (r χ^2) analysis was computed to determine of the point at which the increase in insect number through each of infestation peaks (X1 &X2 &X3) cause significant reduction in the onion yield weight and the obtained results revealed that the three infestation peaks were varied as its effect on yield led to variation in the economic damage threshold values.

During 2016/2017 season, the thrips population during the 1st peak of infestation at mid-March increased from 5 to 9,13,17,20 individuals/plant causing onion yield insignificant decrease in 241-220 g/plant, while the increase of thrips mean from 5 to 25 individuals/plant and more, resulted insignificant reduction in the onion plant yield from (241 to 215 g/plant), (χ^2 value =21.071; $P < 0.01$). Thus the increase in thrips numbers to an average of 25 individuals/plant, *i.e.* 4.16≈ 4 individual/leaf (depending on mean of leaves number/plant = 6 leaves) could be regarded as the economic threshold (ET) for the 1st peak during the beginning of bulbs growth period.

In the same trend, the results of the 2nd peak gave same ET value where the increasing in number of insects from 7 to 10, 14, 18 and 20 individuals/plant decreased the yield of onion plants insignificantly from 241 to 200 g/plant. Meanwhile the increase of thrips number to25 individuals/plant onwards (χ^2 = 16.03**) caused significant decrease in the yield from 241 to 215 g/plant (Table 4). Thus, the increase of thrips numbers to an average of 25 individuals/plant *i.e.* 4.16 ≈ 4 individual/leaf (depending on mean of leaves number/plant = 6 leaves) could be considered as the economic threshold for the 2nd peak during the same growth period. In case of the 3rd peak, the increasing of the thrips number from 3 to 7 and 14 individuals/plant decreased onion yield insignificantly from 241-235 g/plant, while the increase of thrips numbers to 17 individuals/plant (χ^2 = 13.12**) caused significant yield reduction from 241 to 229 g/plant (Table 4). So, the raise of thrips numbers to an average of 17 individuals/plant *i.e.* 2.83 ≈ 3 individuals/leaf (depending on mean of leaves/plant = 6 leaves) could be considered as the economic damage threshold for the 3rd peak during the period of bulbs ripping.

Regarding to the second season of 2017/2018, the three peaks of *T. tabaci* was recorded at the early of January (1st peak X1), end of February (2nd peak X2) and early of April (3rd peak X3). The mean of thrips number during the 1st peak of infestation increased on inspected plants from 4 to 8,10,13,15 and 18 individuals/plant decreased onion yield of these plants insignificantly from 225-210 g/plant, while the increase of thrips numbers to 20 individuals/plant onwards, revealed highly significant reduction(χ^2 **) in the yield from 225 to 208 g/plant. So, the development of thrips numbers to an average of 20 individuals/plant, *i.e.* 3.33 ≈ 3 individuals/leaf (depending on mean of leaves number/plant = 6 leaves) could be recognized as the economic damage threshold for the 1st peak during the vegetative growth of onion plants.

For the second peak (2nd season) at the end of February of 2017/2018 season, the increasing of thrips number on investigated plants from 7 to 10,14,18,20 and 22individuals/plant decreased onion yield of these plants insignificantly from 225-210 g/plant, while the increase of thrips numbers to 27 individuals/plant caused significant reduction (χ^2 = 20.557**) in the onion plant yield from 225 to 208 g/plant (Table 4). So, the increase of thrips numbers to an average of 27 individuals/plant, *i.e.* 4.5 ≈ 5 individuals/leaf (depending on mean of leaves number/plant = 6 leaves) could be recorded as the economic damage threshold for the period of onion bulbs growth starting.

In case of the third peak (2nd season) at early of April, the growth of thrips number on inspected plants from 5 to 9,13,15 and 20 individuals/plant influenced

onion yield insignificantly from 225-211 g/plant, while the increase of thrips numbers to 23 individual/plant (χ^2 = 18.197 **) caused significant decrease in the yield from 225 to 210 g/plant (Table 4). Therefore, the increase of thrips numbers to an average of 23 individuals/plant, *i.e.* 3.83 ≈ 4 individuals/leaf (depending on mean of leaves number/plant = 6 leaves) could be recorded as the economic damage threshold for the period of onion plants bulbs ripening.

The obtained results indicated that the values of economic damage threshold of *thrips tabaci* infested onion plants ranged between 3 to 4 individuals/plant, during the 1st season and 3-5 during the 2nd season where the values were differed based on plants growth periods and seasons. So, the economic injury level (EIL) of *T. tabaci* on onion plants can be determined as the number of thrips follows the value of ET levels for the detected peaks ranged between 4-5 individuals/leaf during the two study seasons. That mean, the control measurements must be taken at the levels of ET determined for onion growth stages.

These results are in harmony with these of Bird et *al.* (2004) who concluded that the economic threshold level of *T. tabaci* was ranged from 4–10 and 10–15 thrips/plant is recommended for onion plant stages of 2–6 leaves and 6 leaves to maturity, respectively. Also, Mishra et *al.* (2014) found that the threshold of *T. tabaci* was 3 thrips/green leaves. On contrast, these results disagreed with those of Rueda et *al.* (2006) who noted that the action threshold of *T. tabaci* ranged between 0.5-1.6 thrips/leaf.

Table (4): Comparison of calculated χ^2 with the χ^2 tabulated values of thrips mean at apparent peaks of *T. tabaci* during the two study seasons of 2016/2017 and 2017/2018

	Marking plants	χ^2 calculated	tabulated χ^2 al (0.01)
First season (2016/2017)	1st peak	1.231	6.635
		3.902	9.210
		8.163	11.345
		12.929	13.277
		21.071	15.086
	2nd peak	0.577	6.635
		2.793	9.210
		5.954	11.345
		9.815	13.277
		16.03	15.086
	3rd peak	0.168	6.635
		8.378	9.210
		13.12	11.345
Second season (2017/2018)	1st peak	1.429	6.635
		2.853	9.210
		5.125	11.345
		8.222	13.277
		13.091	15.086
		17.2	16.812
	2nd peak	0.577	6.635
		2.793	9.210
		5.954	11.345
		9.815	13.277
		13.163	15.086
		20.557	16.812
	3rd peak	1.231	6.635
		3.902	9.210
		6.277	11.345
		12.037	13.277
		18.197	15.086

2. Determination of economic damage threshold level using insecticidal application:

These experiments were carried out during the two study seasons of 2016/2017 and 2017/2018 at al Qassassine region. The common insecticide, Mospilan 20% SP was spayed five sprays as schedule of this trial. The different levels of infestations in various sprayed treatments along with the corresponding average weight of onion and garlic yield in each treatment plot and the statistical analysis are illustrated in Table (5). The damage threshold of onion thrips, *Thrips tabaci* infestation on yield of onion and garlic plants was calculated as proposed by Ibrahim (1994).

The obtained results of mean numbers of thrips and mean yield of onion plants are found to be correlated significantly (r = - 0.859 and - 0.858) during the two study seasons. Although, the mean yield of onion plants differed significantly according to the variation of thrips mean numbers resulted in relatively high effect, R^2 = 67.367 and 67.094; regression coefficient (slop) b = - 0.157* and - 0.234* for the two respective seasons (Table 6).

Table (5): Damage threshold and injury levels for *T. tabaci* on onion plants under insecticidal treatment application in the two study seasons under field conditions of al Qassassine Region, Ismailia Governorate

Season	No. of spray	No. of thrips	Yield in k.g	Calculated yield in k.g	Calculated χ^2 values	d.f	χ^2 tabulated 0.01
2016/2017	**5**	141	243	195.879			
	4	208	211	185.359	17.265	1	6.635
	3	224	134	182.847			
	2	564	89.3	129.464			
	1	871	72.3	81.262			
	0	1167	60	34.787			
2017/2018	**5**	155	270.3	225.564			
	4	158	261.7	224.859	0.051	1	6.635
	3	195	184	216.172	8.607	2	9.210
	2	331	135	184.239	89.36	3	11.345
	1	552	103.3	132.349			
	0	895	80.7	51.814			

Table (6): Statistical analysis (simple correlation and Partial regression) for the relationship between *Thrips tabaci* and the yield of onion under insecticidal treatment application during 2016/2017 and 2017/2018 seasons

	Crop	**Onion**	
Variables		**2016/2017**	**2017/2018**
Partial reg.	**b**	-0.157	-0.234
	S.E	0.0466	0.070
	t	-3.364	-3.345
	P	*	*
	F	11.322	11.195
	P	*	*
	E.V %	67.367	67.094
Simple cor.	**r**	-0.859	-0.858
	P	*	*

* indicates only significant differences.

The mathematic determination as chi-square analysis (rx2) to reach to the point at which the increases of insect number on plants of the sprayed treatments cause a drop in the onion plant yield was calculated. The results in Table (5) indicated that the damage threshold differed from season to another. During 2016/2017 season and there was a significant reduction in the yield from 243 to 211 kg/ $^1/_{100}$ Fed as a result of the increasing infestation from 141 to 208 thrips/sample (χ^2 ***). This level could be considered as damage threshold. Thus, the economic damage threshold of *T. tabaci* on onion ranged between 141 to 208 thrips/25plant (sample size). In other words, the economic threshold level for *T. tabaci* infestation on onion was achieved when number of *T. tabaci* reached an average number of 5.64 ≈ 6 thrips/plant where the thrips control must be taken, then the injury level reach to 8.32 ≈ 8 thrips/plant as the follows population number point where the infestation skip the point of economic damage.

During the second season of 2017/2018, increasing the number of thrips insect from 155 to 158 and 195 thrips/plant caused a significant decrease onion yield from 270.3 - 184 kg/ $^1/_{100}$ Fed, while the increase of thrips numbers to 331 thrips/plant caused significant reduction (χ^2 ***) in the onion plant yield from 270.3 to 135 kg/ $^1/_{100}$ Fed. So, the damage threshold level for *T. tabaci* infestation on onion was achieved when number of *T. tabaci* reached an average number of 195 thrips/sample (25 plant), that mean the damage threshold level reach to 7.8 ≈ 8 thrips/plant; then the injury level reach to 13.24 ≈ 13 thrips/plant (Table 5).

The obtained results indicated that the values of economic damage threshold of *T. tabaci* infested onion plants ranged from 6 to 8 thrips/plant, while the economic injury level ranged between 8 to 13 during the two study seasons, respectively.

The obtained results found are in agreement with those of Bird et *al.* (2004) who concluded that the economic threshold level of *T. tabaci* was ranged from 4.00 to 10.00 and 10.00 to 15.00 thrips/plant is recommended for onion plant stages with 2to6 leaves and 6 leaves to maturity, respectively. Also, these results coincided with those of Mishra *et al.* (2014) who mentioned that the threshold of *T. tabaci* was 3 thrips/green leaves. However, the current results disagree with those of Rueda *et al.* (2006) who noted that the action threshold of *T. tabaci* ranged from 0.50 to 1.60 thrips/leaf.

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تقدير الحد الاقتصادي الحرج ومستويات الضرر لتربس البصل علي نباتات البصل

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أجريت الدراسة الحالية خلال موسمي ٢٠١٧/٢٠١٦ و ٢٠١٨/٢٠١٧ في القصاصين، الإسماعيلية، مصر. والتي هدفت إلي إلقاء الضوء علي بعض الممارسات الفعالة التي يمكن توظيفها في برنامج المكافحة المتكاملة لتربس البصل. يعرف حد الضرر الاقتصادي بمستوى تعداد الآفة الذي يجب عنده اتخاذ تدابير المكافحة. وتم تحديد حد الضرر الاقتصادي الحرج ومستويات الضرر باستخدام طريقتين، هما النباتات المعلمة واستخدام المبيدات الحشرية. أوضح التحليل الإحصائي للنتائج لتجربة النباتات المعلمة وجود علاقة سلبية معنوية بين محصول نباتات البصل المعلمة ومتوسط تعداد التربس للذروات المسجلة. كما أشارت نتائج الارتباط المتعدد أن الإصابة خلال الثلاث ذروات معاً كانت مسئولة عن التأثير المشترك ٩٢.٤٧٦ و ٩٣.٧٠٣٪ على نباتات البصل خلال موسمي الدراسة على التوالي. يمكن تحديد حد الضرر الاقتصادي (EIL) للتربس على نباتات البصل عن طريق تقدير تعداد التربس تبعاً لقيم الحدود الحرجة للذروات حيث تراوحت بين ٤ إلي ٥ فرد/ ورقة خلال موسمي الدراسة. أظهرت نتائج استخدام المبيدات الحشرية وجود ارتباط سالب معنوي بين متوسط أعداد التربس ومتوسط محصول نبات البصل المعاملة خلال موسمي الدراسة على الرغم من أن متوسط إنتاج نباتات البصل كان متبايناً بشكل كبير وفقاً لاختلاف أعداد التربس مما أعطى تأثيراً مشتركاً للذروات الثلاث بارتفاع قدره ٦٧.٣٦٧ و ٦٧.٠٩٤% للموسمين على التوالي. تم تطبيق التحليل الإحصائي مربع كاي (rx2) للوصول إلى النقطة التي تسبب عندها زيادة تعداد الحشرات على نباتات البصل في المعاملات التي تم رشها إلي انخفاض معنوي في محصول نبات البصل. وأظهرت النتائج أن قيم الحد الاقتصادي الحرج للإصابة علي نباتات البصل المصابة قد تراوح ما بين ٦ إلى ٨ تربس / نبات، بينما تراوح مستوى الضرر الاقتصادي من ٨ إلي ١٣ حشرة / نبات خلال موسمي الدراسة على التوالي مما يدل علي ضرورة اتخاذ إجراءات المكافحة عند الوصول إلي الحدود الحرجة لمنع الوصول إلي مستوي الضرر الاقتصادي.

الكلمات الدالة: *Thrips tabaci*، التعداد، مستوي الضرر الاقتصادي، الحد الاقتصادي الحرج