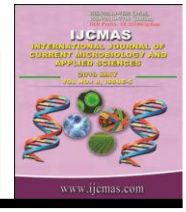
Int.J.Curr.Microbiol.App.Sci (2019) *8*(5): 386-393

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 8 Number 05 (2019)**
Journal homepage: http://www.ijcmas.com



Original Research Article https://doi.org/10.20546/ijcmas.2019.805.046

Population Dynamics and Seasonal Incidence of Major Sucking Pests of Acid Lime, *Citrus aurantifolia* Swingle

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Keywords

Acid lime, Seasonal incidence, *Aleurocanthus woglumi*, *Diaphorina citri*

Article Info

Accepted:
04 April 2019
Available Online:
10 May 2019

A B S T R A C T

Seasonal incidence of blackfly, *Aleurocanthus woglumi* Ashby and citrus psyllids *Diaphorina citri* Kuwayama were studied on acid lime during September 2017 to August 2018. The influence of weather factors on population fluctuation of sucking pests in acid lime ecosystem was recorded at weekly intervals in fixed location. The study revealed that the occurrence of sucking pests was noticed throughout the study period 36th (1st week of September) to 35th (4th week of August) standard weeks. The population of *D. citri* attained its first peak during 19th standard week (1st week of May) with 23.20 nymphs/10cm length of twig. The correlation studies (r) between weather parameters and *D. citri* population revealed that the maximum and minimum temperatures showed significant positive relationship (r = 0.63 and 0.63 respectively), while relative humidity had significant negative relationship (r = - 0.15) with *D. citri*, whereas rainfall exhibited non significant relationship (r = 0.22) with *D. citri*. From the multiple linear regression analysis it is clear that all weather factors, had significant positively relationship. The population of *A. woglumi* attained its first peak during 23rd standard week (1st week of June) with 68.40 nymphs/leaf. During the present period observation, three peaks of *A. woglumi* were recorded, first peak coincided with 23rd standard week (1st week of June). The correlation studies (r) between weather parameters and *A. woglumi* population revealed that the maximum and minimum temperatures showed significant positive impact (r = 0.70 and 0.89 respectively), while the relative humidity had significant negative impact (r = - 0.22) with *A. woglumi*, whereas rainfall exhibited non significant relationship (r = 0.17) with *A. woglumi* in acid lime ecosystem. From the multiple linear regression analysis it is clear that among the weather factors, maximum and minimum temperatures had significant positive relationship, while relative humidity exhibited significant negative association with *A. woglumi* in acid lime ecosystem.

Introduction

Acid lime is mainly cultivated in Tamil Nadu, Andhra Pradesh, Maharashtra, Karnataka, Gujarat and Himachal Pradesh. It is widely grown in the southern region of Tamil Nadu also. Citrus is commercially grown throughout India and occupies a place of prime importance among the major fruits of India, which ranks third after mango and banana. India is one of the principal citrus growing countries in the world with an area of 10.55 lakh hectares with the production of 127.46 lakh tonnes of fruit annually with the productivity of 9.90 tonnes per hectare. In india, acid lime accounts for about 259,000 hectares with the production of 2,789,000 tonnes. In Tamil Nadu, acid lime occupies an area of 9,880 hectares with the production of 34,510 tonnes annually with the productivity of 3.49 tonnes per hectare (Anonymous, 2017). However, there is enormous production gap between potential and average yield. This yield gap is due to a number of cultural and environmental factors and also due to a wide range of insect pests. Citrus is one of the important fruit crops and is grown in more than 52 countries around the world.

In India, Citrus trees are reported to be damaged by more than 250 insect species during different stages of growth, from seedling in nursery till the plant exists (Butani, 1979). Loss due to pest infestation is range from 83-95 per cent (Randhava, 1974). The Citrus butterfly (*Papilio spp.*), citrus leaf miner (*Phyllocnistis citrella* Stainton), ash weevil (*Myllocerus sp.*), citrus leaf roller (*Psorosticha zizyphi* Stainton), citrus trunk borer, *Agrilus sp.*, citrus blackfly (*Aleurocanthus woglumi* Ashby), citrus psylla (*Diaphorina citri* Kuwayama), citrus aphid (*Toxoptera citricida* Kirkaldy), citrus thrips (*Scirtothrips citri* Moult.), citrus whiteflies (*Dialeurodes citri* Ashmead), citrus red scale (*Aonidiella aurantii*), citrus mealybug (*Planococcus citri* Risso) and citrus red mite (*Panonychus citri* McGregor) are the major pests that cause severe damage to acid lime. Among these, Citrus blackfly, *A. woglumi* Ashby is considered as agriculturally important insect in several countries due to economic loss that it causes (Batista *et al.*, 2002). They suck the sap from the Phloem, thereby removing the nutrients and possibly debilitating the plants by injecting toxic saliva (Silva *et al*, 2011). Heavy infestations may cause fast deterioration of plants and yield reduction (Fasulo and Brooks, 1993). Fruit set is greatly reduced, losses caused by *A. woglumi* is up to 80 per cent and more (Eberling, 1954; Yamamoto *et al.,* 2008).

Citrus psyllids (*Diaphorina citri* Kuwayama) also act as carriers of the bacteria *Candidatus liberibacter asiaticus* that cause fatal citrus disease, known as citrus greening (CGD) or Huanglongbing (Halbert and Manjunath, 2004; Mahmood *et al.,* 2014). *D. citri* is a small sucking insect pest (2.7-3.3 mm long) with mottled brown body. Adults are very active and agile and move quickly for little disturbance.

These insect pests remain active from February to October with peak populations in spring and autumn seasons. However, spring population of *D. citri* is the most critical and damaging as this is the flowering and blooming period of citrus crop. Both adults and nymphs suck the sap from young foliage and leaves and tender shoots which in turn become yellowish with stunted growth and wither up. In case of severe attack, defoliation and premature fruit dropping occurs and these sucking insect pests can damage upto 50% to citrus crop if not controlled (Hall *et al.,* 2013). The basic aim of this study was to assess the different prevailing abiotic factors which can act as the major determinants of pests populations on different citrus cultivars.

Materials and Methods

To study the Impact of abiotic factors on the population of sucking pests in acid lime ecosystem with the incidence of sucking pests *viz*., citrus psyllids, citrus black fly were selected in hot spot area at Agricultural College and Research Institute, Madurai, during September 2017 to August 2018. Acid lime foliage of uniform age were selected randomly selected plants (10 Nos) per field were tagged properly/ block and the population of sucking pests were recorded at regular intervals (once in week). The weather parameters *viz.,* Maximum and Minimum Temperatures (^{o}C), Relative humidity (%), Rain fall (mm) were also collected from automatic weather station installed at Agricultural college and research institute, Department of Central Farm, Madurai TNAU, for working out the correlation between weather parameters and population dynamics of sucking pests of acid lime in a given standard meteorological week. Correlation and regression analysis was also worked out with the weather parameters to understand the degree and extend of influence of these abiotic factors on the dynamics of pests populations on acid lime by SAS 9.2 and SPSS 17.0 statistical software package.

Results and Discussion

To understand the seasonal incidence of sucking pests in acid lime ecosystem, citrus field with uniform aged bushes were selected at Agricultural college and research institute, Madurai, during September 2017 to August 2018. The influence of weather factors on population fluctuation of sucking pests in acid lime ecosystem was recorded at weekly intervals in fixed location.

The study corroborated that the occurrence of sucking pests on acid lime (Table 1) found to occur throughout the study period 36th (1st week of September) to 35th (4th week of August) standard week.

Initially the population of *D. citri* was fairly high followed by a gradual decrease from 14.1 to 0.7 nymphs/10cm twig length (Table 1). Then the population of *D. citri* gradually shoot up and progressed to reached its first peak during 19th standard week (1stweek of May) with 23.20 nymphs/10cm twig length. Thereafter the population started increasing gradually coinciding with 4th standard week (4th week of January) followed by a declining trend from 20th standard week (2nd week of May) to 25th standard week (3rd week of June). Further, the *D. citri* population showed the increasing rate of multiplication gradually which reached its second peak during 35th standard week (4th week of August) recording 18.70 nymphs/10cm twig length. Subsequently there was a fluctuation in *D. citri* population from 4th standard week (4th week of January) to 34th standard week (4th week of August) and the minimum population could be observed during 4th standard week (4th week of January) with 0.6 nymph/ twig. The results also revealed that there was a lot of oscillation in *D. citri* population from 4th January to 35th August standard week because of erratic distribution of weather factors by which increasing and decreasing trend of *D. citri* population was observed (Figure 1). The present findings are in conformity with Teck *et al.,* (2011) who found that *D. citri* population fluctuated throughout the year on honey mandarin but nymphs were generally higher during the rainy season *i.e.,* from October to January than during the dry season which differ from the present finding due to the fact that only adults could be noticed for whole year but nymphal population was not found during December-January. The change in temperature coupled with increase of relative humidity reduced the nymphal population from October to December (39.25 to 0.34 nymphs/10 cm twig). Zeb *et al.,*

(2011) noted that the highest (34 adults/leaf) population of *D. citri* on acid lime during May at Khanpur followed by Palai (5.5 adults/leaf) during June. Lowest population (0.7 adults per leaf was recorded in August year at Charbagh from Pakistan.

The correlation studies (r) between weather parameters and *D. citri* population revealed that (Table 2) the maximum and minimum temperatures exhibited significant positive relationship (r = 0.63 and 0.63 respectively), while relative humidity alone had significantly negative relationship (r = - 0.15) with *D. citri*, where as rainfall exhibited non significant relationship (r = 0.22) with *D. citri* in acid lime ecosystem. From the correlation analysis (Table 2), it is evident that an increase in maximum and a reduction in minimum temperatures by 1^{o}C, resulted in an increase of *D. citri* population by 1.91 and 0.96 per cent, nevertheless an increase in relative humidity by 1 per cent, there was a increase in *D. citri* population by 0.26, while an increase in rainfall by 1 mm, there was an increase in *D. citri* population by 0.30 per cent. Multiple linear regression analysis (Table 2) was also carried out by taking into account *D. citri* population as dependent and weather parameters as independent variables. The results revealed that the coefficient of determination was significantly high (R^2 = 0.505), which implies that these weather factors *i.e.,* maximum temperature, minimum temperature, relative humidity and rainfall contributed directly towards the population buildup of *D. citri* in acid lime ecosystem to the extent of 50.50 per cent. From the multiple linear regression analysis it is clear that the all abiotic factors had significant positive relationship, with *D. citri* in acid lime ecosystem. These findings are coinciding with Patel (2007) who revealed a positive correlation between nymphal population of psyllid and minimum temperature, mean temperature and rain fall. Shivankar and Rao (2005) reported that the pest was more active in spring and after monsoon flushes. The low incidence was observed during July (9.4 nymphs/ twig) and a high incidence was recorded during October (17.4 numphs/ twig). Patel and Patel (2006) observed the population of *D. citri* on kagzi lime was higher during March, June and October in North Gujarat. They also noted that minimum and maximum temperature had significantly positive influence on *D. citri* population on kagzi lime.

Initially the population of *Aleurocanthus woglumi* was high followed by gradual decrease from 35.70 to 4.90 nymphs/leaf. Then the population of *A. woglumi* gradually increased as they progressed and reached its first peak during 23rd standard week (1stweek of June) with 68.40 nymphs/leaf (Table 1). The population started increasing gradually during 9th standard week (4th week of February). The sharp decline in *A. woglumi* population could be noticed from 24th standard week (2nd week of June) and Subsequently there was fluctuation in *A. woglumi* population from 9th standard week (4th week of February) to 35th standard week (4th week of August) and the minimum population could be observed during 2nd standard week (2nd week of January) with 4.90 nymphs/leaf (Figure 1). During the present period of study, three peaks were noticed the first peak during 23rd standard week (1stweek of June). Similarly, Wilson *et al.,* (2014) reported that *A. woglumi* was active throughout the year. The population of blackfly was the highest in March to April and number of overlapping generation was found continuously throughout the year. Medeiros *et al.,* (2009) studied the populational dynamics of *A. woglumi* throughout the year. Correla (2011) observed that the seasonal incidence of *A. woglumi* was throughout the year and the peak activity was found during March to October.

Table.1 Population dynamics of citrus psyllid, *Diaphorina citri* Kuwayama and citrus blackfly, *Aleurocanthus woglumi* Ashby in acid lime ecosystem (During September 2017- August 2018)

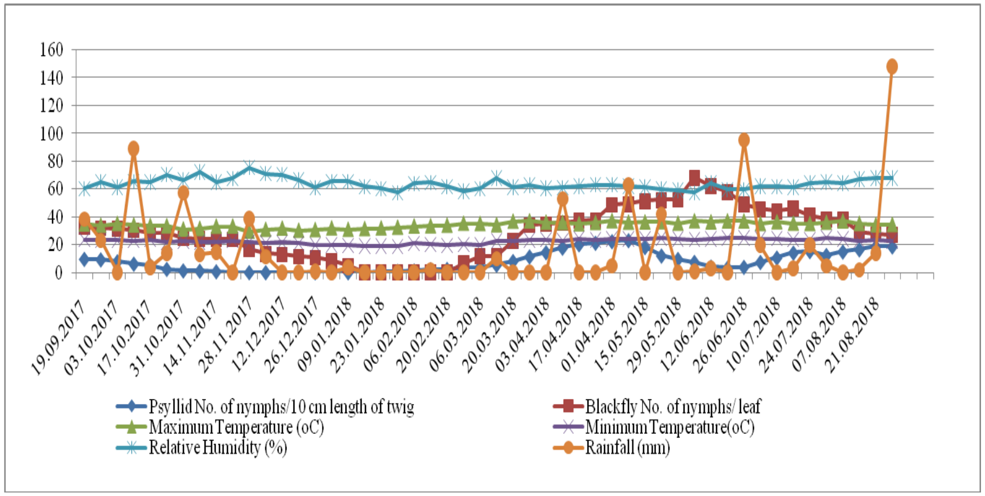
Standard meteorological weeks	Date of Observation	Psyllid No. of nymphs/10 cm length of twig	Blackfly No. of nymphs/ leaf	Standard meteorological weeks	Date of Observation	Psyllid No. of nymphs/10 cm length of twig	Blackfly No. of nymphs/ leaf
05 September 2017	36	14.1	35.7	06 March 2018	10	3.9	11.7
12 September 2017	37	11.4	34.4	13 March 2018	11	5.5	11.9
19 September 2017	38	9.7	32.8	20 March 2018	12	8.1	22.8
26 September 2017	39	9.3	31.9	27 March 2018	13	11.4	34.2
03 October 2017	40	7.9	31.5	03 April 2018	14	14.5	34.8
10 October 2017	41	6.2	30.6	10 April 2018	15	17.8	35.7
17 October 2017	42	5.2	28.4	17 April 2018	16	20.3	37.4
24 October 2017	43	2.4	28.1	24 April 2018	17	21.3	37.6
31 October 2017	44	1.3	24.7	01 April 2018	18	22.5	48.7
07 November 2017	45	1.1	24.2	08 May 2018	19	23.2	49.2
14 November 2017	46	0.7	24.0	15 May 2018	20	18.3	51.4
21 November 2017	47	0.0	23.8	22 May 2018	21	12.1	52.3
28 November 2017	48	0.0	16.5	29 May 2018	22	9.6	52.6
05 December 2017	49	0.0	13.5	05 June 2018	23	7.5	68.4
12 December 2017	50	0.0	13.1	12 June 2018	24	4.1	62.2
19 December 2017	51	0.0	11.4	19 June 2018	25	3.3	57.9
26 December 2017	52	0.0	10.7	26 June 2018	26	3.9	49.1
02 January 2018	1	0.0	8.4	03 July 2018	27	7.4	45.6
09 January 2018	2	0.0	4.9	10 July 2018	28	10.6	44.2
16January2018	3	0.0	0.0	17 July 2018	29	14.2	46.2
23 January2018	4	0.6	0.0	24 July 2018	30	15.3	41.1
30 January2018	5	1.0	0.0	31 July 2018	31	12.4	38.3
06 February 2018	6	1.2	0.0	07 August 2018	32	15	38.1
13 February2018	7	2.2	0.0	14 August 2018	33	16.6	29.4
20 February2018	8	2.4	0.0	21 August 2018	34	18.7	27.5
27 February2018	9	3.5	6.9	28 August 2018	35	18.7	27.2

Table.2 Corelation and multiple linear regression models for weather parameters on Population dynamics of *D. citri* and *A. woglumi* in acid lime ecosystem (During September 2017- August 2018)

Populations	Correlation Coefficient value				Multiple linear regression equation value	Coefficient of determination
	Maxi. Temperature (^{0}C)	Mini. Temperature (^{0}C)	Relative Humidity (%)	Rainfall (mm)		
	(X1)	(X2)	(X3)	(X4)	(Y)	(R^2)
Diaphorina citri **Kuwayama**	0.630**	0.630**	-0.154	0.221	$Y= -97.60+1.91X_1+0.96X_2+0.26X_3+0.30X_4$	0.505
Aleurocanthus woglumi **Ashby**	0.700**	0.890**	-0.222	0.176	$Y= -124.42+0.25X_1+8.52X_2-0.76X_3+0.00X_4$	0.829

**Significant at 1% Probability
*Significant at 5% Probability

Fig.1 Population dynamics of citrus psyllid, *Diaphorina citri* Kuwayama and citrus blackfly, *Aleurocanthus woglumi* Ashby in acid lime ecosystem relation with weather parameters (During September 2017- August 2018)



The correlation studies (r) between weather parameters and *A. woglumi* population revealed that (Table 2) the maximum and minimum temperatures exhibited a significant positive influence (r = 0.70 and 0.89 respectively), while relative humidity had a significant negative relationship (r = - 0.22) with *A. woglumi*, build up while rainfall exhibited non significant relationship (r = 0.17) with *A. woglumi* in acid lime ecosystem. From the correlation analysis (Table 2), it is evident that an increase in maximum and minimum temperatures by 1^{o}C resulted in an increase of *A. woglumi* population by 0.25 and 8.52 per cent respectively, where as an increase in relative humidity by 1 per cent, there was a decline in *A. woglumi* population by 0.76, respectively. Multiple linear regression analysis (Table 2) carried out by taking into account *A. woglumi* population as dependent variable and weather parameters as independent variable, revealed that the coefficient of determination was significantly high (R^2 = 0.829), which implies that these weather factors *i.e.*, maximum temperature, minimum temperature, relative humidity and rainfall contributes directly towards the population build up of *A. woglumi* in acid lime ecosystem to an extent of 82.90 per cent. From the multiple linear regression analysis it is evident that among the weather factors, maximum and minimum temperatures had significant positive correlation, while relative humidity exhibited a significant negative association with *A. woglumi* in acid lime ecosystem. These finding fall in line with the report of Aruna *et al.*, (2017), who also observed that the nymphal population had a highly significant positive correlation with the maximum temperature (r=0.43) and non significant positive correlation with the minimum temperature (r=0.43) and rainfall (r=0.43), whereas a highly significant negative correlation could be observed with relative humidity (r=0.43).

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How to cite this article:

Poovizhiraja, B., C. Chinniah, M. Murugan, S. Irulandi, K. Eraivan Arutkani Aiyanathan and Balamohan, T.N. 2019. Population Dynamics and Seasonal Incidence of Major Sucking Pests of Acid Lime, *Citrus aurantifolia* Swingle. *Int.J.Curr.Microbiol.App.Sci*. 8(05): 386-393.
doi: https://doi.org/10.20546/ijcmas.2019.805.046