INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
1560–8530/2004/06–6–970–973
http://www.ijab.org

Studies on Population Dynamics and Chemical Control of Citrus Psylla, *Diaphorina Citri*

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ABSTRACT

The experiments were conducted on three citrus species (Feuterell's early, Kinnow, Musambi) about the population dynamics and chemical control of citrus psylla at Chak No. 107, Sargodha. Data on the population of citrus psylla showed two peak times in a year, firstly in the month of August and 2nd time in the month of April. Correlation values showed that environmental factors had almost no effect on the population build up of citrus psylla. Three insecticides, methamidophos, dimethoate and imidacloprid applied, had almost equal effect on the population reduction of citrus psylla on all the three species of the citrus.

Key Words: Population; Citrus; Insect pests; Insecticides; Imidacloprid

INTRODUCTION

Among the insects pests, which infest and cause heavy losses to the citrus, citrus psylla *Diaphorina citri* is the most destructive and consequently the most important of all the insect pests of citrus. Citrus psylla is also a vector of a virus (*Citrus tristeza* colesterovirus), which is responsible for the greening disease of citrus (Su *et al*., 1991). The population of citrus psylla fluctuates in relation to the temperature and relative humidity. Citrus psylla peaks twice a year, which coincides with the periods of citrus flushing in the spring and summer (Wang *et al*., 1996; Sahu & Mandal, 1997).

Chemical control measures like insecticides (Dimethoate, monocrotophos, phosphamidon, confidor, decamethrin and fenvalevate), botanicals (neem oil, spray oils (petroleum) and insect growth regulators were tried against citrus psylla with encouraging results based on which recommendations have been made. Two to three sprays of at 10-15 days interval were found to be effective against citrus psylla (Dahiya *et al*., 1994; Nakano *et al*., 1999; Shivankar *et al*., 2000)

In Pakistan, the studies on population dynamics and chemical control of the *D. citri* have been carried out but these studies were not published in scientific literature. The information was confined to the annual reports of research institutes. The present studies were started with the following objectives:

i. To determine the population dynamic of citrus psyllid in relation to climatic conditions (temperature and relative humidity and rainfall) on different species of citrus (Kinnow, Feutrell's early and Musambi) at Sargodha District.

ii. To get the information about the efficacy of three insecticide against citrus psylla. Insecticide (Methamidophos, dimethoate and imidachloprid) were applied @ 500 ml, 300 ml and 250 g/acre, respectively.

MATERIALS AND METHODS

Site. The experiment was conducted at Chak No. 107 Northern Branch in Tehsil Sillanwalli, District Sargodha, situated at the distance of 15 kilometers on Sillanwalli Road, Sargodha.

Population dynamics. The experiment was conducted on three citrus varieties (Kinnow, Musambi and Feuterell's early). One-acre garden of each of the three citrus varieties was selected for conducting the experiment. There were 100 plants in area of one acre at 6.6 m distance from row to row and same distance between plants. The observation on population dynamics was taken from June 2002 to June 2003. For recording the number of citrus psylla (nymphs and adults), an area of 13 x 26 m^2 was selected at the four corners and one in the middle on each of three citrus varieties. In this way the each of five selected areas consisted eight plants. An arrow was thrown in the selected area and the nearest plant to the arrow was selected for counting the number of citrus psylla. From the each selected plant four branches were selected randomly form the four sides of the plant. Then the population of citrus psylla both nymph and adult was counted from the terminal 10 cm of the each selected branch. For population dynamics the data was recorded after every 15 days from June 2002 to June 2003. The meteorological data was taken form Distt. Meteorological Department, Sargodha.

Insecticides trial. For insecticides application two-acre garden of the each of three varieties was selected. In each garden 12 plots were made. The size of each plot was 13 x 26 m^2 feet in three columns and four rows and each plot contain eight plants. There were four treatments including a

control and three replication of each treatment following the randomized complete block design (RCBD). Three insecticides dimethoate, imidachloprid and methamidophos were applied with the help spray gun on a knapsack sprayer.

Statistical analysis. For the analysis of population dynamics the data was subjected to regression and correlation with meteorological data. The efficacy of insecticides was analyzed by One Way ANOVA and means were compared by LSD.

RESULTS

Population dynamics of citrus psylla on three citrus species. Data of mean number of citrus psylla on Feuterell's early per shoot are given in the Table I. The maximum number of citrus psylla on Feuterell's early was recorded on 1-8-2002 (9.25), 15-9-2002 (10.10), 1-04-2003 (11.15) and 15-04-2003 (12.15). The minimum and maximum number of citrus psylla per shoot in the data were zero and 24, respectively, (data not shown). Analysis of the variance of the mean number of citrus psylla at fortnight interval showed highly significant variation among the number of citrus psylla at various fortnights.

Data of the mean number of citrus psylla per shoot on Kinnow are given in the Table I. The maximum no, of citrus psylla on Kinnow was recorded at 1-8-2002 (9.45), 15-9-2002 (10.40), 1-4-2002 (8.50) and 15-4-2003 (10.50). No citrus psylla was seen from 1-12-2003 to 15-2-2003. The minimum and maximum no. of citrus psylla in the data were zero and 25, respectively, (data not shown. Analysis of variance of mean number of citrus psylla at fortnight interval showed highly significant variation among the number of citrus psylla at various fortnights.

Data of mean number of citrus psylla per shoot on Musambi are given in Table I. The maximum number of citrus psylla on Musambi was recorded on 15-7-2002 (11.45), 15-9-2002 (11.80) and 15-04-2003 (12.75). No citrus psylla was seen from 1-12-2002 to 15-2-2003. The minimum and maximum number of citrus psylla per shoot in the data were zero 0 and 27, respectively, (data not shown. Analysis of variance of mean number of citrus psylla at fortnight interval showed highly significant variation among the number of citrus psylla at various fortnights.

Population of citrus psylla vs. climatic factors on three citrus species. The effect of minimum and maximum temperature, relative humidity and rainfall on population dynamics of citrus psylla on Feuterell's early is given in Table II. The correlation values obtained by the Pearson's analysis (Mini Tab11) showed that the relative humidity, rainfall and date-rainfall were negatively correlated with the population. The effect of rainfall and date-rainfall was least significant as correlation values were less than 0.1. The minimum and maximum temperature was positively correlated with the population. The simple regression equation of effects of minimum and maximum temperature, relative humidity, rainfall and date-rainfall showed a positive regression coefficient value. In the equation for the effect of minimum and maximum temperature on the population, R^2 values were very low. The maximum R^2 (19.42) value was observed in multivariate equation of the effect of above-mentioned environmental factors on the population

Table I. Population density of citrus psylla on different citru spp

Dates	Feuterell's Early	Kinnow	Musambi
01-06-2002	0.60±0.04	0.35±0.15	1.10±0.27
15-06-2002	0.00±0.00	0.10±0.06	0.20±0.10
01-07-2002	0.15±0.11	0.05±0.05	0.50±0.17
15-07-2002	2.65±0.59	2.40±0.41	2.95±0.71
01-08-2002	9.25±2.21	9.45±1.66	11.45±2.2
15-08-2002	0.30±0.13	0.10±0.07	0.90±0.23
01-09-2002	4.85±1.14	3.75±0.82	6.60±1.52
15-09-2002	10.1±2.14	10.40±2.2	11.80±2.3
01-10-2002	2.15±0.64	2.10±0.64	2.95±0.62
01-11-2002	3.4±0.96	1.40±0.37	1.90±0.55
01-12-2002	1.25±0.35	0.00±0.00	0.00±0.00
15-12-2002	0.45±0.19	0.00±0.00	0.00±0.00
01-01-2003	0.00±0.00	0.00±0.00	0.00±0.00
15-01-2003	0.00±0.00	0.00±0.00	0.00±0.00
01-02-2003	0.00±0.00	0.00±0.00	0.00±0.00
15-02-2003	0.00±0.00	0.00±.00	0.00±0.00
01-03-2003	0.50±0.17	0.00±0.52	0.8±0.24
15-03-2003	2.35±0.36	0.00±1.48	2.70±0.44
01-04-2003	11.15±0.18	2.00±3.10	11.30±0.89
15-04-2003	12.15±0.81	8.50±3.14	12.75±0.83
01-05-2003	3.95±0.87	10.50±2.2	4.35±0.66
15-05-2003	1.85±0.36	2.00±1.17	2.75±0.47
P-value	0.00**	0.00**	0.00**

The effect of minimum and maximum temperature, relative humidity and rainfall on the population dynamics of citrus psylla on kinnow is given in Table II. The correlation values obtained by the Pearson's analysis (MiniTab11) showed that the relative humidity, rainfall and date-rainfall were negatively correlated with the population. The effect of rainfall and date-rainfall was non-significant as correlation values were less than 0.1. The minimum and maximum temperature was positively correlated with the population. The simple regression equations of the effect of minimum and maximum temperature, relative humidity, rainfall and date-rainfall showed a positive regression coefficient value. In the equation of minimum and maximum temperature on population, R^2 values were very low. The maximum R^2 (16.73) value was observed in multivariate equation of the effect of above-mentioned environmental factors on the population

Regression analysis of the relationship between mean and variance of the population of citrus psylla

Factors	Simple Regression Equation	R^2 Value
Feuterell's early	Y = 0.673 + 1.29	85.1%
Kinnow	Y = 0.58 + 1.23	92.4%
Musambi	Y = 0.46 + 1.37	87.6%

Table II. Correlation values and regression equations between population and environmental factors on Feuterell's Early

	Feuterell's Early	kinnow	Musambi
		Pearson Correlation Values	
		Population	
Population	1	1.00	1.00
Minim Temp.	0.34	0.35	0.394
Max. Temp.	0.40	0.39	0.45
R.H.	-0.38	-0.32	-0.36
Rainfall	-0.076	-0.026	-0.05
Date Rainfall	-0.04	-0.01	-0.01
		Regression Equations	
Factors	**Feuterell's Early**	**kinnow**	**Musambi**
Mini. Temp.	Y = -0.30 + 0.16 x (7.9)	Y = -0.41 + 0.152 x (8)	Y = -55 + 0.21 x (7.9)
Maxi. Temp.	Y = 3.64 + 0.02 x (11.9)	Y = -3.41 + 0.182 x (11.5)	Y = -4.43 + 0.24 x (11.9)
R.H.	Y = 8.02 – 0.09 x (10.7)	Y = 6.39 – 0.07 x (5.8)	Y = 8.66 – 0.095 x (10.7)
Rainfall	Y = 2.99 – 0.18 x (0.00)	Y = 2.49 – 0.056 x (0.00)	Y = 3.44 – 0.120x (0.00)
Date Rainfall	Y = 2.90 – 0.01 x (0.00)	Y = 2.44 – 0.002 x (0.00)	Y = 3.33 – 0.002 x (0.00)
Multivariate equation	Y = 2.12 + 0.01 (min temp.) + 0.11 (maxi. temp) – 0.06 (R.H) + 0.032 (Rainfall) (19.42)	Y = 2.12 + 0.01 (min temp.) + 0.11 (maxi. temp) – 0.06 (R.H) + 0.032 (Rainfall) (16.73)	Y = 0.42 + 0.03 (min. temp.) + 0.15 (maxi. temp) – 0.04 (R.H) + 0.001 (Rainfall) (19.42)

Note: Date rainfall means that it is value between rainfall data on specific dates rather than seasonal average rainfall.

The effect of minimum and maximum temperature, relative humidity and rainfall on the population dynamics of citrus psylla on musambi is given in Table II. The correlation values obtained by the Pearson's analysis (MiniTab-11) showed that the relative humidity, rainfall and date-rainfall were negatively correlated with the population. The effect of rainfall and date-rainfall was non-significant as the correlation values were less than 0.1. The minimum and maximum temperature was positively correlated with the population. The simple regression equations of the effect of minimum and maximum temperature, relative humidity and rainfall and date-rainfall showed a positive regression coefficient values. In the equations of minimum and maximum temperature on the population, R^2 values were very low. The maximum R^2 (20.48) value was observed in the multivariate equation of the effect of above-mentioned environmental factors on the population.

Table II also shows the regression equations of the relationship between mean no of citrus psylla/shoot and the variance. This equation was derived to ascertain the dispersion pattern of citrus psylla. The fit of equation was good as R^2 values were more than 80%. The regression coefficient (b) can be regarded as equal to 1 because the maximum values were 1.37. If it is regarded as more than 1 than the dispersion pattern will be different.

Chemical control of citrus psylla. The comparison of reduction in the population following the application of methamidophos, dimthoate and imidacloprid at 24, 48, 72, 96, 120 hour and one week, is shown in Table III. All the three insecticides had non-significant difference among themselves in suppressing the population of citrus psylla at all intervals on Feuterell's early and Musambi. However, After 24 hours of application imidacloprid had a significant difference from methamidophos and dimethoate, the latter two had non-significant difference between each other while all three insecticides had non significant difference after 48, 72, 96, 120 hours and one week after the treatment, respectively.

DISCUSSION

Citrus psylla is the most destructive and consequently the most important part of all the citrus orchards in Pakistan (Abbas, 2001). Both the nymphs and adults of the citrus psylla suck the cell sap with the help of their sharp piercing mouth parts and cause curling and defoliation of leaves, and flowers and die back of branches from tip to downward, as a result of all these happenings premature dropping of fruits occur (Shah & Saleem, 2000). Citrus psylla is the vector of viruses, citrus *Tristeza colesterovirus* and citrus leaf talter viruses, which causes the greening disease of citrus (Su *et al*., 1991). In case of nymphal population of citrus psylla three peaks were observed 1st in the mid of April, 2nd in the at the end of June and 3rd at the end of September (Sahu & Mandal, 1997). There was a negative correlation between psyllid population and relative humidity. Only few nymphs were present in the month of January when mean temperature was very low (Arora *et al*., 1997).

Table III. Comparison of means of citrus psylla density reduction at different post-treatment intervals following the insecticide application on Feuterell's Early, kinnow and Musambi

	Post-Treatment Intervals					
	Feuterell's Early					
Insecticide	24 h	48 h	72 h	96 h	120 h	One week
Mehamidophos	20.50±0.25a	31.68±3.29a	56.49±2.79a	73.34±3.04a	80.77±2.09a	87.60±1.07a
Dimethoate	24.50±0.30a	39.32±3.12a	59.69±2.90a	70.88±2.20a	80.25±1.90a	89.44±1.82a
Imidacloprid	24.80±2.80a	27.6±13.0a	62.68±1.22a	74.64±2.34a	83.06±1.56a	90.32±1.38a
Pooled st. dev.	2.826	13.75	2.82	2.83	3.22	2.52
	Kinnow					
Mehamidophos	7.85±0.95a	15.71±1.57a	45.96±3.20a	72.26±2.73a	82.10±3.67a	79.52±4.77
Dimethoate	9.93±0.81b	20.59±1.05b	47.75±3.62a	73.81±2.76a	80.38±6.19a	86.21±1.62
Imidacloprid	13.03±1.30b	24.90±4.90b	52.61±0.74a	80.82±2.03a	90.23±2.72a	89.77±1.45
Pooled st. dev.	1.81	5.25	4.88	4.38	7.69	7.69
	Musambi					
Mehamidophos	10.34±1.56a	24.37±1.08a	61.58±2.11a	71.30±1.67a	79.84±3.29a	92.04±2.50a
Dimethoate	10.19±1.86a	25.28±1.45a	61.20±2.00a	71.49±0.597a	78.21±1.54a	91.47±0.82a
Imidacloprid	10.82±1.31a	23.59±2.07a	58.69±2.83a	69.59±2.10a	79.26±1.24a	89.18±1.81a
Pooled st. dev.	2.76	2.75	4.05	2.74	3.83	4.05

Means compared with One Way Anova having the same letters in the column are not significantly different at $\alpha = 0.05$

D. citri in citrus orchards peaked twice each year, which coincides with the periods of fresh vegetative, growth, flushings of citrus during spring and summer (Wang *et al*., 1996). Maximum population was recorded on orange in September and November and population decline was noted in December-January. The present studies clearly depict that environmental were in significantly correlated with the population. On that basis, our results are in contradiction with Sahu and Mandal (1997) and Arora *et al*. (1997). The build up of population appears to be dependent upon the fresh vegetative growth in spring (March) and summer (September).

Many insecticides were applied to control *D. citri*, *out* of which dimethoate, monocrotophos, phosphamidon, decamethrin and fenvalerate gave better control of this pest than did the cypermethrin, chlorpyrifos, dichlorvos, endosulfan, malathion and quinalphos. All test insecticides resulted in 90% reduction up to 7 days after spraying (Dahiya *et al*., 1994). Nine insecticides out of which 6 were made from plant or animal extracts were tested for the control of *D. citri*. Profenofos, triazophos and imidacloprid produced complete control 7 days after spraying. Azadirachtin (0.03%) and neem oil also achieved high level of control around 90% (Chakravarthi *et al*., 1998). Thus 2 to 3 sprays of monocratophos, dimethoate and thiodemeton at 10-15 days interval were found to be effective against citrus psylla (Shivankar *et al*., 2000). Dimethoate and Imidechloprid provided the almost completely control of the 7 days of application. In this case our results are comparable (Dahiya *et al*., 1994; Shivankar *et al*., 2000). In case of methamidophos no comparable data in the literature was available on the efficacy of methamidophos against citrus psylla.

From the present experiments, it was concluded that the population of *D. citri* peaked two times a year, i.e. in the month of April and August. All the insecticides, which we have applied, had statistically equal effect on the reduction of population of citrus psylla. This is so because the use of insecticides in the said District has started very recently, therefore, the present strains of citrus psylla are susceptible to the insecticides.

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(Received 01 August 2004; Accepted 28 September 2004)