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Seasonal incidence and biology of thrips *Scirtothrips dorsalis* hood on pomegranate (*Punica granatum* L.)

Praveen Kumar, SK Mushrif, B Doddabasappa and B Venkateshalu

Abstract
The investigation on seasonal incidence and biology of thrips on pomegranate was conducted at the Department of Entomology, College of Horticulture, Bagalkot, Karnataka during the year 2015-2016. Studies on incidence of thrips on pomegranate under *Ambe bahar* treatment revealed two peaks with major peak from January to April coinciding with flowering and fruit development and another peak from August to middle of October during resting period. Thrips population was noticed on all plant parts with relative high density on tender shoot (9.46/shoot), flower bud (4.02/flower bud), flowers (3.11/flower) and tender fruit (3.03/fruit). Studies on biology of *Scirtothrips dosalis* Hood on pomegranate var. Bhagwa revealed total life cycle period of 14.50 to 20.25 days from egg to adult death. Developmental duration of life cycle included egg, two active feeding larval instars, prepupal, pupal and adult stages *viz*., 2.24 ± 0.26, 2.52 ± 0.39, 4.5 ± 0.41, 0.86 ± 0.13, 1.92 ± 0.22 and 5.29 ± 0.37 days, respectively. Adults and nymphs found feeding on the lower surface of leaves. Females have a saw-like ovipositor with which they inset eggs partially into tissue and young larva cause damage to tender leaves, flower buds and young fruits that resulted in scarring of fruit rind which in turn decreased marketability of fruits.

Keywords: Pomegranate, *Scirtothrips dorsalis*, biology

Introduction
Pomegranate (*Punica granatum* L.), an ancient fruit known as a "Fruit of Paradise" belongs to the botanical family *Punicaceae*, is one among the major fruit crops grown extensively in tropics and subtropics. It is indigenous to Iran and is cultivated extensively in Spain, Morocco, Egypt, Iran, Afghanistan, Arabia and other Mediterranean countries. Among the pomegranate growing states, Maharashtra is the largest producer occupying 2/3rd of total area in the country followed by Karnataka, Andhra Pradesh, Gujarat and Rajasthan. In India, it is regarded as a "vital cash crop", grown in an area of 2, 73,000 ha with a production of 30, 68,000 tonnes and average productivity of 11.24 tonnes during (Anon., 2022) [3]. Pomegranate is a good source of carbohydrates and minerals such as calcium, iron and sulphur. It is rich in vitamin-C and citric acid (Malhotra *et al*., 1983) [14].

Pomegranate production is associated with many problems like non-availability of suitable varieties, environmental vagaries, nutritional deficiencies, physiological disorders, post-harvest glut, post-harvest losses, improper storage, lack of marketing facilities, price fluctuation and biotic constraints like pest and diseases. The losses due to pests and diseases are very high. In spite of 25 to 30 per cent of total cost of production is being spent on plant protection bringing down the losses to the economic level due to biotic constraints is still a difficult task. Perusal of literature revealed a total of 91 insects, 6 mites and 1 snail pest feeding on pomegranate crop in India (Balikai *et al*., 2011) [7].

Among various insects pests, the sucking pests, infestation by pomegranate thrips in general and *Scirtothrips dorsalis* Hood in specific is an important and widely distributed because of its polyphagous nature. In the recent days, it has become very serious on pomegranate necessitating repeated sprays with systemic insecticides. The highest thrips incidence usually coincides with new flesh reducing the vegetative growth, affecting flowering, fruit development and reducing the fruit quality. Thus, it is one of the major constraints for sustainable production of export quality fruits in terms of size, colour, free from blemishes and pesticide residue. Though, farmers are using number of insecticides, the control of thrips is not satisfactory. Therefore, it is necessary to develop effective and need based management practices for thrips. Hence, objective of this paper was to know the seasonal incidence and biology of thrips on pomegranate.

Material and Methods

Study location

The field experiments were carried out at Bagalkot in farmer's field and pomegranate research plot at Main Horticulture Research and Extension Centre (MHREC), University of Horticultural Sciences (UHS), Bagalkot, Karnataka while the laboratory studies were carried out at Department of Entomology, College of Horticulture (COH), Bagalkot. The study area is located at a longitude of 75.7°E and latitude of 16.18°N at an altitude of 533 meters above mean sea level. Normal agronomical practices and plant protection measures against pests and diseases except thrips were taken as per package of practices of UHS, Bagalkot (Anon., 2013) [2].

Seasonal incidence of thrips on pomegranate

This study was undertaken during 2015-2016 season in Main Horticulture Research and Extension Centre, UHS, Bagalkot research plot (fixed plot) from August 2015 to July 2016 under *Ambe bahar* treatment (pruning at November and flowering during January) of variety Bhagwa. Observations on thrips were made from ten randomly selected and tagged plants under unprotected conditions. From each plant, five tender shoots of 10 cm length were selected randomly and were gently tapped on to a stiff black paper board (30x30 cm) and the number of thrips (both nymph and adult) were counted using hand lens. Similarly, number of thrips from ten flower buds, flowers and young fruits per plant were counted visually and recorded. Simultaneously, weather parameters *viz.*, maximum temperature, minimum temperature, relative humidity, total rainfall and wind speed were collected from the meteorological observatory, MHREC, UHS, Bagalkot. The mean numbers of thrips were correlated with the meteorological data and regression equation was developed.

Biology of pomegranate thrips

The biology of *Scirtothrips dorsalis* (Hood), the most common and abundant species infesting pomegranate was studied from February to May 2016 in the Department of Entomology laboratory, College of Horticulture, Bagalkot where laboratory temperature ranged between 25 to 30 °C with a relative humidity of 70 to 80 per cent during study period. Pomegranate plants of var. Bhagwa were maintained in earthen pots and kept free from the other pests by covering them with nylon net cages. Adult thrips, *S. dorsalis* were collected from the pomegranate field and released on these caged plants for egg laying @ 10 adults per seedling. Leaves were collected randomly after 24 hours and observed for presence of egg under stereo zoom binocular microscope, Magnus MSZ-Bi with transmission light. The leaves having one to two eggs were transferred on to leaf arenas kept on wet sterile surgical cotton wad in a Petri plate (9 cm diameter) such 50 Petri plates were maintained for recording developmental durations of egg, larva, pupa and adults. The incubation period was recorded by observing at every six hours till the emergence of first instar larva. The larval instars were studied by transferring freshly hatched larvae onto the fresh leaf arena on wet cotton wad in Petri plates with the help of fine and moistened camel hair brush. Fresh leaf arena was provided once in three days. The number of instars and days taken for completion of each instar was recorded by observing moulted or cast off skin at every six hours interval under stereo zoom binocular microscope with low intensity incident light (to avoid heat). The pupal stages were transferred on to fresh pomegranate shoots of 10 cm retained with 3 to 4 terminal leaves and enclosed in a polythene covers of 20 x 15 cm size. The cut ends of pomegranate shoots were dipped in a plastic vial (15 ml) containing solidified agar-agar medium to maintain the freshness of shoot for a longer period. The duration of the adult thrips from emergence till their death was recorded on pomegranate shoot. Observations were made on all the life stages *viz.*, egg, larval, pupal and adult stages.

Statistical Analysis

Data obtained from the study was subjected to suitable transformation based on nature of the data before subjecting to suitable statistical analysis (Gomez *et al*., 1984) [9]. Population of thrips per plant during crop growth period and weather parameters were all subjected to correlation matrix analysis. The factors showing significant relation at P = 0.05 were identified and subjected to further linear and non-linear analysis. Multiple regression analysis was done to develop multiple regression equation.

Results and Discussion

Seasonal incidence of pomegranate thrips

Thrips population on shoots

Thrips population of both nymphs and adults on pomegranate shoot was noticed throughout the cropping period and its occurrence ranged from 0 to 9.46 thrips per shoot. The peak incidence on shoot was noticed during first week of March [(10th standard meteorological week (SMW)] with a mean population of 9.46 thrips per shoot followed by another peak during second week of February (7th SMW) with a mean population of 9.42 thrips per shoot. However, thrips population was not noticed during the month of November (Table 1).

This was due to the fact that, availability of tender shoots during above said periods probably favoured the multiplication of the pest. This is in conformation with the findings of Ananda (2007) [1] who observed the maximum damage during second fortnight of March on shoot. Murugan (2000) [15] also observed the maximum damage during first fortnight of April and first week of May on leaves. Thrips having rasping and sucking type of mouth parts rasp the tender tissue and suck up the oozing cell sap. They prefer tender tissue for egg insertion partially into the tissues. So, their colonization was most frequently dependent on the availability of new tender shoots.

Thrips population on flower bud

Both nymphs and adults of thrips on flower buds were noticed during flowering period and population ranged from 0 to 4.02 thrips per flower bud. Peak activity on flower bud was noticed during first week of March (10th SMW) with a mean population of 4.02 thrips per flower bud followed by another peak during fourth week of April (17th SMW) with a mean population of 3.78 thrips per flower bud and thrips population was not noticed during the month of November and first fortnight of December and from May till July (Table 1). This is in close agreement with the findings of Murugan (2000) [15] and Asma and Hanumantharaya (2015) [4] who observed peak activity of thrips during dry periods of April and May due to suitability of dry weather for population growth.

Thrips population on flower

Thrips population of both nymphs and adults on flower was noticed throughout the flowering period and its occurrence ranged from 0 to 3.03 thrips per flower. The peak incidence was noticed during second week of April (15th SMW) with a mean population of 3.03 thrips per flower followed by second peak during first week of March with a mean population of 2.80 thrips per flower and reached zero population from November till December third week (Table 1). This is in conformation with the findings of Murugan (2000) [15] who observed the maximum damage during first fortnight of April and first week of May and Ananda (2007) [1] who also observed the maximum damage during second fortnight of March. Pomegranate often bears flower buds and flowers in small bunch of three to five, and this might serve as most favourable site for colonization and feeding. So, thrips infestation was recorded quite consistently at all stages of flower bud and flower with an average of 4.08 and 3.03 during economical flowering period.

Thrips population on fruit

Both nymphs and adults of thrips on fruit was noticed during fruiting period and its occurrence ranged from 0 to 3.47 thrips per fruit. Peak activity on fruit was noticed during second week of April (15th SMW) with a mean population of 3.47 thrips per fruit followed by another peak first week of March with a mean population of 3.11 thrips per fruit and zero population of thrips was noticed during the month of November (Table 1). This is in close agreement with the findings of Murugan (2000) [15] and Asma and Hanumantharaya (2015) [4] who observed peak activity of thrips during dry periods of April and May due to suitability of dry weather for population growth. Thrips infestation was severe on young, developing fruits causing scab patches or longitudinal streaks on tender fruits. But, maturing fruits were not colonized by the thrips.

Thrips population on a plant

Both nymphs and adults of *S. dorsalis* was noticed throughout the cropping period and its occurrence ranged from 0 to 19.39 thrips per plant. The peak incidence was noticed during the first week of March (10th SMW) with a mean population of 19.39 thrips per plant (Table 1) followed by second week of April (17.83/plant). These results are in close conformity with that of Kotikal *et al.* (2009) [12] who reported peak infestation of thrips during second fortnight of March. Murugan (2000) [15] also reported peak thrips population during first fortnight of April.

Table 1: Seasonal incidence of pomegranate thrips, *Scirtothrips dorsalis* (Hood) during *Ambe bahar* of 2015-16

Month	Standard Meteorological Weeks	Mean no. of thrips/Shoot			Mean no. of thrips/Flower bud			Mean no. of thrips/Flower			Mean no. of thrips/Fruit			Total on all parts
		Adults	Nymphs	Total	Adults	Nymphs	Total	Adults	Nymphs	Total	Adults	Nymphs	Total	
August-15	32	2.25	2.22	4.47	1.64	1.25	2.91	0	0	0	0	0	0	7.38
	33	2.14	2.20	4.34	1.59	1.25	2.84	1.05	0.52	1.57	0	0	0	8.75
	34	2.28	2.50	4.78	1.71	1.25	2.96	0.90	0.71	1.61	0	0	0	9.35
	35	2.54	2.40	4.94	1.38	1.12	2.50	0.74	0.64	1.38	1.15	1.12	2.27	11.09
September-15	36	2.98	3.06	6.04	1.43	1.13	2.56	0.85	0.53	1.38	1.22	0.95	2.17	12.15
	37	2.74	2.98	5.72	1.34	1.23	2.57	0.83	0.71	1.54	1.63	1.20	2.83	12.66
	38	2.98	3.16	6.14	1.29	1.19	2.48	0.73	0.50	1.23	1.11	1.13	2.24	12.09
	39	2.38	3.32	5.70	1.74	1.40	3.14	0.78	0.75	1.53	1.24	1.25	2.49	12.86
October-15	40	3.06	3.42	5.48	1.21	1.30	2.51	0.93	0.91	1.84	1.04	1.28	2.32	13.15
	41	2.68	1.40	4.08	0.78	0.36	1.14	0.42	0.11	0.53	0.78	0.22	1.00	6.75
	42	2.08	1.88	3.96	0.99	1.15	2.14	0.62	0.13	0.75	0.81	0.56	1.37	8.22
	43	2.12	1.98	4.10	1.13	0.80	1.93	0.47	0.07	0.54	0	0	0	6.57
November-15	44	2.16	2.18	4.34	0.94	0.73	1.67	0.43	0.05	0.48	0	0	0	6.49
	45	0	0	0	0	0	0	0	0	0	0	0	0	0
	46	0	0	0	0	0	0	0	0	0	0	0	0	0
	47	0	0	0	0	0	0	0	0	0	0	0	0	0
	48	0	0	0	0	0	0	0	0	0	0	0	0	0
December-15	49	1.22	1.30	2.52	0	0	0	0	0	0	0	0	0	2.52
	50	1.68	1.58	3.26	0	0	0	0	0	0	0	0	0	3.26
	51	2.02	2.12	4.14	0.87	1.21	2.08	0	0	0	0	0	0	6.22
	52	2.08	1.84	3.92	0.91	1.16	2.07	0.36	0.37	0.73	0	0	0	6.72
January-16	1	2.00	2.06	4.06	0.94	1.01	1.95	0.77	0.66	1.43	0	0	0	7.44
	2	1.94	2.00	3.94	1.59	1.57	3.16	1.01	0.87	1.88	1.14	0.94	2.08	11.06
	3	2.44	2.24	4.68	1.29	1.64	2.93	0.90	0.53	1.43	1.13	0.85	1.98	11.02
	4	2.36	2.06	4.42	1.34	1.52	2.86	0.78	0.66	1.44	1.02	0.89	1.91	10.63
	5	2.54	2.15	4.69	1.62	1.20	2.82	0.95	0.84	1.79	1.34	0.95	2.29	11.59

Month	Standard Meteorological Weeks	Mean no. of thrips/Shoot			Mean no. of thrips/Flower bud			Mean no. of thrips/Flower			Mean no. of thrips/Fruit			Total on all parts
		Adults	Nymphs	Total	Adults	Nymphs	Total	Adults	Nymphs	Total	Adults	Nymphs	Total	
February-16	6	4.64	3.66	8.30	1.80	1.38	3.18	1.38	1.18	2.56	1.19	1.14	2.33	16.37
	7	5.62	3.80	9.42	2.20	1.41	3.61	1.22	0.98	2.20	1.20	1.04	2.24	16.57
	8	4.10	3.40	7.50	1.45	1.41	2.86	1.18	1.11	2.29	1.37	1.29	2.66	15.31
	9	4.00	3.20	7.20	1.64	1.47	3.11	1.35	1.14	2.49	1.38	1.22	2.60	15.40
March-16	10	4.82	4.64	9.46	2.41	1.61	4.02	1.51	1.29	2.80	1.51	1.60	3.11	19.39
	11	4.48	3.82	8.30	1.98	0.71	2.69	1.21	1.26	2.47	1.64	1.39	3.03	16.49

	12	4.34	3.46	7.80	1.97	1.60	3.57	1.35	1.25	2.6	1.40	1.58	2.98	16.95
	13	4.06	3.56	7.62	1.56	1.73	3.29	1.33	1.24	2.57	1.32	1.43	2.75	16.23
April-16	14	4.18	4.50	8.68	1.85	1.76	3.61	1.27	0.95	2.22	1.26	1.35	2.61	17.12
	15	4.32	3.84	8.16	1.67	1.50	3.17	1.57	1.46	3.03	1.87	1.60	3.47	17.83
	16	4.28	3.58	7.86	1.26	0.71	2.47	1.47	1.07	2.54	1.42	1.30	2.72	15.59
	17	4.34	3.8	8.14	2.14	1.64	3.78	1.39	1.11	2.50	1.14	1.17	2.31	16.73
May-16	18	1.30	0.88	2.18	0	0	0	0	0	0	0.42	0.55	0.97	3.15
	19	1.70	1.28	2.98	0	0	0	0	0	0	0.73	0.69	1.42	4.40
	20	1.40	1.18	2.58	0	0	0	0	0	0	0.59	0.53	1.12	3.70
	21	1.30	1.50	2.8	0	0	0	0	0	0	0.71	0.63	1.34	4.14
	22	1.25	1.42	2.67	0	0	0	0	0	0	0.68	0.47	1.15	3.82
June-16	23	1.10	0.86	1.96	0	0	0	0	0	0	0.62	0.52	1.14	3.10
	24	1.10	1.08	2.18	0	0	0	0	0	0	0.49	0.48	0.97	3.15
	25	1.16	1.00	2.16	0	0	0	0	0	0	0.46	0.47	0.93	3.09
	26	0.98	0.92	1.90	0	0	0	0	0	0	0.48	0.56	1.04	2.94
July-16	27	0.92	0.66	1.58	0	0	0	0	0	0	0.51	0.49	1.00	2.58
	28	1.06	1.08	2.14	0	0	0	0	0	0	0.53	0.41	0.94	3.08
	29	1.16	1.00	2.16	0	0	0	0	0	0	0.57	0.54	1.11	3.27
	30	1.10	1.06	2.16	0	0	0	0	0	0	0.64	0.46	1.10	3.26
	31	1.24	1.12	2.36	0	0	0	0	0	0	0.85	0.68	1.53	3.89

*-Average number of thrips on ten plants

Correlation and regression analysis

Correlation between weather parameters and population of *S. dorsalis*

The weekly incidence of *S. dorsalis* was correlated with various weather parameters *viz.*, maximum temperature, minimum temperature, maximum and minimum relative humidity, rainfall and wind speed (Table 2).

The simple correlation studies during fruiting period revealed that, the population of thrips was significant and positively correlated with maximum temperature (r= 0.856) and minimum temperature (r= 0.453), but significantly and negative correlation with morning relative humidity (r= -0.449). On the contrary, evening relative humidity (r= -0.379), rainfall (r= -0.307) and wind speed (r= 0.156) showed no significant relationship with population of thrips (Table 2).

Correlation analysis during pruning to harvest period (7 months) revealed that, thrips population had significantly negative relationship with evening relative humidity (r= -0.482), rainfall (r= 0.590) and wind speed (r= -0.543) whereas, it had positive and non-significant relation with maximum temperature (r= 0.105) but negatively and non-significant relationship with minimum temperature (r= -0.315) and morning relative humidity (r= -0.332) (Table 2).

Simple correlation studies during twelve months period revealed that, the morning relative humidity (r= -0.432), evening relative humidity (r= -0.444) and rainfall (r= -0.421) had significant and negative relationship with thrips population while, maximum temperature (r= 0.111), minimum temperature (r= -0.267) and wind speed (r= -0.104) did not show any significant relationship with population of thrips (Table 2).

During February to April with availability of foliage, flowers and fruits coupled with the favourable weather parameters like increasing in the temperature and no rains resulted in the development and multiplication of the pest and this might be the reason for the increased population of thrips with an increase in temperature. The present results are in agreement with Bagle (1993) [5], Murugan (2000) [15], Abraham and Harish (2009) [10] and Asma and Hanumantharaya (2015) [4] who reported positive correlation between population of thrips and maximum temperature.

The incidence of *S. dorsalis* also showed a significant and positive relationship with minimum temperature during study (Table 2). The present finding is in agreement with the reports of Murugan (2000) [15] who observed the positive correlation of maximum temperature with the population of thrips.

The morning relative humidity showed significant negative correlation with thrips population. Similar to the present findings, Kotikal *et al.* (2009) [12] reported significant negative relationship between thrips and morning relative humidity. Patnaik *et al.* (1986) [16] also reported negative correlation of *S. dorsalis* on chillies, groundnut and cotton in relation to relative humidity, which is in agreement with the present findings.

Wind speed recorded a non-significant negative correlation with the thrips population. This might be because of presence of thrips beneath the leaves and hiding between compact flower buds compact. The present study is in line with findings of Harish (2009) [10] who also recorded negative correlation of wind speed with incidence of thrips in grape ecosystem.

Rainfall recorded a significant negative relationship with thrips incidence. Heavy rains might wash off thrips down to the soil surface, causing sudden sharp decline in population density (Bailey, 1933; Harish, 2009) [6, 10]. However, the correlations were non-significant which may be due to colonization of thrips within the folds of tender leaves, which are yet to open at the tip of the shoot, and within the flowers. This, besides contributing to aggregation might offer protection from rains and hence the non-significant correlation was observed with rainfall. These observations are comparable with the findings of Kumar *et al.* (1994) [13]. Patnaik *et al.* (1986) [16] also reported non-significant negative correlation of *S. dorsalis* with rainfall, which is in agreement with the present investigation.

Among all correlation factors, only maximum and minimum temperature and morning relative humidity influenced significantly (r= 0.856, 0.453 and -0.449, respectively) on incidence of thrips. According to Patnaik *et al.* (1986) [16] maximum and minimum temperature had significant positive relationship with thrips population, whereas, correlation was significantly negative with morning relative humidity. In the present findings, less influence of rainfall pattern on population of thrips in pomegranate may be attributed to the difference in pruning pattern.

Table 2: Correlation between the population of *Scirtothrrips dorsalis* (Hood) with weather parameters during 2015-16

Weather parameters	Correlation coefficient (r) values		
	Fruiting period (5 months)	Pruning to harvest (7 months)	Throughout the crop growth period (12 months)
Max. Temp. (°C)	0.856*	0.105	0.111
Min. Temp. (°C)	0.453*	-0.315	-0.267
Mrng. RH (%)	-0.449*	-0.332	-0.432*
Evng. RH (%)	-0.379	-0.482*	-0.444*
Rainfall (mm)	-0.307	-0.59*	-0.421*
Wind speed (m/s)	0.156	-0.543*	-0.104

* - Significant at 5%
** - Significant at 1%

Regression analysis between thrips population and weather parameters.

Multiple regression analysis between thrips population with all weather parameters during fruiting period indicated that, every unit increase in maximum temperature resulted in increased number of thrips by 0.999 units. Whereas, every increased unit in minimum temperature, morning relative humidity, evening relative humidity rainfall and wind speed would decrease the number of thrips by 0.452, 0.087, 0.134, 0.764 and 2.230 units respectively (Table 3). The weather parameters influenced the thrips population prediction to the extent of 84 per cent ($R^2 = 0.840$).

Multiple regression analysis of thrips population with all-weather parameters during pruning to harvest period (7 months) indicated that, for every unit increase in maximum temperature there was increase in number of thrips by 0.806 units. Whereas, every unit increase in minimum temperature, morning relative humidity, evening relative humidity rainfall and wind speed led to decrease in the number of thrips by 0.442, 0.045, 0.260, 0.045 and 5.108 units, respectively. The weather parameters influenced the thrips population prediction to the extent of 66 per cent ($R^2 = 0.660$).

Table 3: Regression analysis between populations of *Scirtothrips dorsalis* (Hood) with weather parameters during 2015-16

Cropping period	Prediction model (Regression Equation)	R^2 value
Fruiting period	$Y= -9.617+0.999(X_1)-0.452(X_2)-0.087(X_3)-0.134(X_4)-0.761(X_5)-2.230(X_6)$	0.840
Pruning to harvest	$Y= 24.643+0.806(X_1)-0.442(X_2)-0.045(X_3)-0.260(X_4)-0.045(X_5)-5.108(X_6)$	0.660
Entire crop growth period	$Y= 38.101+0.386(X_1)-0.747(X_2)-0.347(X_3)+0.012(X_4)-0.175(X_5)-0.139(X_6)$	0.435

Y= Number of thrips/plant, X_1= Maximum temperature (°C), X_3= Morning relative humidity (%),
X_5= Rain fall (mm), X_2= Minimum temperature (°C), X_4= Evening relative humidity (%)
X_6= Wind speed (m/s)

The multiple regression equation developed for thrips population with all weather parameters during the entire crop period (12 months), indicated that, every unit increase in maximum temperature and evening relative humidity would result in increased number of thrips by 0.386 and 0.012 units, respectively whereas, every unit increase in minimum temperature, morning relative humidity, rainfall and wind speed would decrease the number of thrips by 0.747, 0.347, 0.175 and 0.139 units, respectively. The weather parameters influenced the incidence of thrips to the extent of 43.50 per cent ($R^2 = 0.435$). Multiple regression analysis between thrips population with all weather parameters during *Ambe bahar* period from pruning to harvest was used to develop regression equation model. However, reliability of regression model to predict thrips population was 66 per cent ($R^2= 0.660$). The low reliability of thrips population prediction could be because of variation in bahar treatment period apart from weather parameters. So, there is a scope to improve prediction model by considering thrips incidence across the bahar treatments.

Biology of thrips *Scirtothrips dorsalis* on pomegranate

The results pertaining to the developmental biology of *S. dorsalis* was studied on pomegranate leaves under prevailing laboratory conditions of 26.50 °C mean temperature and 74.25 per cent relative humidity during March and April 2016 and the results are presented below (Table 4).

Egg

Adult thrips inserts minute, dirty white, bean-shaped eggs preferably on the lower surface or sometimes on the upper surface of the young leaves near the midrib. Eggs are whitish with only tip appearing outside the leaf surface remaining part thrust into the leaf tissue. The eggs appear bean shaped, when observed under Stereo-zoom binocular microscope with transmission light. Egg period ranged from 1.75 to 2.75 days with an average of 2.24±0.26 days (Table 4). The egg developmental period was relatively shorter as compared to reports of Duraimurugan and Jagadish (2011) [8] who reported egg duration of about 3 to 5 days on rose.

Larva

The larval hatching took place during either morning hours (6.30 am) or evening hours (7.00 pm). There were two larval instars, the newly hatched first and second instar larvae were whitish and turned yellowish as they grew and without wing buds. Larval moult on leaf was confirmed with shed/moulted skin under microscope with transmission light and the total larval period ranged from 5.75 to 8.50 days with an average of 7.02±0.62 days (Table 4). The larval developmental periods during the present study were relatively longer compared to reports of Duraimurugan and Jagadish (2011) [8] reported first instar and second instar larval period of one to 2.25 and 2.25 to 3.75 days, respectively and Kandakoor *et al.* (2012) [11] reported one to 2.5 and 2.25 to 4 days, respectively. The present observations on larval duration are in close conformity with Seal *et al.* (2010) [18] who reported 8 to 10 days and Seal and Klassen (2015) [17] who reported 6 to 7 days for completion of both first and second larval instars.

Table 4: Biology of *Scirtothrips dorsalis* on pomegranate under laboratory conditions (n_1=50 & n_2=26)

Sl. No.	Particulars		Developmental duration (Days)		
			Min.	Max.	Mean ± S.D
1	Egg		1.75	2.75	2.24±0.26
2	Larval	I instar	2.00	3.25	2.52±0.39
		II instar	3.75	5.25	4.5±0.41
3	Total larval		5.75	8.50	7.02±0.62
4	Pre pupal		0.75	1.00	0.86±0.13
5	Pupal		1.75	2.25	1.92±0.22
6	Adult		4.50	5.75	5.29±0.37
7	Total life cycle		14.50	20.25	17.33±0.96
8	Temperature (ºC)		25.00	30.00	27.27±1.15
9	Relative humidity (%)		70.00	80.00	77.38±1.36

n_1= Initial sample size, S.D= Standard deviation
n_2= Final survived sample size

First instar larva
The newly hatched larva was whitish in colour. On an average, the first instar larva took 2.00 to 3.25 days with an average of 2.52±0.39 days (Table 4).

Second instar larva
The newly hatched second instar larva appeared similar to first instar except increase in size and colour changed to light yellowish. Average duration of second instar ranged from 3.75 to 5.25 days with an average of 4.50±0.41 days (Table 4).

Pre pupa
Fully grown second instar larva stopped feeding and moulted to prepupa or nymph. The pre pupa was yellowish in colour with wing buds. Average duration of pre pupa ranged from 0.75 to 1.00 days with an average of 0.86±0.13 days (Table 4).

Pupa
Pupa was sluggish with fully developed wing buds and yellowish in colour. Pupa can be easily recognized by their antennae folded back over head. Pupation usually occurs at folded leaf tip or at leaf angles. Pupal period ranged from 1.75 to 2.25 days with an average of 1.92±0.22 days (Table 4). Kandakoor *et al.* (2012) [11] reported pre pupal and pupal duration of 0.75 to 2 and 3.5 to 5 days, respectively and Duraimurugan and Jagadish (2011) [8] reported pre pupal and pupal period of 0.75 to 1.50 and 3.25 to 4.75 days, respectively. Contrary to the present findings, the pupal periods have been reported to be slightly longer. But, Seal *et al.* (2010) [18] reported pupal stage of *S.dorsalis* lasting for 2.6 to 3.3 days and is in close agreement with the present finding. Seal and Klassen (2015) [17] also reported pre pupal period (~24 h) and the pupal period lasting for 2 to 3 days also supports the present data.

Adult
The adult thrips were minute, slender and soft bodied, straw yellowish with fringed black wings. The longevity of adult thrips ranged from 4.50 to 5.75 days with an average of 5.29±0.37 days (Table 4).

Total life period
The total life period of pomegranate thrips *S. dorsalis* ranged from 14.50 to 20.25 days with an average of 17.33±0.96 days (Table 4). The results are in agreement with Kandakoor *et al.* (2012) [11] and Duraimurugan and Jagadish (2011) [8] who reported developmental period from egg hatching to adult emergence of *S.dorsalis* was about 10.25 to 17.25 days which excludes adult longevity from emergence to death. Seal and Klassen (2015) [17] reported total life cycle of 14 to 20 days for *S. dorsalis*, which supports the present findings. Developmental period largely depends on season/weather conditions as a thumb rule for thrips in prolonging developmental period in cooler months compared to warmer months. In present study, the biology was studied during summer months which might have contributed for shorter developmental period. It is evident from the results that, second stage larva took longer period (prolonged feeding stage) which probably dependent on the host/weather conditions and this could contribute for overall thrips population build up on a crop.

Conclusion
The study concludes that seasonal incidence of thrips from August 2015 to June 2016 on pomegranate under *Ambe bahar* treatment revealed two peaks with major peak from January to April coinciding with flowering and fruit development and other peak from August to middle of October during resting period. Thrips infestation was maximum during first week of March followed by second week of April. This could be largely attributed to availability of new foliage, flower and young fruits with favourable weather parameters like high temperature, high morning relative humidity and no rains. Thrips population was noticed on all plant parts with relative high density on flower bud tender shoot, tender fruit and flowers. The study conducted on biology of *Scirtothrips. dosalis* on pomegranate leaves var. Bhagwa at Department of Entomology, COH, Bagalkot revealed total life cycle period from egg to adult death was 14.50 to 20.25 days. Adults and nymphs found feeding on the lower surface of leaves. Females have a saw-like ovipositor with which they inset eggs partially into tissue and young larva cause damage to tender leaves, flower buds and young fruits results in scarring of fruit rind which in turn decreased marketability of fruits.

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