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Population Dynamics of Onion Thrips, *Thrips tabaci*, on Onion Cultivars

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Abstract: *Onion thrips, Thrips tabaci is the most serious insect pest of onion crop throughout the world. Both adults and nymphs attack onion plant and causing reduction in quality and yield. Studies on population dynamics of adult and immature stage of thrips in relation to weather factors: temperature (maximum, minimum and average), relative humidity, wind velocity, dew point and rainfall were carried out for two cropping seasons of 2011-2012. Eight cultivars of onion were cultivated under the insecticides free field conditions. Density of adult and immature stages was observed weekly from randomized onion plants two weeks from day after transplanting (DAT) up to the harvesting. Infestation was started on almost onion cultivars at 56 DAT at 15.5°C with 74.1% relative humidity. A non-significant (P>0.05) variation occurred on average number of thrips on all cultivars. However, the correlation results showed that the temperature, relative humidity and dew point caused significant (P>0.05) effect on adult and immature stages of T. tabaci on almost all onion cultivars.*

1. INTRODUCTION

Onion crop is an important vegetable in India and also all over world. China and India are the largest producers of onion [1]. Various diseases and arthropod pests attack on onion crop that can reduce yield and quality [2]. Among the insect pests, onion thrips, *Thrips tabaci* Lindeman (Thysanoptera: Thripidae), is a major pest of onion crops throughout the world [3, 4, 5]. Its damages result in yield reduction due to reduced size and weight of onion bulb [6]. Yield loss has been estimated up to 90% in Maharashtra [7], while average 10-15 % in India [8] and >50% in USA (9; 10).

Temperature is an important driving force for arthropod growth rate. Agro-climatic conditions with varying weather patterns affect the population of thrips [11]. However, temperature has a pronounced effect on the population dynamics of thrips on onion crops [12, 13, 14]. Faster development and higher number of generations of thrips was reported when temperature was increased [12]. In addition, *T. tabaci* population is also significantly influenced by relative humidity on onion crop [13]. Rainfall has exerted greater control of thrips than either planting date or the chemical application [4]. During rainfall, a decline in the number of larvae and adults of thrips was observed and thus may reduce the infestation level on onion plants [15]. Therefore, Farmers in Australia are using sprinkler for irrigation and to simulate rains for controlling of thrips [16]. However, they breed fast during dry and warm weather so as to attain harmful proportions [17, 18] causing the losses to various Allium vegetables [19]. Mean bright sunshine hours and wind velocity did not significantly affect the population of *T. tabaci* on onion [20].

It is necessary to understand the relationship between different stage of thrips and weather conditions for the development of an integrated management strategy on onion crops. Therefore, it is desired to study the population dynamics of *T. tabaci* (adult and immature stages) under field conditions in relation to weather conditions.

2. MATERIALS AND METHODS

Field experiments were conducted at the Department of Plant Protection, Faculty of Agriculture Sciences, Aligarh Muslim University (AMU), Aligarh, India for two consecutive years (2011-2012). Seeds of Eight onion cultivars: Onion White Marglobe, Onion White, Nasik Red, Tanzanian Red, Nasik Red Plus N-53, Onion Kessar, Onion-Indam Marshal-(Synth-3), Onion Dr-301 (Krishna) were sown in mid-October in the nursery beds)1x3m). Field was prepared by adopting agronomic practices for commercial cultivation of onion. Seedlings were transplanted to plots in the field with 15x30 cm spacing (15 cm in plants and 30 cm in rows) on middle of December. Each plot measured 3x1 m with four rows that consists of 21plants/row. The experimental design consisted of RCB (randomized complete blocks) with three replications. However, thiophorate 70 WP 2 gm/L was used for the treatement of seedlings against root rot for 20-30 minutes at time of transplanting. Fertilizers; a dose of P2¬O 5 45 kg/ha at the time of transplanting and three doses of nitrogen 90 N kg/h: first dose (50%) at time of transplanting, second (25%) and third (25%) after 35 and 45 DAT (day after transplanting), respectively were applied. The seedlings were transplanted between 42-47 DAT. The density of thrips (adult and immature stages) was monitored by randomly selecting three plants/plot from middle lines in form of “V”. Observations were taken at weekly interval from 14 DAT up to harvesting.

The data was analysed by (ANOVA) on average number of adult and immature stages using 'R' (R Foundation for Statistical Computing version) 3.0.1 (2013-05-16). Means were compared by using milti-comparison Tukey-HSD test. Weather parameters: temperature (maximum, minimum, and total average), relative humidity, wind velocity, dew point and rainfall were collected from Department of Physics, AMU, Aligarh. They were analysed by Pearsons correlation in relation to the density of adult and immature stages on different cultivars using SPSS 16.0.0 (2007).

3. RESULTS

3.1 Seasonal abundance

The result (Table-1& 3) revealed that adult and immature stages of *T. tabaci* appeared in field from mid-February (56 DAT) at15.57℃ and 74.11% RH (0.07 adult and 0.24 immature/plant). The infestation gradually increased up to the time of harvesting (first week of April) with fluctuation peaks on cultivars. Immature stage peaked at 70 DAT (last week of February) at 17.58℃ and 61.61% RH on Onion Kessar (7.06 immature/plant) and Onion Dr-301 (Krishna) (3.06 immature/plant). Whereas, adults were abundantly foun in the month of March between 77-105 DAT at 18.71-25.70℃ with 61.61-50.89% RH that the density ranged between 1.06- 2.72 adult/plant on all cultivars, while on immature was at 91-105 DAT (22.25-25.70 ℃ and 54.86-50.89% RH) that ranged between 13.78-43.94 immature/plant on all cultivars except Onion White and Onion-Indam Marshal-(Synth-3). An additional peak of adult stage was at 112 DAT (first week of April) at 28.57℃ and 45.21%RH on Onion White (3.28 adult/plant), Nasik Red (1.61 adult/plant), Tanzanian Red (0.89 adult/plant) and Onion Kessar (1.78 adult/plant), while immature stage peaked on White Marglobe (13.22 immature/plant), Onion White (28.56 immature/plant), Onion Kessar (26.56 immature/plant) and Onion Dr-301 (Krishna) (11.89 immature/plant). However, the total average of adult on cultivars showed that the peak was in second week of March (1.60 adult/plant) at 84 DAT (22.23℃ and 57.75%RH) and in first week of April (1.30 adult/plant) at 112 DAT (28.57℃ and 45.21%RH), while 20.97 immature/plant in last week of March at 105 DAT (25.70℃ and 50.89%RH) on immature stage. Compound ANOVA analysis (Table-2& 4) revealed that considerable ($P>0.05$) difference did not occur between the two years in all weeks except at 70 DAT on adult stage. A significant ($P<0.05$) difference was estimated at 77 and 84 DAT on immature stage. Density of immature was significantly ($P< 0.05$) different in relation to cultivars at 56 DAT, while also significant at 63, 70 and 112 DAT in relation to stages of thrips. Interaction analysis was significant ($P> 0.05$) at 56 and 63 DAT in both stages and 70 DAT in immature stage.

The total average density of immature was greater than the adults (Table 1, 3). The total density of immature stage was 14.9 immature/plant was estimated on Onion-Indam Marshal-(Synth-3), while the density of adult was 1.11 adult/plant on Onion White. However, the density of adult stage was found to be with on Nasik Red (0.75 adult/plant) significantly ($P>0.05$) and 5.42 immature thrips/plant on Onion Dr-301 (Krishna) for immature stage non-significantly ($P<0.05$).

Table 1: Density of adult stage of *T. tabaci* on different cultivars (2011-2012)

Cultivars	White Marglobe	Onion White	Nasik Red	Tanzanian Red	Nasik Red Plus N-53	Onion Kessar	Onion-Indam Marshal(Synth -3)	Onion Dr-301 (Krishna)	Average
56 DAT	0.06a	0.06a	0.00a	0.00a	0.06a	0.22a	0.06a	0.11a	0.07
	(0.06)	(0.06)	(0.00)	(0.00)	(0.06)	(0.14)	(0.06)	(0.07)	(0.02)
63 DAT	0.02b	0.11ab	0.04ab	0.0ab	0.00b	0.15a	0.06ab	0.07ab	0.06
	(0.02)	(0.07)	(0.04)	(0.02)	(0.00)	(0.07)	(0.03)	(0.04)	(0.02)
70 DAT	0.22ab	0.22ab	0.00b	0.28ab	0.44ab	0.67a	0.44ab	0.72a	0.38
	(0.16)	(0.14)	(0.00)	(0.16)	(0.16)	(0.31)	(0.19)	(0.18)	(0.07)
77 DAT	0.83a	1.00a	0.89a	0.94a	0.89a	1.11a	0.83a	2.28a	1.10
	(0.46)	(0.52)	(0.39)	(0.22)	(0.19)	(0.31)	(0.35)	(0.59)	(0.15)
84 DAT	2.72a	1.94a	0.83a	1.44a	1.17a	1.33a	1.44a	1.89a	1.60
	(0.69)	(0.75)	(0.25)	(0.44)	(0.72)	(0.48)	(0.61)	(0.93)	(0.22)
91 DAT	1.72a	0.78a	0.94a	1.61a	0.89a	1.33a	1.61a	0.89a	1.22
	(0.80)	(0.37)	(0.36)	(0.62)	(0.24)	(0.31)	(0.48)	(0.43)	(0.17)
98 DAT	0.78a	1.56a	1.56a	1.22a	1.39a	1.83a	1.72a	1.06a	1.39
	(0.11)	(0.31)	(0.58)	(0.42)	(0.87)	(0.71)	(1.09)	(0.61)	(0.22)
105 DAT	1.72a	1.06a	1.50a	0.50a	1.11a	1.06a	2.17a	0.56a	1.21
	(1.00)	(0.26)	(0.59)	(0.24)	(0.29)	(0.28)	(0.61)	(0.31)	(0.18)
112 DAT	0.61b	3.28a	1.61ab	0.89b	0.83b	1.78ab	1.06b	0.28b	1.30
	(0.25)	(0.73)	(0.80)	(0.44)	(0.17)	(0.14)	(0.13)	(0.10)	(0.19)
Average	0.97a	1.11a	0.82a	0.77a	0.75a	1.05a	1.04a	0.87a	0.92
	(0.10)	(0.14)	(0.15)	(0.17)	(0.13)	(0.18)	(0.20)	(0.20)	(0.06)

SEM is given in parentheses

Table 2: ANOVA table of average number of thrips (adult/plant)

sources of variances	df	M.S									
		56 DAT	63 DAT	70 DAT	77 DAT	84 DAT	91 DAT	98 DAT	105 DAT	112 DAT	Total average
years (A)	1	0.04	0.07	3.346*	3.70	45.37	4.48	6.26	3.34	2.37	0.11
Erorr (a)	2	0.03	0.03	0.09	0.32	2.48	5.81	9.06	3.75	0.57	0.66
Cultivars (B)	7	0.03	0.02*	0.35 **	1.42	2.02	0.91	0.75	1.93	5.31***	0.12
AXB	7	0.05*	0.02**	0.23	1.71	1.35	1.02	1.70	1.84	1.82	0.18
Erorr (b)	28	0.02	0.01	0.10	0.75	1.27	0.72	2.06	1.41	0.99	0.12
C.V%		199.4	113.9	83.6	79	70.6	69.2	103.3	98.1	77.1	36.9

Significant codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Table 3: Density of immature stage of *T. tabaci* on different cultivars (2011-2012)

Cultivars	White Marglobe	Onion White	Nasik Red	Tanzanian Red	Nasik Red Plus N-53	Onion Kessar	Onion-Indam Marshal(Synth-3)	Onion Dr-301 (Krishna)	Average
56 DAT	0.06b	0.17b	0.00b	0.00b	0.06b	1.44a	0.17b	0.00b	0.24
	(0.06)	(0.11)	(0.00)	(0.00)	(0.06)	(0.90)	(0.17)	(0.00)	(0.126)
63 DAT	0.00b	0.24b	0.07b	0.09b	0.06b	1.09a	0.31b	0.56ab	0.30
	(0.00)	(0.24)	(0.06)	(0.06)	(0.06)	(0.50)	(0.27)	(0.39)	(0.10)
70 DAT	0.00b	0.00b	0.39b	0.67b	0.78b	7.06a	2.67ab	3.06ab	1.83
	(0.00)	(0.00)	(0.39)	(0.49)	(0.60)	(3.75)	(2.23)	(2.07)	(0.65)
77 DAT	3.28a	2.22a	5.06a	3.56a	0.94a	6.50a	4.00a	1.44a	3.38
	(1.09)	(1.15)	(2.21)	(1.87)	(0.30)	(3.06)	(2.21)	(0.59)	(0.64)
84 DAT	6.44a	6.72a	10.89a	10.17a	3.00a	6.56a	7.67a	3.78a	6.90
	(2.56)	(2.07)	(3.47)	(7.68)	(1.23)	(2.30)	(5.39)	(1.57)	(1.32)
91 DAT	7.94a	9.28a	26.89a	16.00a	8.61a	17.00a	12.83a	6.61a	13.15
	(1.53)	(2.81)	(12.32)	(3.20)	(2.68)	(4.56)	(4.66)	(3.35)	(1.99)
98 DAT	17.28a	13.78a	17.06a	19.39a	13.50a	15.44a	21.67a	10.56a	16.08
	(4.04)	(4.01)	(8.15)	(6.22)	(6.17)	(6.62)	(6.54)	(6.09)	(2.05)
105 DAT	11.72a	28.22a	22.00a	18.44a	13.78a	18.72a	43.94a	10.89a	20.97
	(2.22)	(10.71)	(10.13)	(5.42)	(4.24)	(5.85)	(17.45)	(3.96)	(3.24)
112 DAT	13.22a	28.56a	21.33a	15.89a	12.00a	26.56a	35.39a	11.89a	20.60
	(2.24)	(3.23)	(7.26)	(7.57)	(3.49)	(3.73)	(10.36)	(4.16)	(2.26)
Average	6.66a	9.91a	11.52a	9.36a	5.86a	11.15a	14.29a	5.42a	9.27
	(0.75)	(1.16)	(2.60)	(2.29)	(1.40)	(2.25)	(3.27)	(1.56)	(0.80)

SEM is given in parentheses

3.2 Weather Factors

The temperature (Table 5) showed a sequential increase up to time of harvesting. The range of maximum temperature was 16.1-30.51 ℃, minimum 14.53-26.63℃ and the average 15.57-28.57 ℃. In addition, total average of temperature was 22.73, 19.86, and 21.29 ℃ for maximum, minimum and average temperature, respectively. However, relative humidity was found to be in a decreasing trend up to time of harvesting. It ranged between 45.21-74.11% RH with a substantial fluctuation. Total average relative humidity was 59.41% RH for 2 years. Wind velocity was ranged 2.38-4.89 km/hr with total average of 3.93 km/hr. Dew point showed gradual increase with time that ranged between10.60-115.45℃ with a total average of 12.45 ℃. However, rainfall was scanty in winter season with total average of 0.14 mm and ranged between 0-1.09 mm.

Table 4: ANOVA table of average number of thrips (immature/plant)

sources of variances	df	M.S									
		56 DAT	63 DAT	70 DAT	77 DAT	84 DAT	91 DAT	98 DAT	105 DAT	112 DAT	Total average
years (A)	1	1.57	4.02	145.84	273.93**	189.34*	5.56	56.33	291.72	5.11	15.98
Erorr (a)	2	0.46	0.35	10.6	1.29	8.75	269.34	10.55	264.21	110.72	16.67
Cultivars (B)	7	1.46**	0.81**	34.92**	20.56	44.99	271.93	74.94	712.96	466.7	57.89 *
AXB	7	1.62**	0.86 ***	36.33**	24.80	90.09	76.61	287.35	222.3	176.8	32.51
Erorr (b)	28	0.40	0.16	9.92	11.29	96.91	201.36	238.06	524.74	223.29	23.36
C.V%		267.4	133.4	172.4	99.6	142.6	107.9	95.9	109.3	72.5	52.1

Significant codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Table 5: Average weather parameters (2011-2012)

DAT	Maximum temperature (℃	Minimum temperature (℃	Average temperature (℃	Relative humidity (% RH)	Wind velocity (Km/hr)	Dew point (°	Rainfall (mm)
56 DAT	16.61	14.53	15.57	74.11	4.63	10.60	0.01
63 DAT	17.13	14.97	16.05	69.04	3.70	9.70	1.09
70 DAT	18.66	16.49	17.58	70.68	3.57	11.69	0.07
77 DAT	19.99	17.44	18.71	61.61	4.89	10.72	0.01
84 DAT	23.63	20.83	22.23	57.75	2.38	13.06	0.00
91 DAT	23.66	20.84	22.25	54.86	3.44	12.34	0.00
98 DAT	26.60	23.34	24.97	50.54	4.23	13.79	0.00
105 DAT	27.73	23.68	25.70	50.89	4.43	14.73	0.00
112 DAT	30.51	26.63	28.57	45.21	4.16	15.45	0.08
Total average	22.73	19.86	21.29	59.41	3.93	12.45	0.14

3.3 Correlation analysis

Immature stage was significantly more affected than adult stage by weather factors (Table-6 &7). A significantly (P<0.05) positive correlation was calculated between temperature (maximum, minimum, and average temperature) and thrips (adult and immature stages) on all cultivars except with adult stage on Onion White Marglobe, Tanzanian Red and Onion Dr-301 (Krishna) which were non-significantly (P>0.05) positive. However, average relative humidity was correlated negatively significant (P<0.05) in relation to thrips on all cultivars but negatively non-significant (P>0.05) correlation was determined for adult stage on Onion White Marglobe, Tanzanian Red and Onion Dr-301 (Krishna). Wind velocity was negatively (P>0.05) affected the adult population on all cultivars, while it has pronounced (P>0.05) effect on immature on almost all cultivars but a negatively non-significant (P>0.05) was observed on Nasik Red and Tanzanian Red. Dew point enhanced the population of immature stage on all cultivars. However, it was significantly (P<0.05) positive on adult stage on Onion white, Nasik Red, Nasik Red Plus N-53, Onion Kessar, Onion-Indam Marshal-(Synth-3), while it was non-significantly (P<0.05) positive on Onion White Marglobe and Tanzanian Red and non-significantly (P<0.05) negative on Onion Dr-301 (Krishna). Finally, rainfall caused an adverse effect (P<0.05) on thrips on all cultivars.

Table 6: Correlation coefficients (r) between weather factors and average number of adult/plants

weather parameters (df=7)	Cultivars								
	White Marglobe	Onion White	Nasik Red	Tanzanian Red	Nasik Red Plus N-53	Onion Kessar	Onion-Indam Marshal-(Synth-3)	Onion Dr-301 (Krishna)	Average
Maximum Temperature(r)	0.466ns	.848**	.945**	0.558ns	.765*	.866**	.800**	0.046ns	.807**
P-val.	0.206	0.004	0.00	0.119	0.016	0.003	0.01	0.906	0.009
Minimum Temperature(r)	0.47ns	.860**	.940**	0.584ns	.771*	.884**	.794*	0.059ns	.817**
P-val.	0.202	0.003	0.00	0.099	0.015	0.002	0.011	0.88	0.007
Average Temperature(r)	0.468ns	.854**	.943**	0.57ns	.768*	.875**	.797*	0.052ns	.812**
P-val.	0.204	0.003	0.00	0.109	0.016	0.002	0.01	0.894	0.008
Relative Humidity(r)	-0.504ns	-.829**	-.972**	-0.662ns	-.807**	-.900**	-.825**	-0.159ns	-.858**
P-val.	0.167	0.006	0.00	0.052	0.009	0.001	0.006	0.682	0.003
Wind velocity (r)	-0.564ns	-0.126ns	0.157ns	-0.394ns	-0.133ns	-0.092ns	-0.125ns	-0.163ns	-0.239ns
P-val.	0.114	0.747	0.687	0.294	0.734	0.814	0.749	0.675	0.536
Dew point(r)	0.451ns	.802**	.859**	0.452ns	.717*	.795*	.763*	-0.026ns	.736*
P-val.	0.223	0.009	0.003	0.222	0.03	0.01	0.017	0.946	0.024
Rainfall(r)	-0.428ns	-0.331ns	-0.44ns	-0.5ns	-0.604ns	-0.552ns	-0.52ns	-0.423ns	-0.565ns
P-val.	0.25	0.384	0.236	0.17	0.085	0.123	0.151	0.256	0.113

*. Correlation is significant at the 0.05 level
**. Correlation is significant at the 0.01 level
ns. Correlation is non-significant

Table 7: Correlation coefficients (r) between weather factors and average number of immature stage/plants

weather parameters (df=7)	Cultivars								
	White Marglobe	Onion White	Nasik Red	Tanzanian Red	Nasik Red Plus N-53	Onion Kessar	Onion-Indam Marshal-(Synth-3)	Onion Dr-301 (Krishna)	Average
Maximum Temperature(r)	.921**	.933**	.861**	.920**	.918**	.936**	.905**	.959**	.967**
P-val.	0.00	0.00	0.003	0.00	0.00	0.00	0.001	0.00	0.00
Minimum Temperature(r)	.923**	.917**	.862**	.920**	.911**	.935**	.884**	.956**	.958**
P-val.	0.00	0.001	0.003	0.00	0.001	0.00	0.002	0.00	0.00
Average Temperature(r)	.922**	.926**	.862**	.921**	.915**	.936**	.896**	.958**	.963**
P-val.	0.00	0.00	0.003	0.00	0.001	0.00	0.001	0.00	0.00
Relative Humidity(r)	-.928**	-.875**	-.892**	-.934**	-.900**	-.907**	-.844**	-.917**	-.942**
P-val.	0.00	0.002	0.001	0.00	0.001	0.001	0.004	0.00	0.00
Wind velocity (r)	0.078ns	0.165ns	-0.078ns	-0.046ns	0.14ns	0.103ns	0.211ns	0.074ns	0.097ns
P-val.	0.842	0.672	0.843	0.907	0.719	0.792	0.586	0.851	0.803
Dew point(r)	.861**	.922**	.785*	.863**	.881**	.898**	.904**	.943**	.931**
P-val.	0.003	0.00	0.012	0.003	0.002	0.001	0.001	0.00	0.00
Rainfall(r)	-0.396ns	-0.298ns	-0.413ns	-0.431ns	-0.361ns	-0.406ns	-0.315ns	-0.372ns	-0.387ns
P-val.	0.291	0.436	0.269	0.246	0.339	0.278	0.409	0.324	0.304

*. Correlation is significant at the 0.05 level.
**. Correlation is significant at the 0.01 level.
ns. Correlation is non-significant.

4. DISCUSSION

4.1 Seasonal abundance

The result data reveals that onion cultivars were colonized by *T. tabaci* (adult and immature) in mid-February when temperature at 15.57℃ and relative humidity at 74.11% RH in both the years successively. This may similarly with result of Ullah et al. [21] and Ibrahim and Adesiyun, [22] that infestation was started in February. However, it was recorded in December [4], and January [23, 24, 22, 14]. Next population of thrips was declined in end of season May [24, 22, 21]. However, we found that density of adult and immature stages showed increasing trend towards end of season with fluctuation peak among different cultivars. Thrips peaked in February for different date of transplanting: November [25, 22] and December [14] transplanting. This above finding seems to agree with our observation on Onion Kessar and Onion Dr-301 (Krishna). In addition, thrips peak population were found in March with several date of transplanting: December [4, 25, 22, 14], and January [4, 25, 22]. All these earlier reports corroborates with the results obtained in present study peak population of immature and adult stage in March on all cultivars except population of immature stage on Onion White and Onion Dr-301 (Krishna). Moreover, population of both adult and immature stages peaked in April on Onion White and Onion Kessar as well as adult stage peaked on Nasik Red and Tanzanian Red while immature stage peaked on White Marglobe and Onion Dr-301 (Krishna). This result may correspond to the observation that thrips peaked in April in various date of transplanting: December [14], February and March [22], as well as in October sowing [21]. On other hand, Peak in May was recorded for April transplant also by Ibrahim and Adesiyun [25].

In our present study, almost peaks of population were recorded in March (77 DAT) and April (112 DAT) was probably due to optimum climate conditions. On the contrary, Srinivas et al. [26] stated that thrips onion was more attracted to onion at the bulb formation stage (45-75 days after planting). Also, Kalafchi et al. [27] showed that the population density of thrips was highest at 130 and 158 days. In this study, the variation between the cultivars are probably because using different onion varieties, agro-climate. Thrips population of adult and immature stages was demonstrated high at time of harvesting 112 DAT at 28.57℃ and 45.21%RH (First week of April) on all cultivars. This finding agrees with conclusion of JianHua *et al.*, [28] that nymphs became more dispersed, as onion plants matured. However, Reuda and Shelton [29] reported that at the end of the season, thrips might not be able to survive in abundance because there is not sufficient green vegetation in the surrounding areas, as April and May being the driest.

Average thrips density of adult and immature stage was non-significant on all cultivars. It provides that all onion cultivars have same level of resistance against density of *T. tabaci*. This result is consistent with result of Shakeel *et al.*, [30] that the thrips infestation was almost similar on all the cultivars tolerant to thrips. On contrary, thrips density indicated significantly different among several onion cultivars or

genotypes either in field or lab condition [6, 13, 27, 31, 32, 33, 34, 35, 36). Our results proved that the highest density of adult was on Onion White (1.11 adult/plant), while immature form was on Onion-Indam Marshal-(Synth-3) (14.29 immature thrips/plant) non-significantly. The lowest adult density was not significant (P>0.05) on Nasik Red (0.75 adult/plant) while immature stage was non-significant on Onion Dr-301 (Krishna) (5.42 immature thrips/plant). However, Yousefi *et al.,* [6] stated that the highest iranian cultivar had more than 25 thrips/plant. In addition, the highest density on highest susceptible cultivar was 22.24 thrips/plant, while the lowest density was 2.65 thrips/plant [34]. Among non-hybrid or hybrid varieties, Loges et al. [32] proved that non-hybrids variety cv. Duquesa had lowest number of immature forms of *T. tabaci*. The cv. Duquesa and hybrids Granex Ouro and Dessex were moderately resistant to the thrips based on yield characters and on the number of immature forms of the insect.

4.2 Correlation analysis

The results revealed that increase in temperature parameters led to increase in population of thrips, particularly immature stage was highly significant positively on all cultivars and total average except adult stage on Onion White Marglobe, Tanzanian Red and Onion Dr-301 (Krishna), which were not significant positively. The effect of temperature was more glaring on immature stage than adult stage. This may agree with result of Hendawy *et al.,* [14] and Leite *et al.,* [13] on onion crop and Arif *et al.,* [37] on cotton. However, it totally disagrees with significant negative result of Khan *et al.,* [38] on mung bean and non-significant negative result of Chhatrola *et al.,* [20] on garlic.

Correlation of relative humidity with adult and immature stages proved negative significance on all cultivars and total average, but it was non-significant negative with adult stage on Onion White Marglobe, Tanzanian Red and Onion Dr-301 (Krishna). Negative and significant result seems to correspond with result of Leite *et al.,* [13] while non-significant negative was reported by Hendawy *et al.,* [14] on onion. In addition, it fully disagrees with non-significant positive result of Chhatrola *et al.,* [20] on garlic and Khan *et al.,* [38] on mung bean. Moreover, not significant result of Arif *et al.,* [37] on cotton agrees with our non-significant result of adult stage on Onion White Marglobe, Tanzanian Red and Onion Dr-301 (Krishna). Correlation of wind velocity with immature stage was non-significant positive on Onion White Marglobe, Onion white, Nasik Red Plus N-53, Onion Kessar, Onion-Indam Marshal-(Synth-3), Onion Dr-301 (Krishna) and total average. This result is totally in agreement with result of Hendawy *et al.,* [14] on onion and Chhatrola *et al.,* [20] on garlic, but it is not in agreement with non significant negative result of adult thrips on all cultivars and immature stage on Nasik Red and Tanzanian Red. Furthermore, dew point with adult and immature stage was significant positive correlation on all cultivars and total average but it was non-significant positive with adult stage on Onion White Marglobe and Tanzanian Red and negatively on Onion Dr-301 (Krishna). Moreover, the correlation of rainfall with adult and immature stage was not significant negative on all cultivars and their total average. The above result was confirmed by Arif et al. [37] on cotton while it is in contrast to Ibrahim and Adesiyun [4] and Workman and Martin, [15] results. Generally, the non-effect of rainfall is as a result of rain lack in the season.

5. CONCLUSION

The observations clearly indicate that adult and immature stages attack the crop in second week of February and that the weather factors and cultivars from February onwards are responsible for gradual population increase on the cultivars. Variation in peak activity was recorded between first week of March to first week of April. Thrips density peaked on cultivars within maturity stage. The cultivars have therefore escaped from the heavy infestation and this may correspond to the fact that use of chemicals can be minimized or not be used at all. In addition, the Onion White is more susceptible than other cultivars but for more authenticity it must be related to yield harvest. Moreover, the temperature parameters (maximum, minimum and average) and relative humidity are more important factors and have high significant effect on thrips. Furthermore, immature stage was more significantly susceptible by weather factors than adult stage. Finally, both onion cultivars and climate factors play important role on abundance and ecology of thrips.

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