Agriculture for Sustainable Development 2(1):27-31, 2014/Article ***ISSN 2347-5358 (Print)/ 2349-2228 (Online)***

Agriculture for Sustainable Development

http://www.sustainableagriculture.in

SEASONAL ABUNDANCE AND ECONOMIC OF LEMON BUTTERFLY ON KAGZI LIME (*CITRUS AURANTIFOLIA* SWINGLE)

JHABAR MAL*, M. M. PATEL, B. M. MEENA, R. NAGAR, S. C. KUMAWAT, S. K. CHAUHAN AND A. MEENA

C. P. College of Agriculture, SDAU, S. K. Nagar (Gujarat) – 385 506, India

Received: 12.02.2014 **Revised accepted: 09.03.2014**

ABSTRACT

The seasonal abundance of lemon butterfly *Papilio demoleus* on Kagzi lime (*Citrus aurantifolia* Swingle) revealed that the major activity of *Papilio demoleus* in terms of infested plant was during 27th standard week of the year 2005-2006 (3.5larvae/plant). The correlation study between larval population and weather parameters indicated that the negative and highly significant correlation was existed between larval population and sunshine hours, while the remaining weather parameters under studies were not influenced the pest population. Efficacy of some newer and conventional molecules and neem products against *Papilio demoleus* and the results of field and nursery experiment based on effectiveness showed that the insecticide, indoxacarb 0.015 % proved to be most effective followed by fenitrothion 0.05 % and carbaryl 0.1 % in checking of this pest. While based on the effectiveness and economics of the treatments, fenitrothion 0.05 % was found good for control of citrus caterpillar.

Keywords:
Bio-efficacy, Butter fly, Citrus, Economic, Kagzi lime, Papilio demoleus

INTRODUCTION

Citrus fruits are grown all over the world. Early records indicate that the citrus fruits such as, orange (*Citrus reliculata* Blanco), Limes (*Citrus aurantifolia* Swingle) and Lemons (*C. limonica* Burn) were being cultivated in South China, Malaya and Sub-Himalayan parts of Assam. From here, they were spread to the tropical and sub-tropical parts of the world. The leading citrus growing country in the world is the U.S.A. with 40 % of the world total acreage under citrus. The other important citrus growing countries are Spain, Italy, Mexico, India, Japan, South Africa and Brazil. Citrus trees are attacked by a wide variety of pests. Ebeling (1959) reported that 823 species of insects damaging citrus in various countries, 175 of them occur in India. Thus, citrus tree in India are attacked by a very large number of insects and mites causing appreciable loss in yield and life of tree. Among all the insect pests lemon butter fly (*Papilio demoleus* L.) is an important pest of citrus causing severe damage at sapling (nursery) and young stage in orchard. Looking to the apparent importance of the pest and there is too little information's are available on seasonal abundance of lemon butterfly under North Gujarat condition.

MATERIALS AND METHODS

Seasonal incidence of Papilio demoleus

To determine the seasonal abundance of lemon butterfly, the observation were recorded from one year old citrus orchard (Var. Kagzi lime) located just near to C.P. College of Agriculture, Sardarkrushinagar. The plot was kept unsprayed throughout the study period. All other recommended agronomical practices were adopted. The numbers of larvae were recorded from 20 randomly selected tagged plants at weekly interval during the July 2005 to June 2006

Chemical Control of *Papilio demoleus*

Field experiment: In order to evaluate the bio-efficacy of different botanical, conventional and modern insecticides against lemon butterfly, *Papilio demoleus*, a field experiment was conducted at Horticultural Instructional farm, C.P. College of Agriculture, S.D. Agricultural University, Sardarkrushinagr during August, 2006.

The details of the experiment were given as under:

Variety	:	Kagzi lime
Spacing	:	6 × 6 m
Design	:	R.B.D.
Treatments	:	11
Replications	:	3

Number of Spray: First spraying on the appearance of pest. If needed, second spray should be given after (15 days of first spray.

***Method of application of insecticides*:** The spray fluid of each treatment was prepared by taking measured quantity of water and respective insecticide and mixed thoroughly before application. The spraying was done with the help of marut foot sprayer. Two year old plant was considered as a treatment and was sprayed with respective insecticide. Method of evaluation, observations on number of larvae were recorded from whole plant 24 hours before spraying and 24, 72 hours and one week after spraying.

**Corresponding author email: jhabarmal.c@rediffmail.com*

Nursery experiment:

In order to confirm the effectiveness of the insecticides tested against *P. demoleus* under field condition revise nursery trial was laid out with same field tested insecticides against this pest.

Method of application of insecticides: Six month old five saplings of Kagzi lime were kept in each treatment replicated thrice. Three larvae of second and third instar laboratory reared larvae were released on each seedling before 24 hours of spray. The concentration and other information regarding each insecticide remained same as in field trial. The spraying was carried out with Knap-Sack sprayer.

Method of evaluation: The observations on number of released larvae were recorded from each treatment 24 hours before spraying and 24, 72 hours and one week after spraying.

Table 1Insecticides used for evaluation of their efficacy against lemon butterfly (*Papilio demoleus*) on Kagzi lime

Technical Name	Trade Name	Formulati	Conc. (%)	Manufacturing agency
Neem Oil	-	-	5.0	Local Market
Azadirachtin	Vanguard	0.15 EC	0.0005	M/S. Agriland Biotech Private Limited, Baroda
Enosulfan	Thiodan	35 EC	0.07	M/S. Hoechst (India) Ltd Mumbai.
Indoxacarb	Daksh	14.5 SC	0.015	M/S. Rallis India Ltd., Mumbai
Profenophos	Elan	50 EC	0.05	M/S. Gujarat Agrochemi Company, Naroda, Ahmedabad.
Fenitrothion	Sumithion	50 EC	0.05	M/S. Rallis India Ltd., Mumbai
Chloropyriphos	Dermet	20 EC	0.05	M/S. BASF India Ltd., Mumbai
Quinolphos	Quinguard	25 EC	0.05	M/S. Gharda Chemicals Mumbai
Cartap hydrochloride	Caldan	50 SP	0.05	M/S. Dhanuka Pesticides Ltd., Gurgaon (HR)
Carbaryl	Sevin	50 WP	0.1	M/S. S.S. Crop Care Ltd Bhopal.

RESULTS AND DISCUSSION

***Seasonal Abundance of Papilio demoleus*:**

The data on larval population (Table-2) showed that the activity of this pest was observed thought out the year except in month of January and February. The larval population was ranged from 0.0 to 3.50/ plant during the studies period. However, the maximum population (3.5 larvae/ plant) of the pest was recorded during 27th standard week of the year 2005, thereafter it declined gradually. Similar observation on the seasonal abundance was also reported by Patel (1978). The data (Table-3) on correlation of larval population and weather parameters indicated that the negative and highly significant correlation were existed between larval population of *Papilio demoleus* and sunshine hours, whereas the remaining weather parameters *viz.*, temperature, relative humidity and wind velocity had no influence on the pest infestation during the study period.

***Chemical Control of Papilio demoleus*:** With a view to study the effectiveness of some newer and conventional molecules and neem products against *Papilio demoleus*, two experiments each in field and nursery condition were conducted on Kagzi lime during the year, 2005-06. The larval population of the pest was not observed in experiment area after 15 days of 1st spray, hence second spray of these insecticides was not done.

Field experiment: The results summarized in Table-4 revealed that there was non-significant difference in number of larvae per plant before spray which indicated that the larval population in the experimental plat was uniform before the application of treatments. After 24 hrs of the spray, all the insecticidal treatments were found to be effective in controlling *Papilio demoleus* and significantly superior over control. Among different treatments, indoxacarb 0.015 % recorded significantly the lowest larval population of the pest (1.33 larvae/Plant) and was at par with fenitrothion 0.05 %, quinolphos 0.05 %, endosulfan 0.07 %, carbaryl 0.1 %, neem oil 5.0 %, azadirachtin 0.0005 %, chloropyriphos 0.05 % and cartap hydrochloride 0.05% which registered 1.67, 2.0, 2.0, 2.0, 2.33, 2.33, 2.33 and 2.33 average number of larvae/plant, respectively. The data on average number of *Papilio demoleus* 72 hours after spray showed that all the insecticidal treatments were found significantly superior over control in reducing larval population. The lowest (0.33 larva/plant) larval population was recorded in the treatment of indoxacarb 0.015% which was at par with fenitrothion 0.05% (0.67 larva/plant), carbaryl 0.1% (0.67 larva/plant), endosulfan 0.07% (1.0 larva/plant) and quinolphos 0.05% (1.0 larva/plant) but significantly superior over rest of the insecticidal treatments. The remaining treatments *viz.*, profenophos 0.05%, chloropyriphos 0.05%, cartap hydrochloride 0.05%, azadirachtin 0.0005% and neem oil 5.0 % were found less effective and were at par with each other in suppressing this pest. One week after spraying, the results on average number of larvae per plant showed that, there was significant different among the treatments. All the insecticidal treatments were found significantly superior to control. The per cent control of this pest was observed in treatments, indoxacarb 0.015% and fenitrothion 0.05 per cent which were at par with carbaryl 0.1%, endosulfan 0.07%, profenophos 0.05%, quinolphos 0.05% and cartap hydrochloride 0.05 per cent and significantly superior over rest of the treatments. The sequence of effectiveness of the treatments in checking of this pest was indoxacarb ≥ fenitrothion ≥ carbaryl ≥ endosulfan ≥ profenophos ≥ quinolphos ≥ cartap hydrochloride ≥ chloropyriphos ≥ azadirachtin ≥ neem oil ≥ control.

Table 2 Seasonal incidence of *Papilio demoleus* in relation to abiotic factors during 2005-06

Month & Year	S. W.	Temperature (°C)		Relative humidity (%)		Wind velocity (km/hrs)	Sun shine hrs	Av. no. of larva per plant
		Max.	Min.	Mor.	Even			
		X_1	X_2	X_3	X_4			
July-2005	27	32.4	26.1	89.6	59.6	10.8	1.3	3.5
	28	34.0	26.7	84.0	55.6	11.2	3.0	2.35
	29	35.3	26.4	79.3	45.7	11.9	4.2	2.40
	30	35.0	26.8	85.9	60.7	11.4	4.1	2.20
	31	31.1	25.4	94.7	82.4	6.5	1.0	2.90
August-2005	32	30.7	24.9	91.6	69.0	10.9	0.7	1.95
	33	32.9	25.2	90.1	58.9	7.8	4.3	2.50
	34	33.0	23.2	86.7	54.3	9.0	5.0	1.80
	35	34.4	24.0	82.1	48.7	5.5	9.1	1.40
Sept.-2005	36	36.9	26.1	83.4	47.7	5.6	6.9	2.80
	37	34.1	30.8	91.7	67.4	5.2	5.5	2.80
	38	32.6	25.5	93.6	68.1	5.9	3.9	2.15
	39	31.4	23.2	90.4	54.0	5.8	6.0	2.15
October-2005	40	34.6	20.8	88.9	38.3	2.8	9.9	0.80
	41	36.6	1.5	81.6	26.0	3.0	10.0	1.35
	42	36.9	19.0	75.0	16.6	3.3	9.4	1.50
	43	35.2	15.0	76.1	20.0	3.6	9.8	1.80
	44	34.8	15.0	64.6	13.6	3.2	9.8	1.65
Nov. -2005	45	33.7	14.3	76.6	21.3	2.7	9.3	1.15
	46	33.6	12.7	86.1	16.9	2.3	9.4	1.00
	47	33.8	12.5	44.9	20.3	2.2	9.4	1.25
	48	29.5	13.3	57.4	16.4	6.1	8.5	0.40
Dec. 2006	49	29.8	9.9	76.1	27.4	3.6	9.3	0.30
	50	29.3	7.9	79.9	27.9	2.3	9.2	0.10
	51	27.0	8.8	77.0	25.0	4.4	8.4	0.15
	52	27.0	8.7	81.8	31.4	3.2	8.2	0.25
Jan. 2006	1	27.0	9.7	66.0	27.3	8.4	8.1	0.00
	2	24.8	7.6	84.4	22.7	3.8	8.8	0.00
	3	28.0	11.3	81.0	33.4	3.5	8.4	0.00
	4	28.5	6.9	83.9	20.4	3.3	9.5	0.00
	5	30.7	11.2	75.0	21.9	3.1	8.8	0.00
Feb. 2006	6	32.4	11.2	81.1	23.7	3.3	9.3	0.00
	7	34.1	13.2	85.0	30.1	4.7	9.4	0.00
	8	35.5	14.1	78.3	21.0	3.3	9.5	0.00
	9	34.4	15.3	55.0	16.1	4.3	9.4	0.00
March 2006	10	32.2	15.5	71.0	27.7	5.3	8.0	0.25
	11	32.4	16.5	75.9	25.7	4.8	9.0	0.30
	12	35.5	18.7	61.6	81.4	5.7	9.7	0.15
	13	35.5	16.0	54.9	11.3	5.7	10.0	0.30
April 2006	14	38.1	20.5	64.6	14.7	5.4	10.1	0.15
	15	38.4	21.3	55.6	11.4	6.3	7.5	0.30
	16	37.8	21.3	57.3	16.0	7.0	9.7	0.25
	17	38.6	23.3	79.6	26.3	5.5	11.1	0.05
	18	40.9	24.0	67.6	16.9	6.2	10.9	0.20
May 2006	19	41.9	24.5	77.6	25.4	11.1	9.8	0.10
	20	39.1	26.1	75.4	32.9	10.2	9.9	0.80
	21	37.8	26.7	74.7	30.7	12.	8.5	0.90
	22	38.3	26.7	80.3	46.1	9.6	6.6	1.20
June 2006	23	38.0	26.9	74.3	38.0	10.4	8.5	0.25
	24	38.5	26.9	77.1	34.0	13.2	9.8	0.15
	25	41.0	28.4	65.1	31.7	7.6	9.7	0.10
	26	37.3	27.9	79.9	49.9	9.9	4.4	0.20

Table 3 Correlation co-efficient between larval populations of lemon butterfly with abiotic factors during 2005-2006.

Temperature (°C)		Relative humidity (%)		Wind velocity (kh/hrs)	Sunshine hrs
Max.	Min.	Morning	Evening		
X_1	X_2	X_3	X4	X_5	X_6
0.01811	0.55281	0.49321	0.63568	0.26312	-0.72963**

****Highly significant at 0.05 per cent level**

Table 4 Effect of different treatments on larval population of lemon butterfly in field condition.

Treatments	Conc. (%)	Average no. of larvae per plant			
		Before Spray	After Spray		
			24 hrs	72 hrs	One week
Neem oil	5.0	1.77* (2.67)**	1.68* (2.33)**	1.68* (2.33)**	1.34* (1.33)**
Azadiachtin	0.0005	1.95 (3.33)	1.68 (2.33)	1.58 (2.00)	1.22 (1.00)
Endosulfan	0.07	2.26 (4.67)	1.56 (2.00)	1.22 (1.00)	1.05 (0.67)
Indoxacarb	0.015	1.86 (3.00)	1.34 (1.33)	0.88 (0.33)	0.71 (0.00)
Profenophos	0.05	2.04 (3.67)	1.77 (2.67)	1.34 (1.33)	1.05 (0.67)
Fenitrothion	0.05	2.19 (4.33)	1.46 (1.67)	1.05 (0.67)	0.71 (0.00)
Chloropyriphos	0.05	2.03 (3.67)	1.68 (2.33)	1.34 (1.33)	1.17 (1.00)
Quinolphos	0.05	1.68 (2.33)	1.56 (2.00)	1.22 (1.00)	1.05 (0.67)
Cartap hydrochloride	0.05	1.86 (3.00)	1.68 (2.33)	1.46 (1.67)	1.05 (0.67)
Carbaryl	0.1	2.11 (4.00)	1.58 (2.00)	1.05 (0.67)	0.88 (0.33)
Control	-	2.27 (4.67)	2.19 (4.33)	2.04 (3.67)	2.27 (4.67)
S.Em		0.14	0.13	0.12	0.14
CD (*P*=0.05)		N.S	0.38	0.35	0.41

*** Figure outside the parenthesis are transformed values of √x + 0.5**
**** Figure inside the parenthesis are retransformed values of √x + 0.5,**
N.S.-Non Significant

Nursery experiment

In order to confirm the effectiveness of different insecticides against *Papilio demoleus*, a nursery trial with same insecticides and concentrations was conducted. Before the spray, equal numbers and second–third instar larvae (15 larvae/5 saplings) were released in each treatment to keep the pest population uniform and non-significant. The presented data in Table-5 showed that after 24 hrs of spray all the insecticides were found to be effective in checking of the pest and significantly superior over control. Among various insecticides, indoxacarb 0.015% recorded significantly the lowest population (0.93 larva/plant) of this pest and was at par with fenitrothion 0.05% which registered 1.53 larvae/plant. Whereas, the treatments quinolphos 0.05%, profenophos 0.05%, endosulfan 0.07%, cartap hydrochloride 0.05% azadirachtin 0.0005% and neem oil 5.0% were recorded more than 2.0 larvae/plant and proved to be less effective. These treatments were at par with one another in checking of the pest. The perusal data (Table-5) on average number of *P. demoleus* larvae 72 hrs after the spray concluded that all the insecticidal treatments were found significantly superior in reducing larval population. The significantly minimum larval population was registered in indoxacarb 0.015% compared to rest of insecticides. The descending order on the effectiveness of treatments was indoxacarb ≥ fenitrothion ≥ carbaryl ≥ quinolphos ≥ chloropyriphos ≥ cartap hydrochloride ≥ endosulfan ≥ profenophos ≥ azadirachtin ≥ neem oil ≥ control. Data (Table-5)

Table 5 Effect of different treatments on larval population of lemon butterfly under Nursery condition.

Treatments	Conc. (%)	Average no. of larvae per plant			
		Before Spray	After Spray		
			24 hrs	72 hrs	One week
Neem oil	5.0	1.87* (3.00)**	1.83* (2.87)**	1.64* (2.20)**	1.35* (1.33)**
Azadiachtin	0.0005	1.87 (3.00)	1.80 (2.73)	1.57 (1.97)	1.22 (1.00)
Endosulfan	0.07	1.87 (3.00)	1.70 (2.40)	1.46 (1.63)	1.14 (0.80)
Indoxacarb	0.015	1.87 (3.00)	1.19 (0.93)	0.71 (0.00)	0.71 (0.00)
Profenophos	0.05	1.87 (3.00)	1.64 (2.20)	1.50 (1.77)	1.38 (1.40)
Fenitrothion	0.05	1.87 (3.00)	1.42 (1.53)	1.14 (0.80)	0.79 (0.13)
Chloropyriphos	0.05	1.87 (3.00)	1.49 (1.77)	1.35 (1.33)	1.00 (0.53)
Quinolphos	0.05	1.87 (3.00)	1.57 (2.00)	1.22 (1.35)	1.05 (0.63
Cartap hydrochloride	0.05	1.87 (3.00)	1.78 (2.70)	1.44 (1.60)	1.11 (0.73)
Carbaryl	0.1	1.87 (3.00)	1.46 (1.67)	1.16 (0.87)	0.94 (0.40)
Control	-	1.87 (3.00)	1.89 (3.07)	1.90 (3.13)	1.92 (3.20)
SEm		0.00	0.08	0.06	0.07
CD (*P*=0.05)		NS	0.25	0.19	0.22

*** Figures outside the parenthesis are transformed values of √x + 0. ****
Figures inside the parenthesis are retransformed values of √x + 0.5,
NS=Non Significant

on average number of larvae one week after spray observed that all the insecticides were found significantly superior over control in suppressing this pest. The percent control of this pest was found in indoxacarb 0.015% which was at par with fenitrothion 0.05% and significantly superior over the rest of insecticides. The descending order on the efficacy of the treatments in checking of this pest was indoxacarb≥ fenitrothion ≥ carbaryl ≥ chloropyriphos ≥quinolphos ≥ cartap hydrochloride ≥ endosulfan ≥ azadirachtin ≥ neem oil ≥ profenophos ≥ control. The results of field trials on efficacy of various insecticides were in close conformity to the nursery trial. Based on the effectiveness of the insecticides, it is concluded that indoxacarb 0.015% was found to be effective in checking of this pest. Next to this treatment, fenitrothion and carbaryl were found effective in suppressing pest population. Earlier, Patel (1978) reported that the spray of fenitrothion 0.02% and carbaryl 0.2% was found to be most effective in suppressin the *Papilio demoleus* on Kagzi lime, whereas Doharey and Butani (1985) recorded that the chloropyriphos and phosalone 0.05% were fond effective against *Papilio demoleus*. Thus the results on effectiveness of fenitrothion, carbaryl and chloropyriphos as reported by previous workers for the control of this pest were in close conformity to the results of present findings of above insecticides.

The economics of the insecticides: The majority of insecticides tried in the experiment were effective in controlling this pest. However, considering the cost and effectiveness of the insecticides tried fenitrothion 0.05% at the rate of 1 ml/litre of water was the cheapest and effective. Next to this, carbary l 0.1% was the cheaper. Thus based on the effectiveness and economics of insecticides, fenitrothion 0.05% and carbaryl 0.1% can be recommended for the control of lemon butterfly (Table-6).

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