*Plant Archives* Vol. 26, Supplement 2, 2026 pp.2708-2713 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org

DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2026.v26.supplement-2.341

# EVALUATION OF CHEMICAL INSECTICIDES AGAINST CITRUS BUTTERFLY ON ACID LIME

**Hemangi Chaudhari, Sushma Deb, Anjali Patel and Jyoti Sharma**

[1]Department of Entomology, N. M. College of Agriculture, Navsari Agricultural University, Navsari- 396 450, Gujarat, India

[2]Department of Entomology, College of Agriculture, Anand Agricultural University, Vaso- 387 380, Gujarat, India

[3]Cotton Research Station, Sardarkrushinagar Dantiwada Agriculture University, Talod- 383 215, Gujarat, India

[4]Department of Entomology, C. P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar- 385 506, Gujarat, India

*Corresponding author E-mail: debsushma@aau.in

(Date of Receiving : 18-04-2026; Date of Revision : 19-06-2026; Date of Acceptance : 07-07-2026)

**ABSTRACT**

The experiment was conducted during 2022-23 at Horticultural Instructional Farm, C.P. College of Agriculture, S. D. Agricultural University, Sardarkrushinagar to evaluate the chemical insecticides against citrus butterfly on acid lime. The experiment was laid out in a completely randomized design and ten chemical insecticides were evaluated against citrus butterfly larvae with three repetitions. Among the treatments, chlorantraniliprole 18.5 SC @ 0.0037 per cent, flubendiamide 480 SC @ 0.144 per cent, emamectin benzoate 5SG @ 0.0002 per cent and indoxacarb 15.8 EC @ 0.00079 per cent exhibited less number of larvae per plant *i.e*., 2.62, 2.32, 2.36 and 3.11, respectively and recorded as effective against citrus butterfly.

***Keywords*** **:** Acid lime, Citrus butterfly, Larva per plant, Chemical insecticides.

## Introduction

The genus Citrus, belonging to the Rutaceae family, is an evergreen shrub thought to be native to Southeast Asia (Zhong and Nicolosi, 2020). Citrus is one of the most extensively cultivated fruit species in the world, with 4000 years of cultivation history and is typically grown in China, USA, Mexico, India, Brazil and Spain (Liu *et al.*,2012). Citrus is the world's third-largest fruit industry, with India now ranking third globally by producing 16.82 million metric tonnes across 1.15 million hectares. Within India, 'Kagzi' or 'Pati' acid lime (*Citrus aurantifolia* Swingle) is a vital commercial crop, yielding 4.38 million metric tonnes from 345,000 hectares with a productivity of 12.7 metric tonnes per hectare (Anon., 2025a).

Kagzi lime is a highly remunerative fruit crop grown across India, with Gujarat maintaining a dominant position in the nation's lime industry. Gujarat contributes approximately 15.2% of the national production, with cultivation expanding to approximately 52,410 hectares and yielding a total production of 531,360 metric tonnes (Anon., 2025b). In North Gujarat, commercial cultivation remains a key economic driver, particularly in the districts of Mehsana, Gandhinagar, Banaskantha, Sabarkantha, Patan and Aravalli. These six districts collectively account for an estimated 21,150 hectares with a consolidated production of 234,840 metric tonnes, representing a significant portion of the state's total citrus output (Anon., 2025c).

Citrus crops face devastating yield losses of 83% to 95% due to a wide array of specialized pests. Major threats include defoliators like the citrus butterfly and leaf miner, alongside sap-sucking insects such as blackflies, psylla, aphids, thrips and whiteflies. The crop is further compromised by structural pests like the trunk borer and ash weevil, as well as infestations from red scales, mealybugs and mites, all of which collectively cause severe agricultural damage (Afzal *et al.*,2023).

Citrus butterfly, its principal host plants are the members of the genus Citrus and serious pest of citrus in India and four species of citrus butterflies *viz*., *Papilio demoleus* Linnaeus, *Papilio polytes* Linnaeus, *Papilio polymnestor* Cramer and *Papilio helenus* Linnaeus were recorded to damage citrus in South India (Shivankar, 1999). Citrus butterflies were found throughout the year, though rare during winter and is a serious citrus pest in India (Pathak and Rizvi, 2002). The infestation of citrus butterfly is more pronounced in nurseries and young plantations where the seedlings and trees may be completely defoliated (Butani, 1979). The citrus butterfly, *P. demoleus* cause 83 per cent defoliation in young citrus trees. The larvae are a serious pest of citrus nursery stock (trees 1-2 ft. in height) and other young citrus tree in Asia and Middle East (Narayanamma *et al*., 2001).

## Materials and Methods

The experiment was conducted at Horticultural Instructional Farm, C. P. College of Agriculture, S. D. Agricultural University, Sardarkrushinagar to evaluate the chemical insecticides against citrus butterfly on acid lime during the year 2022. The experiment was laid out in a completely randomized design with eleven treatments and three repetitions. Ten chemical insecticides *viz*., Quinalphos 25 EC @ 20 ml, Indoxacarb 15.8 EC @ 5 ml, Chlorantraniliprole 18.5 SC @ 2 ml, Spinosad 45 SC @ 1 ml, Emamectin Benzoate 5 SG @ 4 g, Novaluron 10 EC @ 7.5 ml, Flubendamide 480 SC @ 3 ml, Profenophos 40 + Cypermethrin 4 EC @ 20 ml, Tolfenpyrad 15 EC @ 20 ml, Cyantraniliprole 10.26 OD @ 3 ml, diluted in 10 litre of water were sprayed and evaluated against the pest. Trees without any application were also maintained as untreated check.

### Method of application

The spraying was done with the help of Knapsack sprayer. For each treatment three plants of identical age were selected, each tree was considered as one repetition. First spray was applied on the appearance of pest and second spray at 15 days after first spray.

### Observations recorded

For recording observations on number of citrus butterfly larvae, 4 twigs from 4 directions (North, South, East & West) were selected and larval count was done a day before and 3, 6 and 9 days after each spray. Fruit yield (t/ha) was recorded at a time of picking. The data thus obtained were statistically analysed.

### Increase in yield over control

On the basis of yield, increase in yield over control was calculated as per the formula derived by Khosla (1977)

$$\text{Increase in yield over control (\%)} = \frac{\text{Yield in treatment - Yield in control}}{\text{Yield in control}} \times 100$$

### Avoidable losses

On the basis of yield of various treatments under study, the avoidable losses due to citrus butterfly in acid lime was calculated by applying the following formula derived by Khosla (1977)

$$\text{Avoidable loss (\%)} = \frac{\text{Highest yield in treated plot - Yield in treatment}}{\text{Highest yield in treated plot}} \times 100$$

### Economics

In order to know the economics of different treatments evaluated against citrus butterfly infesting acid lime, Protection Cost Benefit Ratio (PCBR) was worked out. For the purpose, total cost of insecticidal treatments per hectare was calculated for each treatment based on prevailing market price. Total income (Rs./ha) was worked out for each treatment based on yield (tonne/ha) and market price of fruit (Rs./tonne) over control. The net realization (Rs./ha) for each treatment was computed by deducting the income of control treatment from the income of each various treatment. The net gain (Rs./ha) was worked out by deducting the cost of insecticidal treatment from the net realization. The PCBR was calculated by dividing net gain with the cost of treatment.

**Table 1:** Treatment details of chemical insecticides evaluated against citrus butterfly on acid lime

| Tr. No | Treatments | Concentration (%) | Dose (g or ml per 10 L of water) |
|---|---|---|---|
| $T_1$ | Quinalphos 25 EC | 0.05 | 20 ml |
| $T_2$ | Indoxacarb 15.8 EC | 0.00079 | 5 ml |
| $T_3$ | Chlorantraniliprole 18.5 SC | 0.0037 | 2 ml |
| $T_4$ | Spinosad 45 SC | 0.0045 | 1 ml |
| $T_5$ | Emamectin Benzoate 5 SG | 0.0002 | 4 g |
| $T_6$ | Novaluron 10 EC | 0.0075 | 7.5 ml |
| $T_7$ | Flubendamide 480 SC | 0.144 | 3 ml |
| $T_8$ | Profenophos 40 + Cypermethrin 4 EC | 0.088 | 20 ml |
| $T_9$ | Tolfenpyrad 15 EC | 0.03 | 20 ml |
| $T_{10}$ | Cyantraniliprole 10.26 OD | 0.003 | 3 ml |
| $T_{11}$ | Untreated (Control) | - | - |

## Results and Discussion

One day before spraying, there is no significant difference between the treatments for the mean number of larvae per plant. The larval population in the different treatments varied from 8.61 to 10.27 per plant.

The pooled data of the first spray presented in Table 2 clearly showed that all the chemical treatments were significantly different from the untreated control (10.13 larvae/plant). Among the various chemical pesticides, chlorantraniliprole 18.5 SC @ 0.0037 percent showed the minimum (2.85 larvae/plant) number of larvae on acid lime and proved to be the most effective treatment. However, it was at par with flubendiamide 480 SC @ 0.144 percent (2.92 larvae/plant) and emamectin benzoate 5SG @ 0.0002 percent (3.00 larvae/plant) EC. The next better treatment recorded was indoxacarb 15.8 EC @ 0.00079 per cent, which recorded 3.78 larvae/plant. The trees which recorded 5.07 and 5.26 larvae/plant were treated with spinosad 45 SC @ 0.0045 per cent and novaluron 10 EC @ 0.0075 per cent, respectively, which were at par with each other. The highest number of larvae recorded were in the case of cyantranilliprole 10.26 OD @ 0.003 per cent (6.16), tolfenpyrad 15 EC 0.03 per cent (6.26 larvae/plant), and quinalphos 25 EC @ 2 per cent (6.79), which were at par with each other. The highest number of citrus butterfly larvae were recorded in the case of profenophos 40 + cypermethrin 4 EC @ 2 per cent (7.23 larvae/plant), which were at par with quinalphos 25 EC.

Pooled data of second spray presented in Table 2 indicated that all the treatments were significantly superior over untreated control (11.26 larva/plant). Among the insecticidal treatments, the lowest number of larvae (1.72) was found in trees sprayed with chlorantraniliprole 18.5 SC @ 0.0037 per cent and it was statistically at par with flubendiamide 480 SC @ 0.144 per cent (1.78) and emamectin benzoate 5 SG @ 0.0002 per cent (1.81). Indoxacarb 15.8 EC @ 0.00079 per cent registered 2.53 larvae per plant and found moderately effective against the pest. Treatments *viz*., spinosad 45 SC @ 0.0045 per cent (3.87) and novaluron 10 EC @ 0.0075 per cent (4.25 larvae/plant) were equally effective against the pest. The higher number of larvae were registered in cyantranilliprole 10.26 OD @ 0.003 per cent (5.26) followed by tolfenpyrad 15 EC @ 0.03 per cent (5.36) and quinalphos 25 EC @ 0.05 percent (6.00) and they were at par with each other. The maximum population was recorded in the trees sprayed with profenophos 40 + cypermethrin 4 EC @ 0.088 per cent (6.36).

The number of larvae per plant varied from 2.62 to 6.79 among various insecticidal treatments (Table 2) and all the treatments were significantly superior to untreated control (10.66). Among various treatments, chlorantraniliprole 18.5 SC @ 0.0037 per cent recorded the least larvae per plant (2.62) and it was at par with flubendiamide 480 SC @ 0.144 per cent (2.32 larvae/plant) and emamectin benzoate 5SG @ 0.0002 per cent (2.36). Trees sprayed with indoxacarb 15.8 EC @ 0.00079 per cent was significantly different from rest of the treatments which registered 3.11 larvae per plant. Spinosad 45 SC @ 0.0045 per cent and novaluron 10 EC @ 0.0075 per cent recorded 4.43 and 4.74 larvae per plant, respectively and they were on par with each other. Cyantranilliprole 10.26 OD @ 0.003 per cent (5.70 larvae/plant), tolfenpyrad 15 EC @ 0.03 per cent (5.80) were less effective treatments and on par with each other. Maximum number of larvae were harboured in profenophos 40 + cypermethrin 4 EC @ 0.088 per cent (6.79) and it was at par with quinalphos 25 EC @ 0.05 per cent (6.42). The current research supports the findings of Haque *et al*. (2019) reported that Spinosad application effectively controlled *Papilio demoleus* L. on Jara lemon, resulting in a minimum leaf infestation of 17.83%, maximum yield of 1.35 t/ha. Mangrio and Sahito (2022) reported that the flubendiamide 480 SC had the highest efficacy and reduction percentage against *P. demoleus* larvae (80.88±8.94), followed by the fipronil 5 SC (74.11±8.61), and Emamectin benzoate 1.9 EC (72.53±8.52 The pesticides novaluron and emamectin benzoate showed ovicidal effects against *P. demoleus* eggs, with 95% and 85% mortality, respectively. Sable *et al*. (2022) reported that Cyantraniliprole 10% OD (@ 70 g a.i./ha) was highly effective in managing *Papilio demoleus* L., reducing the larval population to 2.68 per plant. Devi and Yadav (2024) reported that Chlorantraniliprole 18.5 SC was the most superior treatment against *P. demoleus* on kinnow mandarin with a significant larval reduction ranging from 90.45% to 94.20% within 10 days of application.

### Yield

The data on fruit yield of acid lime are presented in Table 3. The efficacy of various chemical treatments against citrus butterfly was also reflected on fruit yield. Among various treatments, the fruit yield of acid lime ranged from 1.40 to 2.40 t/ha. The highest fruit yield (2.40 t/ha) of acid lime was obtained from the trees treated with chlorantraniliprole 18.5 SC @ 0.0037 per cent which was at par with flubendiamide 480 SC @ 0.144 per cent (2.37 t/ha) and emamectin benzoate 5SG @ 0.0002 per cent (2.33 t/ha). Trees treated with indoxacarb 15.8 EC @ 0.00079 per cent, spinosad 45

SC @ 0.0045 per cent, novaluron 10 EC @ 0.0075 per cent cyantranilliprole 10.26 OD @ 0.003 per cent, tolfenpyrad 15 EC @ 0.03 per cent (69.15%) and quinalphose 25 EC @ 0.05 per cent recorded fruit yield of 1.92 to 1.56 t/ha and they were at par with each other. Among the chemical treatments the lowest fruit yield (1.40 t/ha) was registered from profenophos 40 + cypermethrin 4 EC @ 0.088 per cent.

### Per cent increase in yield over control

The per cent increase in yield over control in acid lime was worked out and presented in Table 3. The data revealed that highest per cent of increase in yield over control was recorded in the treatment of chlorantraniliprole 18.5 SC @ 0.0037 per cent (155.32%). Treatments *viz*., flubendiamide 480 SC @ 0.144 per cent, emamectin benzoate 5SG @ 0.0002 per cent and indoxacarb 15.8 EC @ 0.00079 per cent recorded 152.13, 147.87 and 104.26%, respectively. Spinosad 45 SC @ 0.0045 per cent and novaluron 10 EC @ 0.0075 per cent recorded 97.87 and 94.68 per cent increase in yield over control, respectively. Lowest per cent increase in yield over control was noted in the treatment of cyantranilliprole 10.26 OD @ 0.003 per cent (78.72%) followed by tolfenpyrad 15 EC @ 0.03 per cent (69.15%), quinalphose 25 EC @ 0.05 per cent (65.96%) and profenophos 40 + cypermethrin 4 EC @ 0.088 per cent (48.94%).

### Avoidable loss

The percentage of avoidable loss caused by butterfly larvae in acid lime ranged from 0.00 to 41.67 percent across different treatments. The avoidable yield loss for acid lime was lowest with chlorantraniliprole 18.5 SC at 0.0037 per cent (0.00%), followed by flubendiamide 480 SC at 0.144 per cent, emamectin benzoate 5 SG at 0.0002 per cent, and indoxacarb 15.8 EC at 0.00079 per cent, which recorded losses of 1.25%, 2.92%, and 20.00%, respectively. The remaining treatments showed a preventable loss ranging from 22.50 to 41.67 percent.

### Economics

The economics of different treatments revealed that, among different chemicals highest net return was realized in the treatment of chlorantraniliprole 18.5 SC @ 0.0037 per cent (Rs. 54,260/ha) followed by emamectin benzoate 5 SG @ 0.0002 per cent (Rs. 52,420/ha), flubendiamide 480 SC @ 0.144 per cent (Rs. 51,300/ha), indoxacarb 15.8 EC @ 0.00079 per cent (Rs. 36,725/ha) and spinosad 45 SC @ 0.0045 per cent (Rs. 34,600/ha) (Table 4). The data on the benefit cost ratio revealed that highest benefit cost ratio was obtained in emamectin benzoate 5 SG @ 0.0002 per cent (16.48) followed by spinosad 45 SC @ 0.0045 per cent (15.73), novaluron 10 EC @ 0.0075 per cent (15.56), indoxacarb 15.8 EC @ 0.00079 per cent (14.84) and chlorantraniliprole 18.5 SC @ 0.0037 per cent (13.11) (Table 4).

**Table 2:** Effect of chemical insecticides evaluated against citrus butterfly on acid lime under orchard condition

| Sr. No. | Treatment | Conc. (%) | No. of larvae/plant | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Before Spray | Days after 1$^{st}$ Spray | | | | | Days after 2$^{nd}$ Spray | | | | | Pooled over sprays |
| | | | | 3 | 6 | 9 | 14 | Pooled over periods | 3 | 6 | 9 | 14 | Pooled over periods | |
| $T_1$ | Quinalphos 25 EC | 0.05 | 3.10$^{a}$ (9.13) | 2.75$^{cd}$ (7.07) | 2.71$^{de}$ (6.84) | 2.66$^{c}$ (6.58) | 2.68$^{cd}$ (6.70) | 2.70$^{de}$ (6.79) | 2.61$^{d}$ (6.30) | 2.59$^{d}$ (6.20) | 2.50$^{d}$ (5.76) | 2.51$^{d}$ (5.82) | 2.55$^{de}$ (6.00) | 2.63$^{ef}$ (6.42) |
| $T_2$ | Indoxacarb 15.8 EC | 0.00079 | 3.28$^{a}$ (10.27) | 2.18$^{ab}$ (4.24) | 2.10$^{ab}$ (3.89) | 1.95$^{a}$ (3.31) | 2.04$^{ab}$ (3.65) | 2.07$^{b}$ (3.78) | 1.85$^{ab}$ (2.91) | 1.75$^{a}$ (2.58) | 1.64$^{a}$ (2.20) | 1.72$^{a}$ (2.45) | 1.74$^{b}$ (2.53) | 1.90$^{b}$ (3.11) |
| $T_3$ | Chlorantraniliprole 18.5 SC | 0.0037 | 3.14$^{a}$ (9.37) | 1.89$^{a}$ (3.07) | 1.82$^{a}$ (2.83) | 1.80$^{a}$ (2.73) | 1.82$^{a}$ (2.80) | 1.83$^{a}$ (2.85) | 1.62$^{a}$ (2.14) | 1.48$^{a}$ (1.70) | 1.41$^{a}$ (1.49) | 1.45$^{a}$ (1.61) | 1.49$^{a}$ (1.72) | 1.66$^{a}$ (2.62) |
| $T_4$ | Spinosad 45 SC | 0.0045 | 3.05$^{a}$ (8.82) | 2.46$^{bc}$ (5.56) | 2.34$^{bc}$ (4.98) | 2.29$^{b}$ (4.75) | 2.34$^{bc}$ (4.98) | 2.36$^{c}$ (5.07) | 2.17$^{bc}$ (4.22) | 2.09$^{b}$ (3.86) | 2.04$^{b}$ (3.67) | 2.06$^{b}$ (3.73) | 2.09$^{c}$ (3.87) | 2.22$^{c}$ (4.43) |
| $T_5$ | Emamectin Benzoate 5 SG | 0.0002 | 3.23$^{a}$ (9.95) | 1.96$^{a}$ (3.33) | 1.85$^{a}$ (2.90) | 1.82$^{a}$ (2.81) | 1.84$^{a}$ (2.89) | 1.87$^{a}$ (3.00) | 1.65$^{a}$ (2.21) | 1.52$^{a}$ (1.80) | 1.45$^{a}$ (1.59) | 1.48$^{a}$ (1.70) | 1.52$^{a}$ (1.81) | 1.69$^{a}$ (2.36) |
| $T_6$ | Novaluron 10 EC | 0.0075 | 3.06$^{a}$ (8.86) | 2.53$^{cd}$ (5.92) | 2.39$^{bcd}$ (5.19) | 2.30$^{b}$ (4.78) | 2.38$^{bc}$ (5.17) | 2.40$^{c}$ (5.26) | 2.26$^{c}$ (4.59) | 2.19$^{bc}$ (4.28) | 2.13$^{bc}$ (4.04) | 2.16$^{bc}$ (4.15) | 2.18$^{c}$ (4.25) | 2.29$^{c}$ (4.74) |
| $T_7$ | Flubendamide 480 SC | 0.144 | 3.08$^{a}$ (8.96) | 1.93$^{a}$ (3.23) | 1.83$^{a}$ (2.86) | 1.81$^{a}$ (2.76) | 1.83$^{a}$ (2.85) | 1.85$^{a}$ (2.92) | 1.62$^{a}$ (2.14) | 1.51$^{a}$ (1.79) | 1.44$^{a}$ (1.56) | 1.46$^{a}$ (1.64) | 1.51$^{a}$ (1.78) | 1.68$^{a}$ (2.32) |
| $T_8$ | Profenophos 40 + Cypermethrin 4 EC | 0.088 | 3.17$^{a}$ (9.56) | 2.86$^{de}$ (7.68) | 2.80$^{e}$ (7.33) | 2.71$^{c}$ (6.83) | 2.74$^{d}$ (7.00) | 2.78$^{e}$ (7.23) | 2.71$^{d}$ (6.83) | 2.66$^{d}$ (6.56) | 2.54$^{d}$ (5.96) | 2.55$^{d}$ (6.02) | 2.62$^{e}$ (6.36) | 2.70$^{f}$ (6.79) |
| $T_9$ | Tolfenpyrad 15 EC | 0.03 | 3.02$^{a}$ (8.61) | 2.67$^{cd}$ (6.63) | 2.59$^{cde}$ (6.23) | 2.55$^{bc}$ (5.98) | 2.58$^{cd}$ (6.15) | 2.60$^{d}$ (6.26) | 2.51$^{cd}$ (5.81) | 2.42$^{cd}$ (5.33) | 2.38$^{cd}$ (5.17) | 2.39$^{cd}$ (5.20) | 2.42$^{d}$ (5.36) | 2.51$^{de}$ (5.80) |
| $T_{10}$ | Cyantraniliprole 10.26 OD | 0.003 | 3.20$^{a}$ (9.74) | 2.66$^{cd}$ (6.60) | 2.59$^{cde}$ (6.22) | 2.52$^{bc}$ (5.86) | 2.54$^{cd}$ (5.94) | 2.58$^{d}$ (6.16) | 2.50$^{cd}$ (5.76) | 2.40$^{bcd}$ (5.26) | 2.34$^{bcd}$ (4.99) | 2.37$^{bcd}$ (5.12) | 2.40$^{d}$ (5.26) | 2.49$^{d}$ (5.70) |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $T_{11}$ | Untreated Control | - | 3.09$^{a}$ (9.05) | 3.20$^{e}$ (9.71) | 3.22$^{f}$ (9.86) | 3.29$^{d}$ (10.32) | 3.35$^{e}$ (10.73) | 3.26$^{f}$ (10.13) | 3.39$^{e}$ (10.98) | 3.40$^{e}$ (11.08) | 3.44$^{e}$ (11.31) | 3.47$^{e}$ (11.56) | 3.43$^{f}$ (11.26) | 3.34$^{g}$ (10.66) |
| S.Em± | Treatment(T) | | 0.14 | 0.10 | 0.10 | 0.09 | 0.10 | 0.05 | 0.10 | 0.10 | 0.10 | 0.10 | 0.05 | 0.04 |
| | Period(P) | | - | - | - | - | - | 0.03 | - | - | - | - | 0.03 | 0.01 |
| | Spray (S) | | - | - | - | - | - | - | - | - | - | - | - | 0.015 |
| | T×P | | - | - | - | - | - | 0.10 | - | - | - | - | 0.10 | 0.05 |
| | T×P×S | | - | - | - | - | - | - | - | - | - | - | - | 0.100 |
| CD at 5 % | | | N.S. | 0.30 | 0.31 | 0.29 | 0.30 | 0.13 | 0.30 | 0.28 | 0.28 | 0.29 | 0.12 | 0.10 |
| C.V.% | | | 7.83 | 7.24 | 7.68 | 7.27 | 7.48 | 7.42 | 7.82 | 7.66 | 7.90 | 7.92 | 7.83 | 7.62 |

**Note:** Figures in parentheses are retransformed values of $\sqrt{x+0.5}$ transformation, Treatment means with the letter(s) in common are not significant by DNMRT at 5 per cent level of significance.

**Table 3:** Effect of chemical insecticides on fruit yield, increase in yield over control and avoidable loss in acid lime

| Sr. No. | Treatments | Conc. (%) | Fruit yield (tonne/ha) | Increase in yield over control (%) | Avoidable loss (%) |
|---|---|---|---|---|---|
| $T_1$ | Quinalphos 25 EC | 0.05 | 1.56$^{bc}$ | 65.96 | 35.00 |
| $T_2$ | Indoxacarb 15.8 EC | 0.00079 | 1.92$^{b}$ | 104.26 | 20.00 |
| $T_3$ | Chlorantraniliprole 18.5 SC | 0.0037 | 2.40$^{a}$ | 155.32 | 0.00 |
| $T_4$ | Spinosad 45 SC | 0.0045 | 1.86$^{b}$ | 97.87 | 22.50 |
| $T_5$ | Emamectin Benzoate 5 SG | 0.0002 | 2.33$^{a}$ | 147.87 | 2.92 |
| $T_6$ | Novaluron 10 EC | 0.0075 | 1.83$^{b}$ | 94.68 | 23.75 |
| $T_7$ | Flubendamide 480 SC | 0.144 | 2.37$^{a}$ | 152.13 | 1.25 |
| $T_8$ | Profenophos 40 + Cypermethrin 4 EC | 0.088 | 1.40$^{c}$ | 48.94 | 41.67 |
| $T_9$ | Tolfenpyrad 15 EC | 0.03 | 1.59$^{bc}$ | 69.15 | 33.75 |
| $T_{10}$ | Cyantraniliprole 10.26 OD | 0.003 | 1.68$^{bc}$ | 78.72 | 30.00 |
| $T_{11}$ | Untreated Control | - | 0.94$^{d}$ | - | 60.83 |
| | S.Em.± | - | 0.11 | - | - |
| | CD at 5 % | - | 0.32 | - | - |
| | C.V. % | - | 10.52 | - | - |

**Note:** Treatment means with the letter(s) in common are not significant by DNMRT at 5 per cent level of significance.

**Table 4:** Economics of chemical insecticides evaluated against *P. demoleus* on acid lime

| Tr. No. | Treatments | Conc. (%) | Quantity of insecticides required for two sprays (Litre/ha) | Cost of pesticides (Rs./ha) | Cost of labour (Rs./ha) | Total cost of plant protection for two sprays (Rs./ha) | Fruit yield (tonne/ha) | Gross realization (Rs./ha) | Net realization Over control (Rs./ha) | Net profit (Rs./ha) | PCBR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $T_1$ | Quinalphos 25 EC | 0.05 | 2 | 780 | 1400 | 2180 | 1.56 | 62400 | 22620 | 20440 | 1:10.38 |
| $T_2$ | Indoxacarb 15.8 EC | 0.00079 | 0.5 | 1075 | 1400 | 2475 | 1.92 | 76800 | 36725 | 34250 | 1:14.84 |
| $T_3$ | Chlorantraniliprole 18.5 SC | 0.0037 | 0.1 | 2740 | 1400 | 4140 | 2.40 | 96000 | 54260 | 50120 | 1:13.11 |
| $T_4$ | Spinosad 45 SC | 0.0045 | 0.1 | 1440 | 1400 | 2840 | 1.86 | 74400 | 34600 | 32400 | 1:15.73 |
| $T_5$ | Emamectin Benzoate 5 SG | 0.0002 | 0.4 | 1780 | 1400 | 3180 | 2.33 | 93200 | 52420 | 49240 | 1:16.48 |
| $T_6$ | Novaluron 10 EC | 0.0075 | 0.75 | 750 | 1400 | 2150 | 1.83 | 73200 | 33450 | 31300 | 1:15.56 |
| $T_7$ | Flubendamide 480 SC | 0.144 | 0.3 | 4500 | 1400 | 5900 | 2.37 | 94800 | 51300 | 45400 | 1:8.69 |
| $T_8$ | Profenophos + Cypermethrin 40 + 4 EC | 0.088 | 2 | 2000 | 1400 | 3400 | 1.40 | 56000 | 15000 | 11600 | 1:4.41 |
| $T_9$ | Tolfenpyrad 15 EC | 0.03 | 2 | 3600 | 1400 | 5000 | 1.59 | 63600 | 21000 | 16000 | 1:4.20 |
| $T_{10}$ | Cyantraniliprole 10.26 OD | 0.003 | 0.3 | 6326 | 1400 | 7726 | 1.68 | 67200 | 26638 | 23676 | 1:8.99 |
| $T_{11}$ | Untreated Control | - | - | - | - | - | 0.94 | 37600 | - | - | - |

**Note:** Market price of fruit yield: Rs. 40/kg; Labour charges: Rs. 350/ labour/ day (Two labours per hectare required for one spray)

| | |
|---|---|
| Quinalphos 25 EC - Rs. 390/ L | Novaluron 10 EC - Rs.1000/ L |
| Indoxacarb 15.8 EC - Rs. 2150/ L | Flubendamide 480 SC - Rs. 17980/ L |
| Chlorantraniliprole 18.5 SC - Rs. 13600/ L | Profenophos 40 + cypermethrin 4 EC - Rs. 1000/ L |
| Spinosad 45 SC - Rs. 8000/ L | Tolfenpyrad 15 EC - Rs. 1800/ L |
| Emamectin Benzoate 5 SG - 4450/ kg | Cyantraniliprole 10.26 OD - Rs. 12500/ L |

## Conclusion

Out of all treatments, chlorantraniliprole 18.5 SC @ 0.0037 percent had shown the least number of larvae/plant i.e., 2.62 and found most effective against citrus butterfly. This was followed by flubendiamide 480 SC @ 0.144 percent with 2.32 larvae/plant, and emamectin benzoate 5SG @ 0.0002 percent with 2.36 larvae/plant.

**Acknowledgement**

The authors are thankful to the Professor and head, Department of Entomology, C. P. College of Agriculture, S.D.A.U., Sardarkrushinagar for providing the necessary facilities during the experiment.

## References

Afzal, M. B. S., Banazeer, A., Serrao, J. E., Rizwan, M. and Naeem, A. (2023). Ecology, biology, damage, and management of sucking and chewing insect pests of citrus. In *Citrus Research-Horticultural and Human Health Aspects*. IntechOpen.

Anonymous (2025a). District-wise area and production of horticultural crops in Gujarat 2024-25. Department of Agriculture, Farmers Welfare and Co-operation, Government of Gujarat.

Anonymous (2025b). Horticultural Statistics at a Glance 2024-25. Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture and Farmers Welfare, Government of India.

Anonymous (2025c). Horticultural statistics at a glance 2024-25: Second advance estimates. Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture and Farmers Welfare, Government of India.

Butani, D. K. (1979). Insect pests of citrus and their control. *Pesticides*, **13**(4), 15-21.

Devi, M. and Yadav, S. (2024). Bio-efficacy and residue of different insecticides against leaf miner, *phyllocnistis citrella* stainton and citrus butterfly, *papilio demoleus* linnaeus in/on kinnow mandarin. *International journal of research*, **7**(12), 01-06.

Haque, R., Maleque, M. A., Rahman, S. M., Khan, A. U. and Bhuiyan, M. L. (2019). Evaluation of new management approaches against lemon butterfly (*Papilio demoleus* L.) infesting jara lemon in Sylhet, Bangladesh. *Bangladesh Journal of Entomology*, **29**(2), 1-2.

Khosla, R. K. (1977). Techniques for assessment of losses due to pests and diseases of rice. *Indian Journal of Agricultural Sciences*, **47** (4): 171-174.

Liu, Y., Heying, E. and Tanumihardjo, S. A. (2012). History, global distribution and nutritional importance of citrus fruits. Comprehensive reviews in Food Science and Food safety, **11**(6), 530-545.

Mangrio, W. M. and Sahito, H. A. (2022). Insecticidal and repellent comparative toxicant efficacy against *Papilio demoleus* (L.) infesting Citrus limon. *Advances in Agriculture and Animal Sciences*, **38**(2), 113-122

Narayanamma, V. L., Savithri, P. and Ramakrishna Rao, R. (2001). Influence of citrus butterfly, *Papilio demoleus* L. damage on growth parameters of the sweet orange host plant. *Indian Journal Plant Protrotection*, **29**(1 and 2), 140-141.

Pathak, K. N. and Rizvi, P. Q. (2002). Age specific life table of *Papilio demoleus* on different hosts. *Annuals of Plant Protection Science*, **10**: 375-376.

Sable, M. G., Das, A. K. and Gupta, S. (2022). Cyantraniliprole mode of action against *Diaphorina citri* and *Papilio demolius* in *Citrus reticulata*. *The Indian Journal of Agricultural Sciences*, **89**(11), 1881–1884.

Shivankar, V. J. (1999). Insect pests of citrus and their management. *Citriculture*, (Ed) Shyamsingh Kalyani Publication, 241-256.

Zhong, G. and Nicolosi, E. (2020). Citrus origin, diffusion and economic importance. In The citrus genome, Pp, 5-21.